APPROPRIATENESS OF MARGINAL-COST-BASED ELECTRICITY PRICES IN DEREGULATED MARKETS

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CERTIFICATE OF ORIGINAL AUTHORSHIP

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ABSTRACT

This thesis examines the appropriateness of marginal-cost-based principles for pricing electricity in deregulated markets. This examination is prompted by the rising concerns about the incessant increases in electricity prices; disconnects between costs and prices; social equity and justness of prices; and – more broadly – increasing disparity between expected and actual outcomes of electricity market reform. While it is true that these outcomes are a result of a complex array of factors, this thesis is however premised on the argument that electricity pricing practices, based on marginal-cost principles, is a dominant factor in affecting the above noted market outcomes. In view of multi-dimensional foci of this research, recourse is made to the body of knowledge residing in several academic disciplines (e.g., engineering, economics, and public policy) and research methodologies (e.g., historic review, empirical research, inferential analysis, and econometrics). The case-examples for this thesis are provided by the electricity industries in the developed world (primarily, the US, UK and Australia, but – more broadly – Germany and France). The analysis reveals that pricing philosophies of the earlier times (from the Aristotelian, to the medieval times) – that are precursors to the modern-day pricing practices – quintessentially emphasized considerations of social justice and fairness in pricing; profit, rather profiteering, was generally viewed unfavourably in those times. The coincidental births (in the mid-to-late 1880s) of the electricity industry and neo-classical ideology however appears to have imparted a profit-seeking ethos to the foundations of the electricity industry. Assisted by rapidly rising (and highly, inelastic) electricity demand, technology-innovation-induced economies-of-scale, and mutually-symbiotic 'understanding' between diverse industry interest (namely, utilities, customers, equipment manufacturers, fuel suppliers, regulators, investors, governments), the electricity industry – up until the 1960s- continued to earn super-normal profits, while maintaining lowering cost and price trends for electricity. These trends however reversed in the 1970s, turning the electricity industry into a rising-cost, even faster-rising-prices, and a shrinking profit industry. Concomitant with the rise of neo-liberal thinking in the eighties, the electricity industry began to be deregulated – in accord with neo-liberal principles. A key element of this reform was the re-enforcement of faith in market-discovered, marginal-cost-based electricity prices – as the best means to achieve allocative efficiency, lower electricity costs and prices, and investment-attractive returns (profits). In view however of the plateauing of technological advancements in the 1970s and 1980s, availability of alternative technologies (e.g.,

low-capital-high-operation-cost gas turbines, renewables), systems (e.g., decentralized), and structural and governance arrangements (completion, choice, light-handed incentive regulation), marginal cost-based prices failed to deliver on the expectations. The only course of action for the industry to recoup capital costs (in this high-capital cost industry) was to 'game' the system, through the abuse of market power, taking advantage of the indispensability of electricity. Cost (euphemism for profit) considerations became the motor of all major decisions. This sent the system into a disarray – costs became disconnected from prices, households bore the brunt of price increases, and the technical integrity of the system was compromised. In addition to empirical validation, this research has substantiated these claims through econometric analyses. This research further makes a case for developing alternative pricing paradigms, underscored by considerations, for example, of continual efficiency improvements, incentivizing technology innovations, benchmarking costs to improved efficiencies, and - above all – ensuring that social justice and fairness are central to the pricing strategies for various segments of society.

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I dedicate this work to my (late) Granduncle and Parents.

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ABBREVIATIONS

AC	Alternating Current
ACT	Australian Capital Territory
ADB	Asian Development Bank
AGR	Advanced Gas-cooled Reactor
ANOVA	Analysis of Variance
ASI	Adam Smith Institute
AUC	Australian Cent
AUD	Australian Dollar
BCA	Business Council of Australia
BPA	Bonneville Power Administration
BST	Bulk Supply Tariff
BTU	British Thermal Unit
CBI	Confederation of Business Industry
CCGT	Combined Cycle Gas Turbine
CEB	Central Electricity Board
CEGB	Central Electricity Generating Board
CPS	Centre for Policy Studies
CSE	Citizens for Sound Economy
DC	Direct Current
DECC	Department of Energy and Climate Change
DSM	Demand Side Management
EFL	External Financing Limit
EIA	Energy Information Administration
ELCON	Electricity Consumers Resource Council
EPA	Energy Policy Act
ESAA	Energy Supply Association of Australia
ESI	Electricity Supply Industry
FERC	Federal Energy Regulatory Commission

FPC	Federal Power Commission
GDP	Gross Domestic Product
GHG	Green House Gases
GNP	Gross National Product
GT	Gas Turbine
GW	Gigawatt
HC	Holding Company
HF	Heritage Foundation
HVDC	High-voltage-direct current
IEA	International Energy Agency
IMF	International Monetary Fund
IPA	Institute of Public Affairs
IPP	Independent Power Producer
IRP	Integrated Resource Planning
LCP	Least Cost Pricing
LRMC	Long Run Marginal Cost
MPT	Marginal Productivity Theory
MW	Megawatt
NELA	National Electric Light Association
NEM	National Electricity Market
NETA	New Electricity Trading Arrangements
NG	Natural Gas
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
PPA	Power Purchase Agreement
PSBR	Public Sector Borrowing Requirement
PUHCA	The Public Holding Company Act
PURPA	The Public Utility Regulatory Policies Act
QF	Qualified Facilities

REC	Regional Electricity Company, UK
SA	South Australia
TFP	Total Factor Productivity
TI	Tasman Institute
TVA	Tennessee Valley Authority
UK	United Kingdom
UKP	UK Pound
US	United States
USC	US Cent
WDI	World Development Indicators
WEA	World Energy Agency

1 INTRODUCTION

1.1 Background

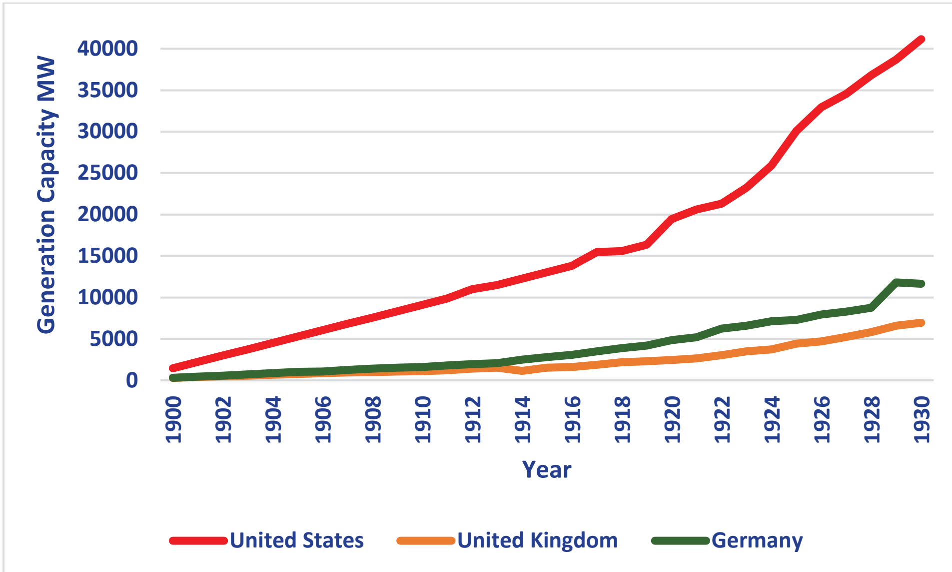
Electricity was regarded as a mysterious force and lightning as a sign of God's wrath even as late as the eighteenth century. It took over two centuries (early 1700s to early 1900s) and the untiring efforts of maverick geniuses of that period, the likes of Benjamin Franklin, Voltas, Humphry Davy, Michael Faraday, Nikola Tesla, Michael Dolivo-Dobrowolsky, and Charles F Scott to harness this primal energy and make it genuinely useful for mankind. Providing an alternative to the steam engine (the workhorse of the industrial revolution) and creating an even more significant industrial revolution was the dream of electricity enthusiasts.

True to this dream, electrical form of energy has carved a niche for itself as the most versatile and preferred form of energy. Electrical energy manifests itself as a universally available flow of energy that can be tapped to avail wide range of services that serve human society as well as all sectors of the economy, scientific and research establishments of the world in many conceivable ways.

1.1.1 Historic Evolution of ESIs

Electricity Supply Industry (ESI) took birth in the United States in the late 1880s. Its formative period was phenomenally successful. The ideology of "progressivism" that was prevalent during this period nurtured this industry. Individuals of great calibre and business acumen set the industry on an enduring path by uniquely tackling all the critical controlling factors of the business so that an expanding business can naturally evolve (Hughes 1993, Hirsh 1999). Pricing strategies and technology that offered incrementally improving productivities shaped the ESIs in the US. Consequently, the ESI of the US became the forerunner among the ESIs of the world – by its capability to achieving consistently highest rate of growth of capacity to generate electricity Figure 1-1 below provides a comparison of growth rates of electricity capacity among the industrially leading countries of the time – the US, the UK and Germany.

Figure 1-1 Historic Evolution of Electricity Capacity



Sources: Developed from: US - (US-CENSUS 1902-1970, Neufeld 1987), UK - (DOEUK 2016), Germany - (Miller 1936, Lagendijk 2008)

The US also set up its mark as the country with the largest electrical equipment manufacturing capability as well as the country to provide its people with highest amount of electricity per capita (FPC 1964).

Large scale (Steam Turbine) technology increased productivities with increasing unit sizes; large area transmission technology provided benefits by way of optimized economic mix and through distribution technology scale economies were obtained. Technology backed up the ESIs with continuously decreasing costs and the impetus for growing capacity for over seven decades till the mid-1960s (Hirsh 2002).

Large scale and large area technology made the ESIs highly capital intensive and growth oriented. The capital intensiveness of the ESIs also meant very high fixed costs, which posed a challenge for the ESIs in determining the criteria for apportioning the fixed costs between the consumers. This problem overwhelmed some of the early ESIs to the extent of making their business unviable.

Samuel Insull, a brilliant strategist, acclaimed as the "founding father" by some and as "hedgehog" by some others, could convert the high fixed cost challenge of ESIs into an opportunity to foster his business interests (Hughes 1993). The non-storable nature of electricity helped him discriminate price of electricity between consumers without any difficulty; he divided the fixed cost between consumers according to the 'value of electricity services' to the consumers. He strategized a price discrimination technique for achieving higher load diversity which enabled higher capacity utilisation and consequent reduction in per unit cost of electricity; and higher profit by charging a price according to the value of electricity services to the consumer.

To assess the value of electricity services conveniently, he developed a sophisticated "profit maximizing price discrimination mechanism." This mechanism was based on Hopkinson and Wright's two-part pricing philosophy[1]. Utilising Wright's demand charge meter, Insull could assess the cost of production of electricity of his competitor the 'Isolated Facilities' (IFs) – the captive electricity providers for the industry. He could then strategically set selling price to the industry that earned him high profits as well as be able to outprice the IFs option of self-generating electricity. ESIs, to promote growth of business, also resorted to differentiating prices between consumers – higher prices for consumers with low elasticity of demand and lower prices for large consumers with high elasticity of demand attracting them to increase consumption (Neufeld 1987, Faruqui and Eakin 2012).

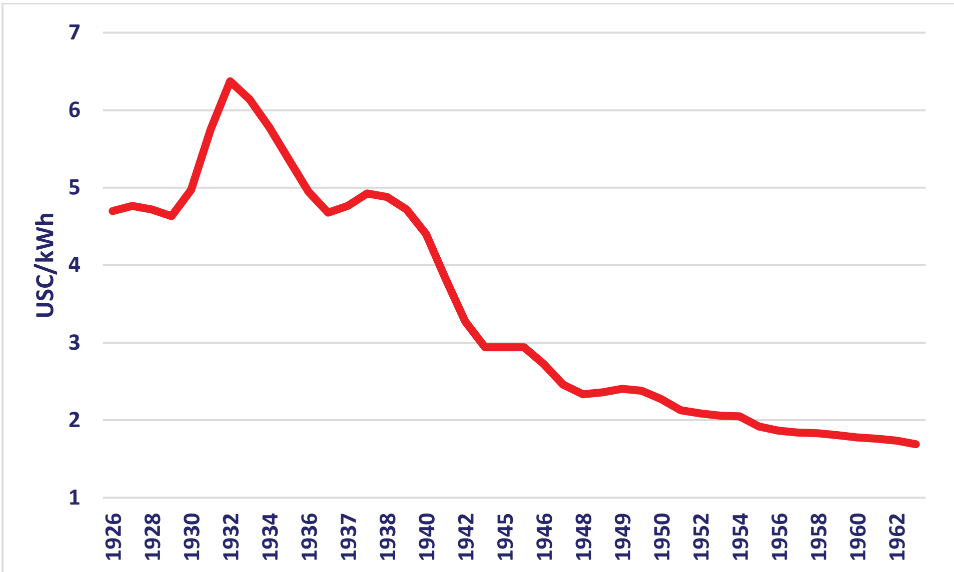
To generate a permanency for his ESI business, Insull negotiated with the government of his time and obtained a 'natural monopoly' status for the ESIs and a pricing formula with regulatory oversight which provided legitimacy to the price. The pricing formula accorded to the ESIs by the "Progressives"[2] was very generous; it allowed reimbursement of all prudently incurred expenses and included a generous return to the investor on the regulator-approved asset base;

[1] Hopkinson and Wright advocated pricing based on value of electricity service to the consumer. Wright developed a *demand charge meter* which he claimed could be used to assess the value of electricity service thus providing a strategic pricing mechanism. This meter which provided information on consumer's individual peak enabled the ESIs to arrive at the generation cost that will be incurred by the consumer if he opted to self-generate electricity.

[2] *Progressives* were reformers of the *Progressive era* of the late nineteenth century and early twentieth century in the US. They initiated a socio-political movement that favoured regulation to save large utilities that demonstrated increasing returns from competition. They reasoned that competition would be counterproductive creating duplication of resources leading to wastage. Instead they preferred a monopoly status that went with a strict regulatory oversight that could rein in monopoly excesses – this was expected to benefit the society and economy.

besides the return, the investor was also allowed to price discriminate between consumers on the basis of *value of services* for apportioning the fixed cost element between the consumers (Neufeld 1987, Hirsh 1999).

Figure 1-2 Average Price 1926-1963 (Real-1963)

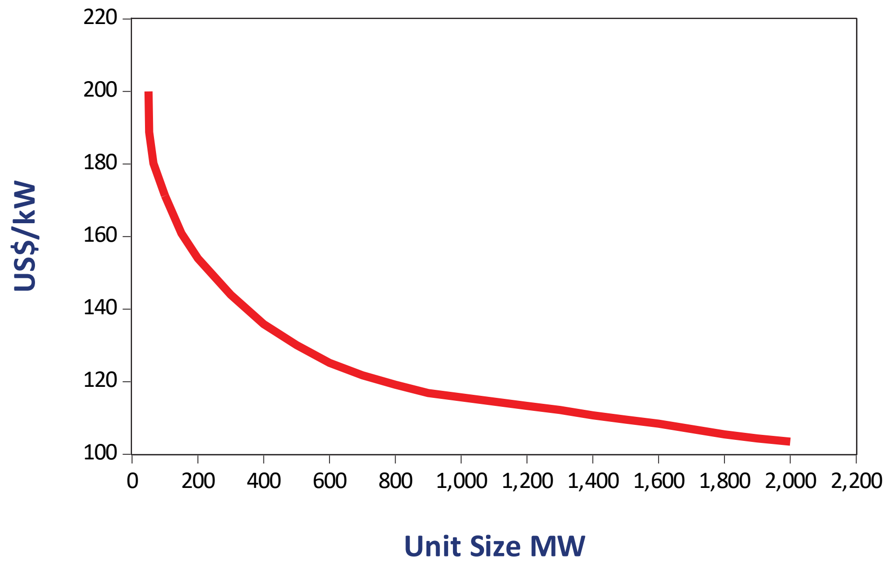


Source: *FPC (1964)*

Technology, regulatory pricing, and value-based price discrimination between consumers provided all the means that Insull needed to make his ESI business flourish with growing profit. Insull always maintained electricity prices on a declining trajectory (see Figure 1-2 above) – the cost reductions from scalable economies were substantial to allow him to earn high profits while at the same time enable him to share some of his profits to sustain a favourable consumer confidence. This approach secured his ESI business. Its profitability, rates of growth of productivity and rates of growth of capacity overwhelmingly surpassed all comparable industries in the US during this initial period. For instance, the ESIs experienced average annual total factor productivity improvement of 5.5% over the period 1889-1953, as compared to 1.7% by the rest of the private sector in the domestic economy (Hirsh 2002).

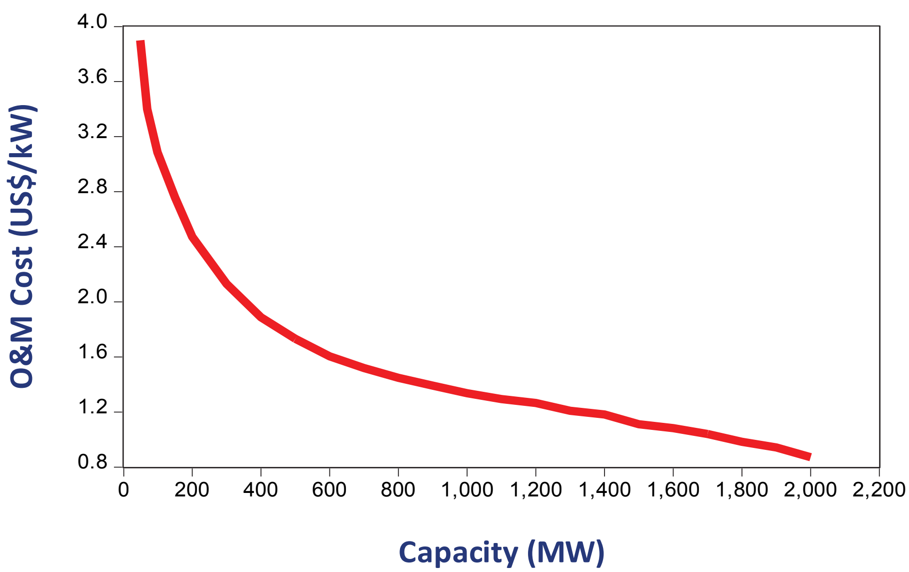
The reducing-cost feature of technology provided the ESIs (see Figure 1-3 and 1-4) a window of opportunity for earning big profits. Each 1MW increase in unit size increased the capital cost by only 0.6%. ESIs, during the mid-1960s, made profits of 14 cents on every dollar of revenue, compared to 6.1 cents by other leading manufacturing firms in the United States (Hirsh 2002).

Figure 1-3 ESI Scale Economy (US)



Source: FPC (1964)

Figure 1-4 Unit Size-O&M Cost $/kW



Source: FPC (1964)

Improved living standards, improved industrial and agricultural productivities came along with increased usage of electricity; its consumption became a key factor for achieving economic growth which eventually led the US to become the largest per-capita consumer of electricity in the world. The overwhelming economic returns to the capital invested by the ESIs exemplified electricity's phenomenal potential as a saleable product. Investor-owned ESI demonstrated itself as a shining example of a business that bespoke capitalistic ideology and culture. This was in sharp contrast to the public-ownership culture of the ESIs prevalent among the European countries during the same period which sought only negligible profit for their capital.

Assured reimbursement of all the expenses to the ESIs also enabled electrical equipment manufacturing companies to grow with phenomenal profits as they could price their equipment with good profit margins. The manufacturing companies assured by the growing popularity of electricity service and assured economic base of ESIs were emboldened to foray into other financial ventures to grow their business and fortify their profits. In the initial times, electrical equipment manufacturing companies provided start-up ESI companies which lacked financial means with a manageable arrangement by agreeing to accept stocks and bonds of such companies in partial payment for the electrical equipment purchased.

Overtime, this practice evolved to become a financial innovation known as the "Holding Company (HC)". General Electric Company, the forerunner in the manufacture of electricity generating equipment in the US was also the originator of the rationale of HC and is credited for the setting up of "Electric Bond and Share Company", a favourite holding company in the year 1905.

Holding companies began by accepting relatively unattractive stock and bond issues of upcoming electricity supply companies in exchange for their purchase of generators and associated equipment produced by them. In turn, HCs issued their own stocks and bonds with the securities of various electricity companies they had acquired.

Investors preferred the securities offered by the HC, because they provided diversification and more secure returns than did offerings from individual companies. The holding companies evolved to become a phenomenon; they attracted capital and expanded rapidly thus contributing to the prosperity of the ESIs. A phenomenal 7 billion dollars was spent by US ESIs on plant and equipment over the period 1920-1930 (Buchanan 1936, Hirsh 1999).

By year 1925, most of the performing ESIs were under the control of HCs and the common stocks of the operating companies were lucrative. Besides normal profit the common stocks of the operating companies also earned a lot of speculative profit for the HCs. HCs earned huge profits by charging the operating companies exorbitantly and from speculative profits obtained from the common stock. Innovative pyramid-like HC structures began to emerge allowing stockholders of top HCs to control assets of several operating companies. This culture led to a situation wherein only a handful of HCs achieved control of almost all the ESIs of the United States by the early 1930s. Interestingly the HCs did not come under the purview of regulatory authorities as much of their businesses crossed state boundaries. This also helped them to increase their earnings by masking profits of the operating companies as expenses (Buchanan 1936, Hirsh 1999).

With utilities performing extremely well in the US, the zeal for regulatory oversight began to wane in the late 1910s; the role of the regulatory oversight began to be looked down upon and even seen as a drag on the prospering utilities. The continuance of the regulatory commissions came under question. The ESIs, however, took to protecting the regulatory fraternity; for them, the continuance of regulatory pricing formula was crucial as it provided a legitimacy to their price structuring between consumers. Further, the pricing formula was the mainstay to run their businesses smoothly; they could without any reservation employ the required workforce and pay them handsomely and get the best cooperation of all its equipment suppliers and pay them generous prices in return for a continuing supply of equipment with increasing scale economies and productivity. ESIs made special efforts to uphold the office of regulators and even praised them for contributing to the success of the ESIs and the continuously declining electricity prices. This also led to an obligatory position for the regulators and weakened their stature and made them subservient to the cause of ESIs (Hirsh 1999).

The economies of scale and price discrimination between consumers increased profits as well as reduced factor costs for the ESIs. The prevailing electricity prices provided a huge margin for profits; the ESIs could earn supernormal profits even after allowing marginal reductions in electricity price. As the regulatory pricing formula only allowed approved rates of return over rate-base, the ESIs began to find ways to increase the rate-base. They did this by showing excess revenues as expenses of holding companies. ESIs could mask additional profits by inflating their allowable rate base by showing the additional profits as expenses towards the services rendered by HCs. This method of readjustment which brought the returns within the allowed norms was also referred to as *stock watering*. The already subdued regulators acted favourably allowing

ESIs with their rate base valuations and construction plans. This stock watering was a regular feature as was disclosed by the report of an inquiry conducted by the Federal Trade Commission instituted by the government during the 1920s. The reports revealed that these adjustments resulted in approximately one billion dollars of transfers being passed on to the investor-owned ESIs. These unethical earnings, by masking the profits as expenses, should have been rightfully shared with the consumers by way of lowered electricity prices (Hirsh 1999, Beder 2003). Investigations into the Stock-market crash of 1929 exposed the complicity of ESI holding companies. The Government passed the Public Utility Holding Act to bring ESIs under closer scrutiny to prevent them from profiteering. This Act prohibited sales of goods and services between company affiliates at a profit, disallowed increasing cost-based regulated rates by artificially marking up the prices paid by ESIs (operating companies), limited the ways ESIs could be organized, and brought ESIs under close scrutiny by a newly created Securities and Exchange Commission (Hirsh 1999).

The Roosevelt administration went one step further and established a government-run ESI, Tennessee Valley Authority (TVA). TVA sold electricity at lower rates; these rates were designed to stimulate demand and raise the standard of living for rural residents and to serve farm customers who had been ignored by investor-owned ESIs (Hirsh 1999, Beder 2003).

Investor-owned ESIs survived the stock-market crash and the government inquiries; the abundant availability of electricity at reducing prices, and favourable disposition of regulators shored them up (Hirsh 1999). The promotional efforts to improve domestic and industrial consumption favoured the ESIs with increasing demand for electricity. The boom economy that followed World War II put paid to any further efforts by the US government to wrest control of the investor-owned ESIs.

Armed with sound economic base provided by the generous regulatory pricing formula, increased profits sustained by incrementally improving scale economies, and stable macroeconomic conditions the ESIs envisioned a prosperous future with benefits flowing to all the stakeholders (electricity manufacturers, investors, regulators and consumers).

Evolution of ESIs in the UK and Germany

While the evolution of ESIs in the US was robust and rapid, the experiences in other countries varied. Hughes (1993) has examined the evolution pattern of ESIs in three countries – the US, the UK, and Germany. Country specific local conditions shaped the evolution of ESIs in each of these countries. In the US, technology dominated politics, in the UK, politics dominated technology, and in Germany, there was a balanced and mature coordination between the political and technological institutions.

The advent of electric power, according to Hughes, was path breaking and transformational – the productivities of factories as well as the living standards of society changed dramatically. Rapid industrialization was a common factor both in the US and Germany – the growing availability of electricity dovetailed with rapid industrialization in a symbiotic manner and provided the impetus for a vibrant economy in both the countries. He regarded this as equivalent to a *second industrial revolution* spearheaded by the US and Germany as they were chiefly responsible for introducing large-scale and large-area technologies and promote the use of electric power (Hughes 1993). Hughes identified three key industry specific factors, namely, *load diversity*, *incrementally improving scalable technology*¸ and *large area technology* that facilitated optimization of economic activity. The load diversifying techniques that could foster growing demand, scalable and large area technology that could reduce cost perennially made ESIs commercially lucrative and Hughes regarded this industry as an embodiment of well-conceived technological and economic concepts.

In Germany, ESIs thrived, due to excellent coordination between political and technological realms. Like in the U.S, the German government was very supportive, allowing for the introduction of unproven technology, and encouraging private sector. However, German ESIs were provided with limited franchises unlike *carte blanche* approach that was adopted in the U.S. The Government and the ESIs handled pricing issues through a process of positive negotiations. The German government also encouraged industries including transport to rely on electrical energy. Differential rates between consumers were encouraged to improve load factors. ESIs also were encouraged to set up other energy-intensive industries such as aluminium smelting and street car manufacturing facilities. Germany largely followed the U.S model in respect of evolution of the ESIs.

Symbiotic relationship between industrialization and electric power, however, did not exist in the UK. Hughes was surprised at the slow pace of progress of ESIs and per-capita electricity consumption in the UK, and ascribed it to political conservatism. However, some English historians (e.g., Leslie Hannah and ICR Byatt) disagreed with such observations; they argued that the progress and rapid adoption of electric power in the US and Germany came about only because of favourable factors, such as growing population and industrialization (Byatt 1979, Hannah 1979). Despite differing opinions, it was generally acknowledged that the evolution of ESIs in the UK was laggard. Primacy of politics and a deep instinct of conservatism led UK ESIs to come under the jurisdiction of local authorities (counties, municipal boroughs and parishes) right from the beginning. The authorities in turn were under the control of the parliament, and hence governance of the industry was in accord with the government legislation. The ESIs could be owned by both private companies as well as municipal undertakings. Municipal undertakings, with their political affiliations and access to cheaper funds were in advantageous position to own large power stations. In general, however, the size of ESIs were set by traditional administrative boundaries, not by any economic considerations. Thus, there emerged a combination of privately-owned pocket-sized franchises operating side by side with the municipally owned ESIs – this encouraged a culture of inertia, avoidance of risk-taking and parochialism in the shaping of ESIs in the UK. Bickering between municipal undertakings and private companies often resulted in inefficient decisions and consequent diseconomies.

The culture also encouraged continuance of status quo and opposition to any change initiatives. The status quo remained impregnable before World War I, a situation not unlike what prevailed in the rest of Europe except Germany. Attempts by Charles Merz a man known for his successes in setting up large power stations in the North East of England before World War I was in vain. The need for greater importance to electricity generating capacity became apparent only during the World Wars.

Absence of adequate electricity generating capacity was profoundly felt in the UK during World War I especially when contrasted with the superiority of Germany in this regard. This dented the conservatism of British politics and set in motion a process of reforming ESIs in the UK. After a few unsuccessful attempts, the government, in the year 1926, legislated the Electricity Supply Act of 1926 and set up Central Electricity Board, with the mandate to build “National High

Voltage Transmission Grid" and introduce large-scale efficient power generating plants. The existing municipal owned and privately-owned undertakings were allowed to continue and permitted to access new markets based on their economic potential. The National Grid became fully operative in 1936. By 1938 the entire electricity sector began to operate on standardized frequency. The introduction of National Grid improved capacity utilization of the ESIs significantly; wholesale price reduced from 1.098 in 1923 to 0.34 UKP per kWh in 1939; the electricity sector carved a net surplus of UKP 2.75 million in 1939. By 1940, capacity shortages and previously projected lags were overcome, enabling the British electricity sector to set itself on a steady growth path where costs and prices both declined. Even though the franchised power stations stayed with the existing owners, they were brought under commercial and fiscal control of the Central Electricity Board (CEB).

The advent of CEB also established the foundations of a commercial approach for pricing electricity both for the municipal owned as well as private company owned ESIs. CEB allowed generating companies to set electricity prices as dictated by the elasticity of demand. As a result, generating companies gained significant profits which were also fortified by reduced costs following improvements in capacity factors.

Beginning early 1920s, private companies in the UK tended to become part of large holding companies as had happened in the US. Electricity generating plant manufacturers in the UK also maintained their shareholdings to exercise commercial leverage. Profit remained the prominent motive for the holding companies. For instance, Edmundson Group, a holding company of the UK presents an interesting case of how a moribund British Company transformed after coming under the ownership of GLCT (an American Company) and become the largest supplier of electricity in the UK. They engaged in the worst form of abuses of a holding company system (Hannah 1979, Beder 2003).

This was in contrast to the municipally-owned ESIs, who passed on, to the consumers, any cost reductions that came from increased load factors. This obviously improved their political appeal. Further lowering of prices also led to increased consumption.

The improvement in the load factors in the UK was primarily due to increased domestic consumption, following initiatives taken by the CEB to encourage space heating and water heating using electricity. In contrast, in the US and Germany improved load factors were due to increased industrial loads (Hannah 1979, Hughes 1993).

Though CEB removed many of the obstacles that impeded the pace of growth of ESIs, the problems of small scale operation and division of ownership continued. The Second World War heightened the inadequacies of ESIs and damages to the power plants during the war further worsened power availability. Post war, the country realized that security of power supply was needed not only for wartime efforts but also for the reconstruction and economic growth of the country. This provided a fillip to the view that was supportive of unifying the electricity industry under national control. This view also found favour with both the labour and conservative political parties (Hannah 1979). The legislation for nationalizing electricity industry was passed in the year 1947, and it came into effect in 1948. The British Electricity Authority was established; all the municipal and privately owned ESIs were nationalized, and compensated at market rates. This British experience reverberated in other parts of Europe. The Governments of France, Italy, Iceland, Greece and Portugal followed suit and took control of their electricity systems (Beder 2003).

Thus, history witnessed the evolution of ESIs. In the US, ESIs emerged predominantly as investor-owned regional monopolies; in Germany, as public-private partnership companies; in Britain and other European countries, as publicly owned national monopolies.

1.1.2 Electricity Pricing

While the US ESIs had successfully evolved and reached a stage of maturity during the period 1880-1930, other industrially developed countries began their journey with earnestness only after the Second World War. The capital intensiveness of this industry was a challenge which in turn had salient implications for pricing of electricity.

Electricity prices, up until the1940s, were within *regulatory* oversight in most countries of the world though in some countries (e.g., the UK) it was not strictly within governmental control; prices were allowed to be set by the respective generating companies—the presence of dominant municipal ESIs who were keen to keep prices low provided a moderating effect on privately-owned ESIs (Hannah 1979).

Under the regulatory pricing framework, all prudently incurred expenditures of the ESIs were reimbursed and a rate of return was paid on an approved rate-base which essentially was determined by the net-investments (total investment minus paid depreciation); rate of return itself was determined by the respective governments or independent regulators.

The overall rate determined the average price per unit of electricity. However, prices to consumers were differentiated based on differing rationales. Investor-owned ESIs tended to be highly profit motivated and adopted strategic price discrimination between consumers to gain monopoly profits, higher load factors and increasing growth of demand. Government owned ESIs tended to discriminate prices between consumers to gain political advantage. This, generally, resulted in lower prices to the less privileged section of the society.

The electricity experience of the US exerted considerable influence in shaping the ESIs in other countries. The importance of electricity in promoting economic growth and improved standards of living, as well as the versatility of electricity, firmly established its pre-eminence.

The profitability of ESIs was underscored by regulated prices that allowed reimbursement of all expenses. The imperative of large scale and large area technologies in conjunction with regulated prices presented ample scope for excessive capitalisation.

Additionally, versatility and amenability to price discrimination made electricity an ideal commodity for gaining large commercial benefits through price manoeuvrings.

1.1.3 Pricing based on marginal principles and PURPA

The advent of marginal principle in pricing

Post Second World War, the war-torn European countries were in economically devastated conditions. The political mood sought national security, reconstruction and economic modernization. The centrality of electricity for revitalizing the economy was well recognized.

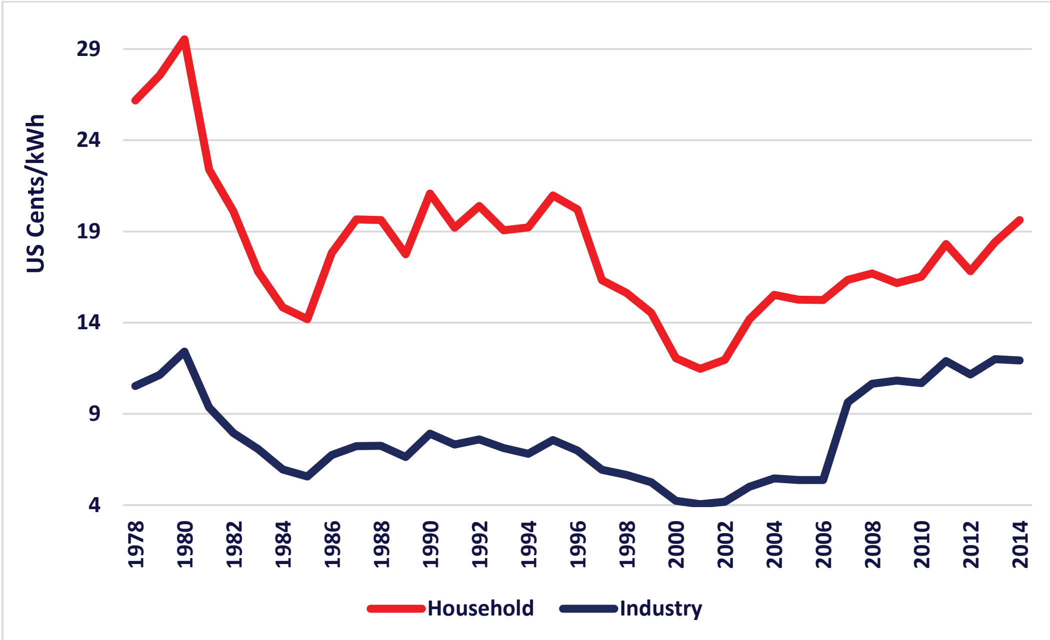
Modernizing the capital-intensive ESIs required access to huge amounts of money. To achieve this objective, leading economists of the time strongly advocated pricing of electricity on marginal principles (Meade 1944, Davidson 1955, Boiteux 1957, Bonbright 1961, Kahn 1970, Westfield 1980). Pricing based on marginal principles, they argued, will be non-discriminatory, reflective of cost and produce the best allocative efficiency of resources. Charging electricity prices at the margin also meant higher returns for plants that are operating at lower than marginal costs.

These (and other) economists worldwide were against average-cost based pricing on the grounds that it will be wasteful as it would not reflect the true values of goods at the time of sale. They also argued that regulated pricing system incentivises inefficiencies, as factors of production are not obtained competitively, and hence prices are not efficient (Averch and Leland 1962). Economists also argued that regulated prices encouraged profligate consumption by allowing predatory pricing during peak hours. This was resorted to sustain capacity growth for the sake of higher revenues (David Gordon 1951, Davidson 1955, Bonbright 1961, Demsetz 1968).

Pricing based on marginal principles in France

The war-devastated France, in its effort to revitalize its economy, sought modernization of its electricity industry. This obviously required substantial funds. The government of France used nearly 80 percent of its borrowings under the Marshall scheme to fund its electricity sector development (Nelson 1964). Repayment of borrowed money was, however, a big challenge for the government as the French Franc was at its lowest level against the US dollar at that time and the French ESI was overburdened with debts. Further, electricity prices were at untenably low levels in those years. Leading French economists of the time (Maurice Allais, Gerrard Debreu, Gabriel Dessus and Marcel Boiteux) argued that the government should place EDF, the dominant French electricity company, on sound economic footing. They recommended pricing based on marginal principles for this purpose. Boiteux provided a pragmatic framework for such pricing, incorporating Ramsey-style exploitation of price-inelastic consumer. This type of discrimination also meant that industrial users of electricity would pay lower prices by virtue of their high elasticity of demand (Ramsey 1927, Train 1991). The economists preferred this approach as it would facilitate economic modernization of France. Thus, a pricing system, that shifted the burden of paying large proportion of fixed costs of electricity on to the most vulnerable sections of the society, emerged in France. The wide divergence between domestic and industry prices in favour of the latter can be seen in Figure 1-5 below.

Figure 1-5 France Electricity Prices (Real 2010)



Sources: Data developed from IEA (2017m), IEA (2017n)

Pricing based on marginal principles in the UK

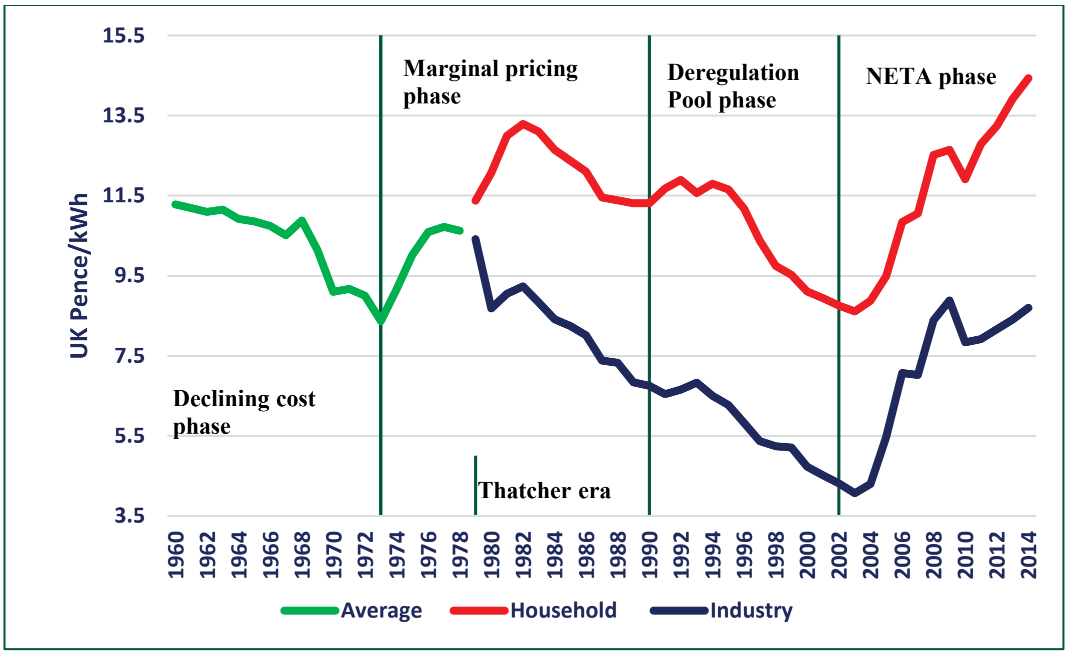
War-weakened UK was also eager to revitalize its economy. The modernization of British ESI was a central element of this revitalization programme. The British modernization program however earnestly considered the issue of affordability for the vulnerable and rural sections of society.

The nationalization of ESI was undertaken in accord with recommendation of Jowitt Committee's report on electricity industry (1942). The committee recommended that electricity for domestic consumers should be treated as a necessity and regarded in the same way as water and sewerage facilities. The committee also recommended that 'public interest' should be the main focus of nationalization. Thus, the ESI nationalization program was dictated by public interest. The government adopted average-cost based pricing of electricity, and encouraged cross-subsidization in favour of rural and domestic consumers.

During the run-up to nationalization, a debate ensued between James Meade – a strong proponent of marginal principles for pricing electricity and the incumbent government – the political will set this aside, in favour of average pricing (Chick 2006, Chick 2007).

The pro-domestic tariff policies adopted by the UK government during the initial years (1948-1958) following nationalization initially resulted in improved load factors, increased profits and lower prices. Increased load factors were attributable primarily to significantly increased domestic electricity consumption as consumers aggressively embraced electric heating after years of experience of harsh winter due to coal rationing. The *declining cost phase* continued till year 1973 as can be seen from Figure 1-6 below.

Figure 1-6 UK Electricity Prices (Real 2010)



Sources: Data developed from DOEUK (2016), IEA (2017b), IEA (2017c), IEA (2017m), IEA (2017n)

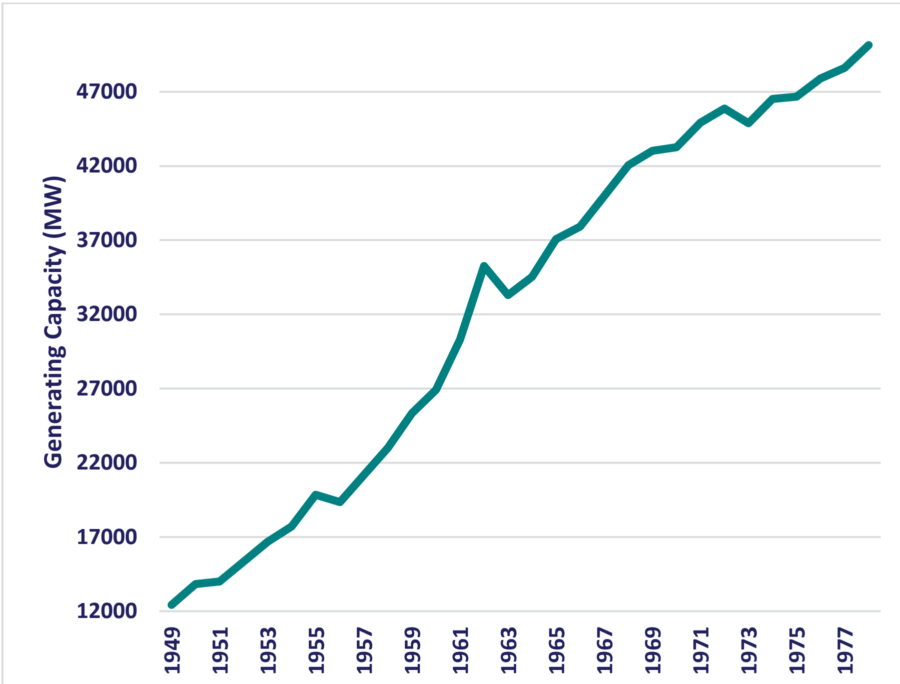
Over time such domestic consumption reversed the load factor trends and resulted in increasing peak demands warranting significant capacity additions; the space heating load that represented one-fifth of domestic sales showed up as three-fifth of peak demand (Chick 2002).

Then nationalized ESI, initially adopted a conservative capacity addition program, deploying moderate size units. Soon its inadequacy became apparent. With post-war housing boom, there was significant pressure to increase electricity capacity (Hannah 1979).

This forced the nationalized ESI to change its planning approach. The early years of the 1960s witnessed the UK government's ever-higher GDP growth targets. This warranted accelerated capacity additions and the need for rapid scaling up of the unit sizes (see

Figure **1-7** below).

Figure 1-7 Electricity Generating Capacity Growth (post-nationalisation)



Source: DOEUK (2016)

The UK government pursued a nationalistic approach to electricity capacity expansion by mandating the ESI to employ indigenously produced power equipment. With equipment supply procured from different manufacturing companies, the task of coordinating and integrating plant designs became the responsibility of the nationalized ESI. Equipment manufacturers also had to rely on indigenously developed technologies which were unproven. Like in the US, scaling up of unit sizes, from 30-60 MW to over 500 MW also took its toll, with manufacturing companies resorting to geometrical upscaling without design verification as would be done in the US in the 1970s and 1980s. This led to manufacturing of unreliable units and consequent outages, breakdowns and financial losses (Surrey 1996). Accelerated capacity enhancements together with complexities arising from the decision to rely on indigenous equipment led to design, manufacturing and coordination errors and consequent delays in construction and commissioning for the new projects; also, unreliable equipment led to forced outages and delays in commercial operation.

Cost overruns and financial losses prompted economists, most prominently, Ronal Edwards of London School of Economics to advocate electricity pricing based on marginal principles (Surrey 1996). From the year 1961 onwards, successive governments introduced a range of financial objectives and targets for the nationalized ESI. Long-run marginal cost based electricity pricing and financial targets (Public Sector Borrowing Requirement (PSBR) targets) – to ensure that investment costs do not become a government liability were introduced from the 1960s (Chick 2011). The government also introduced performance audits to reduce cost of generation. Government also produced White Papers based on such audit reports; for example White Papers (reports) were issued in the years 1961, 1967 and 1978 (Surrey 1996). These reports helped the government to pressurise the management of the nationalised industries by restricting their autonomy and formulating investment, industrial relations and pricing policies in alignment with capitalistic ideologies (Kay and Thompson 1986).

The adoption of LRMC based pricing also meant that peak load consumers, mainly the most vulnerable sections of the society, would bear most of the fixed costs including costs of forced outages as well as the increases arising from excess infrastructure spending (Surrey 1996, Chick 2011). The increasing divergence in electricity prices between household and industrial consumers in favour of industrial consumers is shown in Figure 1-6.

Conservative government under the leadership of Margaret Thatcher imposed increased financial controls on the nationalized ESI. Financial targets by way of increasing rate-of-returns were introduced. This period was also marked by the UK government subjecting the ESI to a range of ad hoc audits carried out by different bodies of the government. These audits investigated the implicitness of the ESI in some of the strategic decisions that were taken, such as, nuclear reactor choice, heavy dependence upon deep-mined coal, and reliance upon British equipment suppliers even though these were essentially borne out of government policies. Although the audits did not hold the industry responsible for taking such decisions, they however affected the morale of the industry, and subjected the management to increased pressure.

Regardless of such unsustainable allegations against the industry by the Thatcher government, the industry was internationally held in high esteem for its success in expanding electricity generating capacity and for providing high quality of electricity supply. The industry had also measured up to the UK governments expectation of playing a major role in supporting the British coal industry and providing business opportunities for the indigenous British heavy electrical industry, notwithstanding the errors in design and technology arising from accelerated capacity expansion programs. The performance of the British ESI, electricity prices, thermal efficiency of the UK plants and labour productivity in the UK were quite favourable by international comparisons (Surrey 1996).

The introduction of financial targets and marginal-cost-based-pricing in effect helped the UK government not only to reduce debt burden faster but also to generate additional revenues as return on ESI investments almost mimicking the ethos of investor-owned ESI (Surrey 1996).

Pricing based on marginal principles in Australia

In the 1970s and early 1980s, the Commonwealth Government, in anticipation of a mineral-led boom, encouraged accelerated build-up of electricity generation and transmission capacity. Various Australian states made considerable investments to expand their ESIs (Beder 2003, Booth and Booth 2003).

The state of NSW which had a stable performance till year 1970 with declining electricity prices accelerated its development program and introduced large-sized electricity projects. One project (Project Liddell) however experienced serious problems due to some reliability issues associated with its generators. This forced the State to search for alternate sources of electricity supply. The resultant losses from Liddell adversely impacted electricity prices; prices increased by over 40 per cent during the 1980s. Investigations revealed that these price increases were primarily due to deficient technology imported from the UK – the same technology which was the cause of financial woes in the UK. Similarly, Victoria made some mistakes in the procurement of large-sized power plants; this led to serious outages, losses and electricity price increases (Booth and Booth 2003).

As was done in the case of the UK following technology failures and outages, the Australian federal government appointed Industry Assistance Commission in the 1989 to investigate the performance of State ESIs and affix responsibilities (IAC 1989, IC 1991). The investigations brought the managements of the ESIs under scrutiny. The initiatives taken by the management did improve the performance of the ESIs. Australia followed the footsteps of the UK in handling the cost overruns and financial losses. Victoria and NSW governments introduced stringent financial controls and conducted frequent management audits. Introduction of pricing based on LRMC however led to increases in electricity prices, as well differentiation of prices between households and industry consumers that favoured the industry generally.

PURPA introduced ostensibly to check increasing prices in the US

The technology-induced productivity-improving feature of the ESIs which anchored reducing cost trends began to ebb in the mid-1950s, and by the1960s; this feature altogether ceased to have any further effects on industry costs. This dented the credibility of ESIs, particularly their claim for unquestioned investments. The credibility was further dented by some other developments. Most notably, stagflation following the Korean and Vietnam Wars, when inflation rose from 3% during the early 1950s, to a nearly 6.7% by the 1970s, while GNP decreased. Inflation also contributed to rising trends in fuel prices (Hirsh 1999, Hirsh 2002).

The Handy-Whitman Index representing cost of labour and materials, rose by over 10% annually during the 1970s, in contrast to 2.3% annually during the 1960s. Further, the oil shocks of the 1970s resulted in high oil prices. Coal prices also surged because of labour troubles as well as ripple effects from oil prices. Additionally, environmental and consumer activism of those years worsened the situation for the ESIs. Governments introduced a wide range of environmental legislations. Compliance with these legislations meant huge costs for the electricity industry, and an overall loss in productivity (Hirsh 1999). Consumer activism created a general hostility towards ESIs – regulators who readily approved any requests from ESIs now became hesitant to approve rate increases.

Adverse macroeconomic conditions, and fall in stock prices of ESIs led to tremendous increases in borrowing costs for the ESIs; there was a doubling of the borrowing costs over that decade. Unprecedented demand increases occurring contemporaneously (in the early 1970s) brought both the ESIs and electrical equipment manufacturers under intense pressure. They collaborated to speed up manufacturing, by resorting to scaling up of unit capacity, based on “extrapolation techniques” rather than scientifically validated design principles. They cited unprecedented increase in demand for adopting such an approach. One can however surmise that the real reason for such aggressive technology upgrade was the prospects of phenomenal profits arising from increasing demand. Contrary to expectations this led to some serious reliability problems for the scaled-up units; unforeseen failures took place, resulting in huge cost overruns and financial losses raising the spectre of demise of steam turbine technology (Hirsh 2002). These hurried actions taken resulted in highly unreliable units coming into operation, increased outage losses made generation costs to significantly increase. From the traditional position of being able to offer declining electricity prices, the ESIs were now confronted with a situation that made sharp increases in electricity prices inevitable. These developments considerably weakened their position, in contrast to the commanding positions they held while dealing with regulators when the going was good.

The Middle-East oil shocks, the growing energy imports, and the unprecedented increases in electricity prices unnerved the US government during the 1970s. The administration developed a national energy policy which aimed to regain control over the energy and economic future of the country. The national energy policy was supported by a legislation, namely, "Public Utility Regulatory Policies Act" (PURPA) sought to significantly change the energy landscape of the country. For example, PURPA discouraged price-discrimination that caused allocative-inefficiencies; instead it laid emphasis on pricing based on marginal principles. The Act encouraged energy conservation and mandated regulators to support implementation of energy conservation measures. PURPA also included special provisions to encourage generation of electricity by small power plants that deployed efficient technology, and power plants that generated electricity using renewable resources, waste heat, municipal waste and other similar resources. These plants were designated as 'Qualifying Facilities' (QFs); they also came to be known as Independent Power Producers (IPPs). The PURPA provisions for these plants included: access to grid, assured market, generous pricing formula on the basis of 'marginal avoided cost', and attractive financing schemes to fund capital investments (Hirsh 1999).

PURPA's emphasis on encouraging new technology that was efficient and low in cost was a good success. Independently owned cogeneration units and small-scale renewable energy facilities evolved rapidly. The 1980s witnessed the introduction of gas-turbine technology for power generation. Legislation that allowed natural gas as fuel for power generation and fall in gas prices following deregulation of this industry fortified this initiative. Introduction of gas technology resulted in rise in efficiency levels to 50%; moreover, capital costs of gas technology were low. By year 1992, 60 percent of new capacity additions were combined cycle gas turbines (Hirsh 1999).

Thus, PURPA, by providing assured market and generous pricing scheme based on marginal avoided cost did succeed to introduce new low-cost-high-efficiency technology; but, excessive enthusiasm in providing such concessions by regulators led to a move away from concerns to keep electricity prices under check (DOE 1996).

Energy conservation initiatives were also fully supported by PURPA. Sophisticated Demand Side Management (DSM), Least Cost Pricing (LCP) and Integrated Resource Planning (IRP) practices to optimize the mix of supply-side and demand-side measures, to effect conservation and to improve efficiency were introduced (Hirsh 1999). These initiatives significantly reduced energy intensiveness of manufacturing industries and contributed to a departure from overtly energy consuming culture. Motivated by this success, the advocates of conservation also went on to recommend changes in the structure of economy, to promote reductions in energy intensity.

PURPA's success in promoting energy conservation directly affected the asset-base of the ESIs, thus also affecting their revenues. To keep the ESIs financially motivated alternative compensating methods were introduced to obtain their participation in promoting conservation initiatives. The implementation of PURPA, however, did not bring about any reduction in electricity prices; rather the prices maintained an increasing trend. For instance, implementation costs of energy conservation programs increased the average cost of electricity for consumers, specifically industry consumers, in the range of 1.5 to 5.5% during the early 1990s (Hirsh 1999).

PURPA was also responsible for establishing the applicability of free-market principles for electricity pricing, through the adoption of competitive bidding for determining the price at which IPPs will be paid for electricity dispatch (Hirsh 1999).

The application of marginal principles (marginal avoided cost) to price electricity sold by QFs and IPPs was very attractive for they could sell electricity at prices which were three to four times their costs. PURPA also provided attractive compensation to ESIs for implementing conservation schemes (as noted earlier). PURPA therefore succeeded in challenging the traditional ESIs, and heralding a movement to undermine the natural monopoly status of ESIs (Surrey 1996, Hirsh 1999, Dubash and Bouille 2002).

Thus, the 1970s and 1980s were generally the years of increasing costs (and prices) for the ESIs – on account of the plateauing of technology and extensive use of untested technologies and increases in factor costs; this was in contrast to the decreasing cost (price) trends of the 1960s. Most of the developed countries where ESIs were State-owned the response to increasing costs was to switch to marginal-cost-based prices. In the United States, where ESIs were predominantly investor-owned the rising costs were blamed on inefficient regulation and therefore a solution was sought to be introduced in the form of PURPA legislation—a composite approach comprising energy conservation and low-cost-high-efficiency generation technologies. Despite the differences in approaches on both sides of the Atlantic the end-result was similar, i.e., increasing electricity prices. Any cost reductions that came about did not translate into corresponding reductions in electricity prices.

1.1.4 Neoliberalism and deregulation of ESIs

The macroeconomic conditions in the US and other developed world in the mid-to-late1970s and early 1980s were challenging. Growing global competition, plateauing of productivities, and disarrayed international monetary system (primarily caused by generous spending on social welfare programs) overwhelmed the economies of the developed world. The deep crisis of the 1970s in the US remained immune to Keynesian remedies, and national economies becoming increasingly interdependent with international trade and capital mobility.

To overcome these issues, prominent economists of the time, especially from the University of Chicago, sought an end to the expanded role of government in the economy – an end to the policies that underpinned the post-war economic and social governance. They advocated ideology of *Neoliberalism* instead. *Neoliberalism* emphasises efficiency gains through the application of free-market principles. This ideology overwhelmingly appealed to the right-wing polity and the business community of the times. It professed advantages of privatization and deregulation of businesses, disempowering of labour unions, and reductions of taxes especially for those in the top income brackets (Surrey 1996, Hirsh 1999, King and Wood 1999, Beder 2003, Wikipedia 2015).

The US, the UK and Australia were among the forerunners in the group of countries that introduced *neoliberalism*. Think-tanks played a major role in propagating this ideology. For example, the Institute of Economic Affairs (IEA) and CPS aggressively favoured the spread of *neoliberalism* in the UK (Beder 2003). IEA, funded by large multinational and several big companies, from its inception in the 1970s set out to gain wide acceptance for the "philosophy of the market economy" through lobbying opinion leaders, such as intellectuals, politicians, business and journalists. IEA managed to enrol several prominent MPs of the UK to their cause. The CPS, an outgrowth of IEA, was founded by Keith Joseph (an influential figure in the UK politics and an avid supporter of free market principles), Alfred Sherman and Margaret Thatcher. CPS engaged in converting the conservative party to economic liberalism and to formulate policies for the party that were in line with this philosophy (Beder 2007). The Heritage Foundations (HF) and Citizens for Sound Economy (CSE) promoted *neoliberalism* in the US (Hirsh 1999, Beder 2003). Business Council of Australia (BCA) and Tasman Institute (TI) played a key role in propagating *neoliberalism* in Australia (Beder 2007).

The support of political leadership, for example, Margaret Thatcher in the UK and Ronald Reagan in the US, the affinity of the Anglo-American market economies to the ideology of neoliberalism, and the increased capital mobility following the collapse of Bretton Woods fixed exchange rate system provided a fillip to the advent of neoliberalism (Kitschelt 1999). There was a quick turn of events during the period 1970s and 1980s as the world was overtaken by neoliberal movements across the US, the UK, Australia and Europe, leading to an era of total commitment to furthering business interests (Hirsh 1999, Beder 2003, Wikipedia 2015). The market-based economy needed a political environment that would assure its autonomous functioning. Neoliberal think-tanks played a crucial role during the times of election by providing tacit support to political parties that favoured neoliberal ideology; they also supported the agenda that benefitted their businesses and autonomy functioning (Kitschelt 1999).

The ideology of neoliberalism also became the accepted ideology of the World Bank, IMF and other multilateral aid agencies. The World Bank and the IMF used their growing influence over debt-laden developing nations to pressurize them to open their public services, including electricity services, to foreign investment. While these very organizations in the 1970s had viewed government debt in less developed countries as unproblematic; in fact, it was argued that government debt was a necessity for setting up the infrastructure and providing public services for national economic growth. In the 1980s, however these international agencies changed their opinion and began to discourage governments from accumulating balance-of-payment deficits. The World Bank introduced changes to lending terms for advancing electricity sector loans to developing countries so as to ensure that the obligations of debt-servicing are met unfailingly by the recipient countries. Even agencies like International Energy Agency (IEA) began to support ESI privatization and deregulation (Dubash and Bouille 2002, Beder 2003).

Deregulation in the UK

The CPS campaigned for privatizing ESIs in the UK. It argued that the UK ESI was inefficient, inflexible and secretive. Adam Smith Institute (ASI), another think tank in the UK, had the reputation of getting radical ideas turned into policy, campaigned with the industry users of electricity and convinced them that electricity supply provided by the Central Electricity Generating Board (CEGB) was expensive because of the social goals that they pursued. Through its efforts (during the later-half of the1980s) two business coalitions were mooted – "The Major Energy Users' Council" and "The Energy Intensive Users Group". The Energy Intensive Users Group played an influential role in "pressing for privatization and deregulation of ESI" (Beder 2003).

Thatcher made privatization as a central feature of her government policy; the proceeds from privatization could mitigate the effects of the severe recession on the public-sector finances, it was argued. This was politically more acceptable than raising taxes or cutting public spending. In mid-to–late 1980s the UK government earned nearly £ 37 billion from privatizations of public services (Surrey 1996).

Thatcher popularised her privatization endeavours by eulogising the concept of a 'share-owning democracy'. The shares sales were directed towards general public and profit was enabled by under-pricing share prices.

Victory in the Falklands War emboldened Thatcher government to embark upon privatizing major public utility companies from the mid-1980s. An earlier failed attempt, in the year 1983, to privatise the electricity supply industry had increased the resolve of the government to achieve this more resolutely. The government also took note of the strong opposition to regulatory pricing by the economists in the US and had decided to go for privatisation and deregulation as well. Disregarding all the good work and improvements carried out by the CEGB, the government portrayed inefficiency and high electricity prices as the primary reasons for resorting to privatization and deregulation (Surrey 1996, Pearson 2012).

The government ignored the concerns, arguments and criticisms against privatisation and deregulation of a large and technically complex industry (CEGB) that was providing a fundamentally important service to the society. It held deregulation and privatization of CEGB as sacrosanct, and cited the example of the success of PURPA which had established that IPPs could co-exist with incumbents without causing any security or stability issues. IPPs employing new technologies with low capital and operating costs did not demonstrate scalable efficiency. They however proved to be a better option than the incumbent steam turbine technology which was no longer scalable. As scalability was considered an integral feature justifying the monopoly status awarded to the electricity generating companies, the economists felt that there was sufficient justification for the termination of natural monopoly status for the ESIs. Falling oil prices (oil prices in real terms had reduced by over 50 per cent following the decision taken by Saudi Arabia to lift the production embargo) further reduced the risks faced by the government (Pearson 2012).

The CEGB, was privatized and deregulated by the passage of *The Electricity Act, 1989*. Besides the professed economic considerations for electricity reform, there were underlying political motives. The broad political motives were debt reduction, breaking the strong interdependence between ESI and the British coal industry, and disempowerment of the militant National Union of Mineworkers.

The British ESI experiment of privatization and deregulation was indeed radical, underscored by a totality of implementation, and was viewed as a great accomplishment by the neoliberal think tanks (Surrey 1996).

Deregulation in the US

The Heritage Foundation (HF), funded by large automobile and fuel companies, had campaigned for deregulation of ESIs in the US. Adam Thierer, a fellow of the HF and the author of "Energising America: A Blueprint for Deregulating the Electricity Market" was a vocal campaigner for deregulation of ESIs (Thierer and Walker 1997, Hirsh 1999).

Prominent economists (e.g., Alfred E Kahn and Paul Joskow) were among other strong supporters of deregulation of ESIs. Kahn was a key policy adviser to President Carter at the time PURPA was promulgated; he however later became a critic of PURPA as he realized that

PURPA-induced reforms had overreached the stated objectives of PURPA. These economists did not favour PURPA's emphasis on conservation. They opined that this led regulators straying into public-interest matters. They were however supportive of the achievements of PURPA in promoting free-market principles successfully. They also argued that QFs and IPPs were able to operate with new technologies with low capital and operating costs without exhibiting traits of scale economies thus clearly invalidating the argument about the natural monopoly status of ESIs. Forging together such arguments economists and neoliberal think tanks sought unbundling and deregulation of ESIs in the US as has been done in the UK (Thierer and Walker 1997, Hirsh 1999).

The initiatives taken by HF resonated with the interests of the industry users who had by now united and formed organisations, for example, the Electricity Consumers Resource Council (ELCON). This group was aggrieved by the spiralling costs of electricity following the implementation of conservation initiatives. They were impressed by the potential of deregulation projected by HF. They therefore lobbied with HF to expedite deregulation of ESIs as this would enable them to broker bilateral contracts at cheaper prices with IPPs/QFs.

Neoliberalism in the US began to surface during the later years of Carter presidency, but gained real strength during the presidency of Ronald Reagan. Oil price increases following the Persian Gulf War made the Bush administration to review the U.S Energy Plan which emphasised the importance of securing more domestic energy resources and the adoption of free-market principles.

The Bush administration sought to amend the Public Holding Company Act of 1935 (PUHCA), to enable competition between traditional ESIs and non-traditional QFs and IPPs, to enlarge market with open access – to facilitate local as well as distant power producers to access customers. The government enacted the Energy Policy Act of 1992, which encouraged adoption of market-based principles. This Act allowed greater competition; it provided opportunities for exchange of wholesale power through open transmission access across states. This facilitated greater opportunities for large industry users to access cheaper power (Hirsh 1999).

Deregulation in Australia

Like in the UK and the US, neoliberal think tanks played a major role in promoting deregulation in Australia. Generally, Australia closely followed the foot-steps of the UK; major Australian business-groups funded the same think tanks who were deployed by the UK for introducing deregulation in Australia. Business users were led by the belief that deregulation could bring about substantial reduction of electricity prices as the cross-subsidies (that favoured households and rural consumers) would be withdrawn. Such cross-subsidies for instance, increased electricity prices for the businesses by around 28% in Victoria.

The measures recommended by the IAC (1989) and IC (1991) produced significant improvements in the performance of the ESIs in Australia; it was also well recognized that the prevailing problems of Australian ESIs were more manufacturer-related, as discussed earlier. IC (1991) however maintained that Australia's power sector had still scope to further improvement. They recommended unbundling and competition – such reform they argued would bring improvement in GDP by 0.7% annually and increase in annual disposable income by Australian Dollars (AUD) 300 per household. A national approach to commence the multi-faceted ESI reform process was agreed at the Council of Australian Governments' meeting in 1994 – the approach outlined the process of unbundling, introducing competition among electricity generating companies, and other processes leading up to the launching of National Electricity Market comprising the states Victoria, New South Wales (NSW), Queensland, South Australia (SA), Tasmania and Australian Capital Territory (ACT) (OECD 2009).

The newly elected government in Victoria in February 1994, was faced with a substantial debt burden which was attributed to poor performance of ESIs. Deregulation and privatisation presented an opportunity to reduce State debt and the new government chose to exercise this option (Booth and Booth 2003, OECD 2009). *ESI-Reform Unit* comprising members who were previously strong proponents of the UK electricity reforms was set up in Victoria to execute ESI reforms.

Victorian ESI began to operate as a deregulated industry from early 1995; power was bought and sold through Victoria Power Pool. Privatisation of electricity generating companies took place during 1996-97. New South Wales began deregulation from around early 1998. Electricity generating companies of New South Wales and Queensland did not opt for privatisation.

Australia began its *National Electricity Market* (NEM) in December 1998 with its participation by Victoria, New South Wales and South Australia. Queensland began deregulation process in 1998 and became a part of NEM in 2001. Tasmania joined the NEM in 2005 and became fully operational in the market after the establishment of Basslink HVDC interconnector between Loy Yang Power Station (Victoria) and George Town substation in Tasmania. (Booth and Booth 2003, OECD 2009).

Australia followed the UK model of deregulation; with California and other countries following the same approach, a precedence was set for other countries to emulate.

ESI Reform model

Newbery (2006) has referred to the electricity market reform as an exemplar. Besant-Jones (1996) despite reservations about the electricity reform model of England and Wales regarded this model as appropriate. The World Bank and IEA too considered this model worthy of replication. The following section discusses the main features of the UK electricity reform experiment which became the model for electricity reforms worldwide. The vertically integrated ESI would be unbundled into its competing segments (generation and retail supply) and monopoly segments (transmission and distribution). The generation segments would be horizontally disaggregated into suitable number of separate units which would compete with each other effectively. A wholesale market would be set up to facilitate the process of sale between the generating companies and the retail suppliers. It was expected that prices emerging from the wholesale market would approximate the cost of producing the last kWh of electricity. On the whole this system enabled a market-clearing price that would approximate marginal energy costs when the supply is more than demand; during periods of relative shortage of generating capacity they could also rise to a higher level that reflect marginal capacity costs in addition to marginal energy costs. The monopoly segments (transmission and distribution) would be regarded as natural monopolies. Transmission and distribution prices would be set by incentive-based regulation or performance-based regulatory pricing methods. Competition at the retail level would provide consumers with the choice to select their electricity supplier (Surrey 1996, IEA 1999, IEA 2000a, IEA 2000b)

The professed rationale for reform

The rationale and perceived benefits of the electricity reform as professed by the proponents of electricity reforms (as also discussed earlier in this-section) are summarised as follow.

Market discovered prices, under conditions of unfettered competition and private ownership, will impart commercial ethos to the electricity business which will lead to real efficiency improvements and innovative methods for cost reduction. Electricity prices will fall, and economic welfare will ensue.

Some of the oft-cited potential reasons for cost reductions in deregulated markets included: improvements in capacity utilization and operational efficiencies; renovation and modernization of existing assets that can increase the longevities and operating efficiencies of existing generating plants; possible introduction of new innovative technologies that bring about lower capital costs and higher operating efficiency; optimization O&M staff requirements, improvements in O&M techniques (by focusing on reliability centred maintenance techniques and other innovative approaches); avoidance of social-welfare costs that are obtained by cross-subsidising from consumer prices (Paffenbarger, Lammers et al. 1999).

Reality versus rhetoric of the new pricing principles

The new pricing paradigm had its pitfalls and not all claims could be fulfilled. This evoked mixed responses from stakeholders and observers. Skeptics have raised fundamental questions about the ability of the new pricing paradigm to deliver lower prices. The non-storable nature of electricity enables price-discrimination between consumers according to their elasticity of demand (as discussed earlier). Additionally, the imperative of having to match supply and demand on a real-time basis for ensuring system stability makes electricity demand totally inelastic and vulnerable to price volatilities (Borenstein 1999, Borenstein 2002, Stoft 2002).

The proponents of reforms on the other hand have maintained that the new pricing fundamentals were based on sound economics and its perceived erratic behaviour was attributable to flawed implementation – they also argued that such pricing reforms are an evolutionary process and stressed the need for fixing glitches along the way; and that reforms would definitely produce benefits in the long-run (Pollitt 1997, Steiner 2000, Newberry 2002, Hattori and Tsutsui 2004, Stridbaek 2006).

World Bank, IMF, other multilateral funding agencies and IEA were strong advocates of deregulation and privatisation of ESIs, much like other neoliberal think tanks (as also discussed earlier in this chapter). These agencies portrayed the perceived success of competitive pricing in the UK ESI post-reform as worthy of emulation by other countries (Hutzler 1998, IEA 1999, Dubash and Bouille 2002, Beder 2003, EIA 2010).

The inordinate price spikes experienced by California which had followed the UK reform model, were illustrative of the inappropriateness of this market derived, marginal-cost based pricing paradigm; in fact, California was a spectacular failure. In Victoria, the electricity companies were reduced to the brink of bankruptcy following the adoption of the new pricing paradigm.

The UK deregulation, according to some, was wrapped with complex regulatory features to facilitate profits to the privatised companies. Factor cost increases were passed on to the captive (largely household) consumers while benefits from reduction in fuel (coal) costs (in the range of 30-40%) were allowed to be passed on to the shareholders and privatised companies. Generous pricing formula was provided for the network segments. Generating Companies were able to exercise market power and set up wholesale prices well above the new-entrant prices. In 1995, the profits recorded by National Power, Power Gen, REC supply business, National Grid, REC distribution business were 0.75, 0.6, 1.5, 0.7 and 1.75 billion UKP, respectively. Profits increased at over 15 per cent per year – share prices increased by more than three times in a span of less than 5 years. Divergence of electricity prices between households and industry/large consumers got accentuated. In sum, cost-reductions did not translate into corresponding price reductions for consumers; instead the industry became a vehicle for wealth shifts, from the poor to the rich. Reforms have only reinforced the ethos to profiteer; heightened the price disparity between consumers favouring industry/large consumers; aggravated the conditions of millions of households by making them to spend larger and larger percentages of their incomes towards meeting electricity charges; evidence seems to suggest a link between increased rates of deaths occurring during winter and unaffordable prices preventing usage of space heating (Surrey 1996, Thomas 2001, Chick 2007, Pearson 2012).

There are even more reports that portray the impact of pricing reforms in poor light, particularly the price increases engineered by exercise of market power. Watts (2001), Dubash and Bouille (2002), Beder (2003), Chick (2006), Sioshansi (2006), Thomas (2006), Beder (2007), Thomas

(2007) have provided ample evidence of electricity generating companies resorting to setting higher electricity prices through exercise of market power. Exercising of market power with pernicious intent led to failure of California electricity market; Canada electricity market failure similarly is a case of excessive indulgence in market power by the generating companies.

Deregulation of ESIs in California, South Korea, Canada, and Brazil were perceived as failures following significant price spikes (Galal, Jones et al. 1994, Beder 2003, De Oliveira 2003, Byrne, Glover et al. 2004, Sioshansi 2006, Gilbert and Kahn 2007, Sioshansi 2013). In the less developed countries this aggravated social inequalities.

Multinational electricity companies like AES, EDF which entered developing country markets as part of a massive lending program launched by World Bank which had stipulated reform of ESIs as a precondition, made huge profits in Latin American and African countries – for instance, EDF made a profit of € 5.2 billion in the year 2003, share prices in privatized electric companies in Chile appreciated by over 1000 per cent, profits soared following abnormal increases in electricity prices—abnormal wealth transfer from the state/electricity consumers to privatized electricity companies took place and foreign multinational companies benefited (Yotopoulos 1989, Hirsh 1999, Dubash and Bouille 2002, Beder 2003, De Oliveira 2003, Sioshansi 2006, Victor and Heller 2007). Brazil became the most unequal economy following implementation of electricity reforms; prices rose by 400 percent and 40 percent of electricity workers lost their jobs (Yotopoulos 1989, Dubash and Bouille 2002).

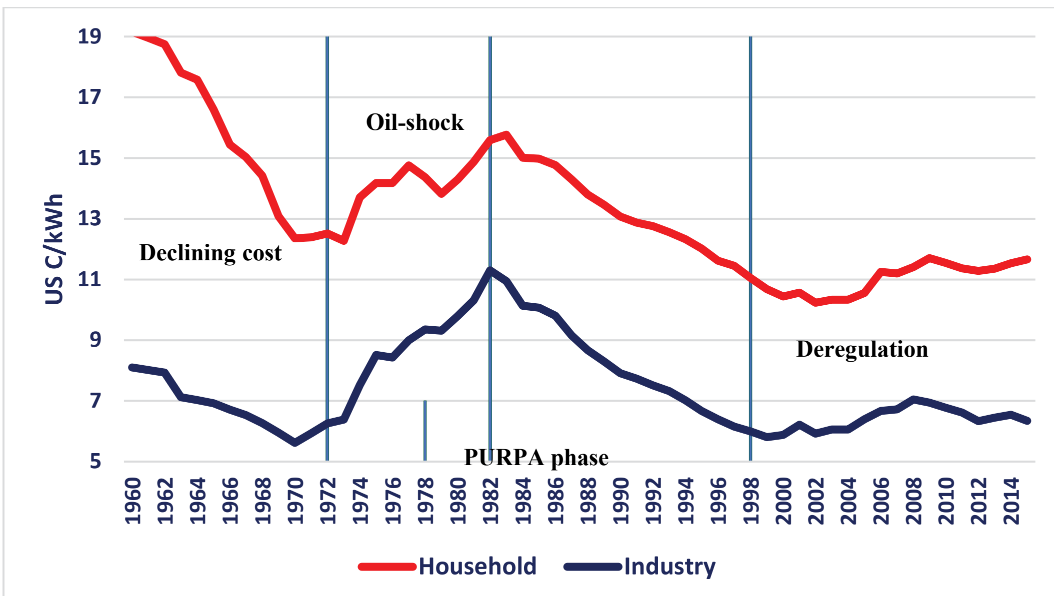
With the new pricing model emphasising profits for electricity generating companies, conservation efforts were viewed as a cost burden best avoided. For instance, energy conservation programs (DSM and IRP) that had been launched before deregulation in California were discontinued on the plea that they led to increased costs. Following California electricity market crash, government had to hurriedly reintroduce the above noted programs to bring demand under control (Hirsh 1999, Dubash and Bouille 2002).

High electricity prices blunted need for new investments in electricity generating capacities even as existing base-load plants were reaching maturity. This began to engage the attention of governments which apprehended supply shortages of a magnitude that could destabilise them. Even such investments as were made targeted low capital-cost and high variable-cost technologies that would maintain the profit levels. According to Economist (2011), the UK and

Nordic governments had to step in to build new power plants to stave off a collapse of the security of electricity supply.

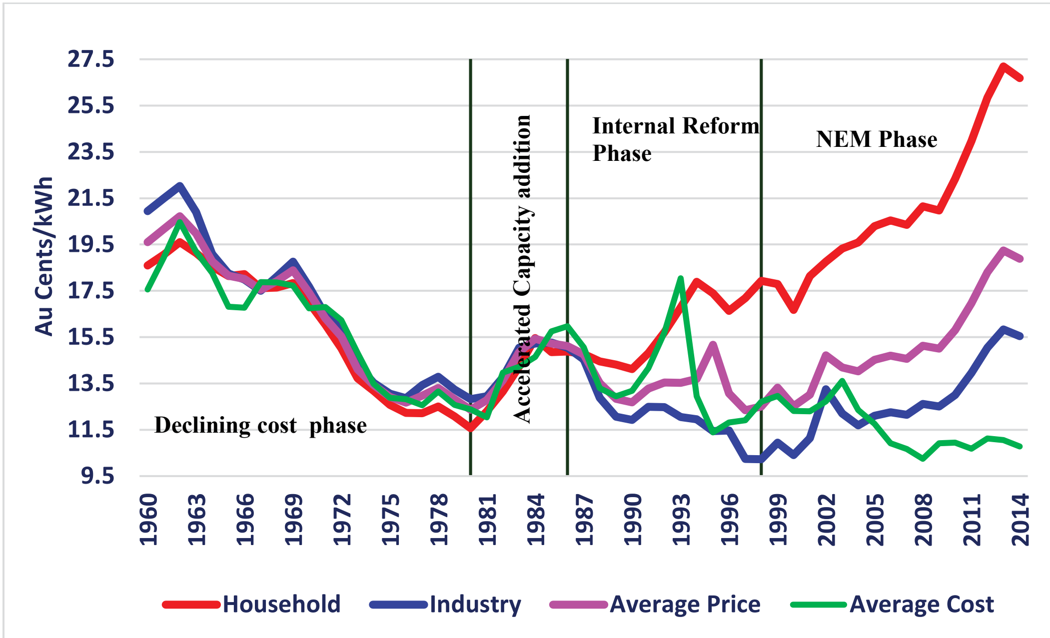
To substantiate the foregoing observations, this thesis presents electricity price and cost trends in figures 1-6, and 1-8 to 1-13, based on data from IEA, Energy Information Administration (EIA) and Department of Energy and Climate Change (DECC) for the United Kingdom, the United States, Victoria, New South Wales, Queensland, and South Australia. These price trends adduce evidence to unabated increasing electricity prices and growing divergence between household and industry user prices (favouring industry).

Figure 1-8 US Electricity Prices (Real 2010)



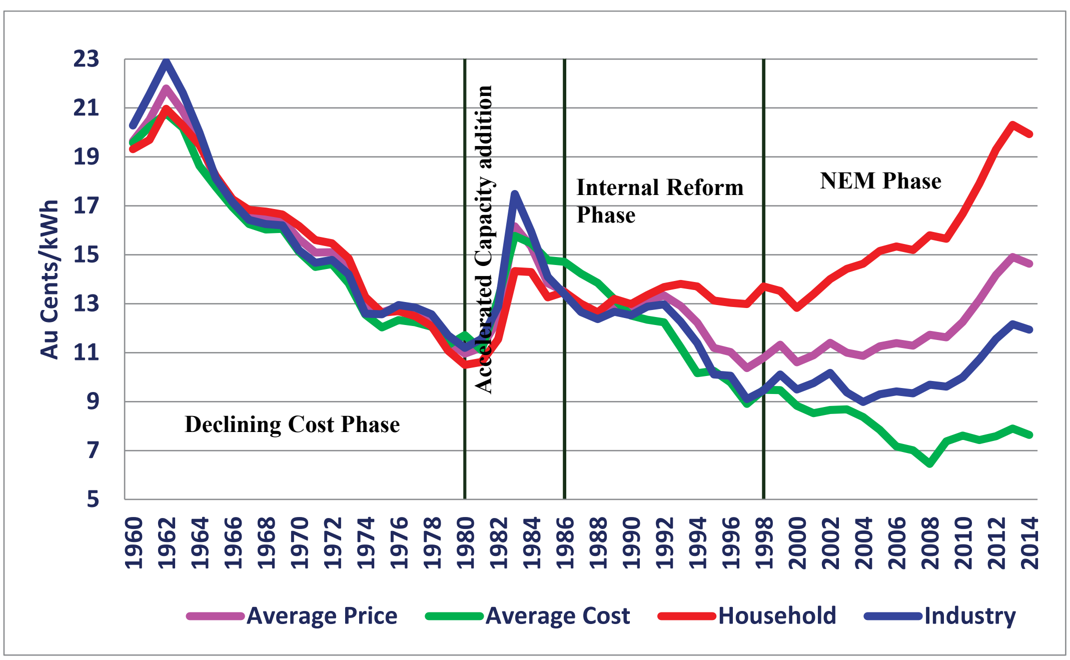
Source: Data developed from EIA (2016), DBWDI (2017)

Figure 1-9 Victoria Electricity Prices (Real 2010)



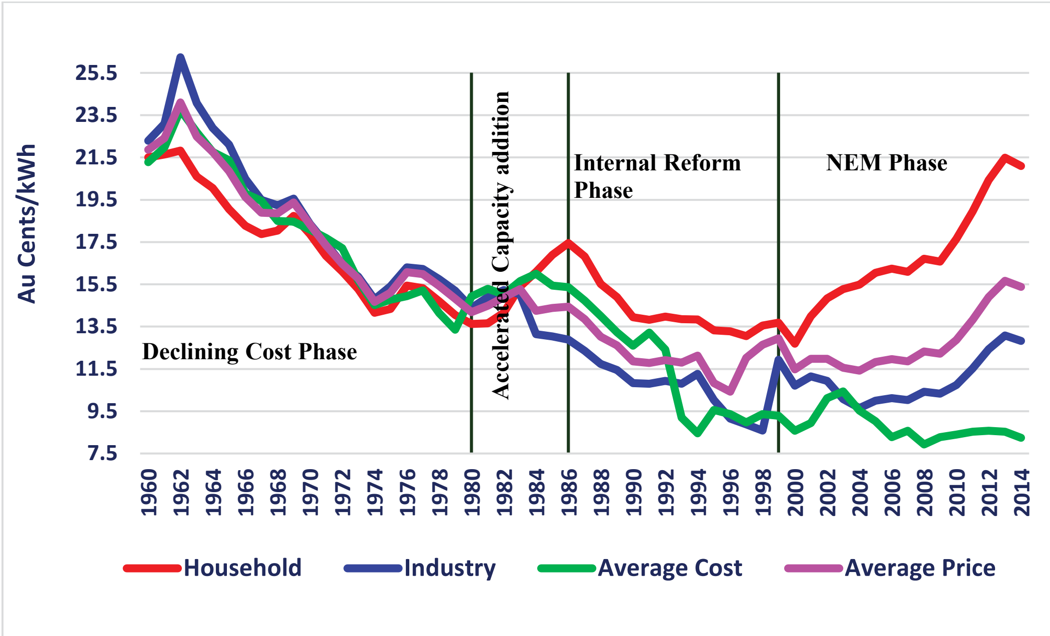
Sources: Data developed from ESAA (2016), WDI (2016), IEA (2017e), IEA (2017f)

Figure 1-10 New South Wales Electricity Prices (Real 2010)



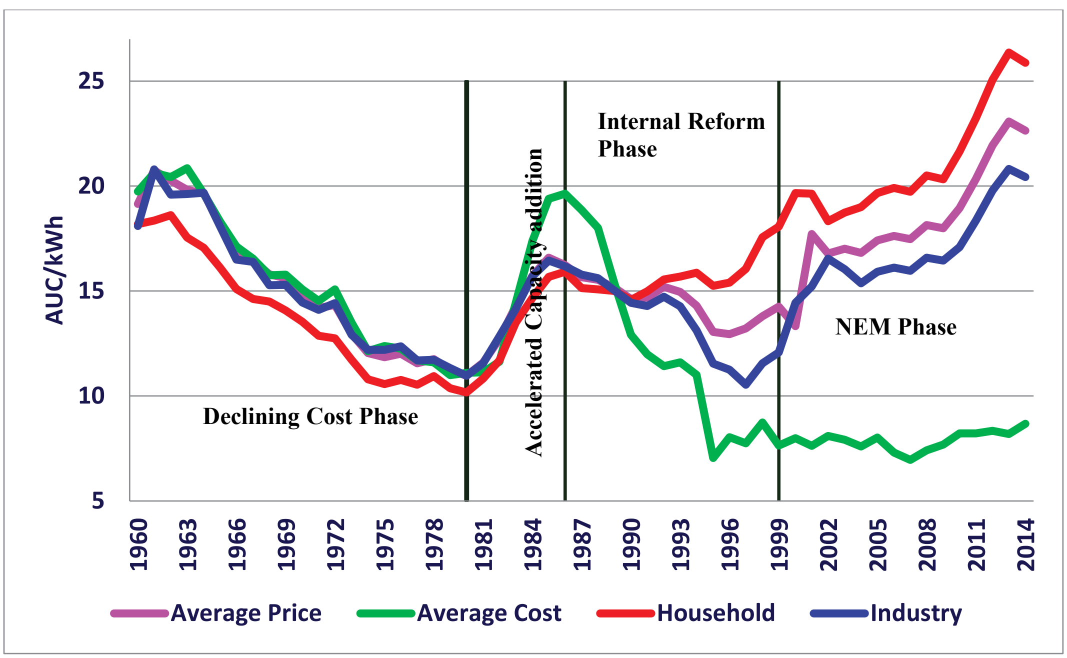
Sources: Data developed from ESAA (2016), WDI (2016), IEA (2017e), IEA (2017f)

Figure 1-11 Queensland Electricity Prices (Real 2010)



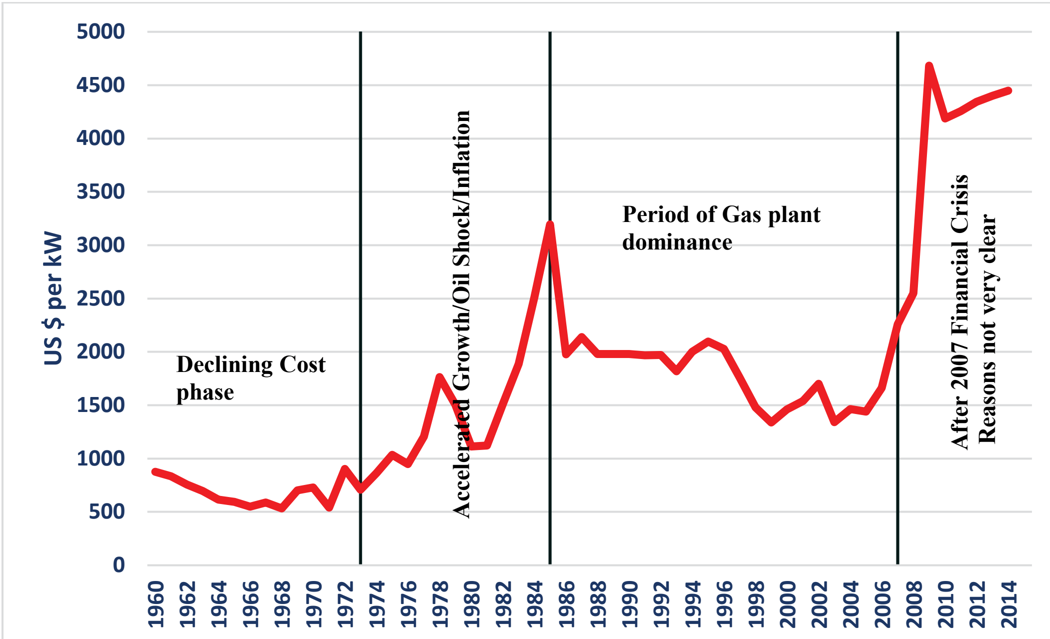
Sources: Data developed from ESAA (2016), WDI (2016), IEA (2017e), IEA (2017f)

Figure 1-12 South Australia Electricity Prices (Real 2010)



Sources: Data developed from ESAA (2016), WDI (2016), IEA (2017e), IEA (2017f)

Figure 1-13 Steam Electricity Generation Plant Cost per kW



Sources: Data developed from FPC (1964), MacDonald (2012), IHSCERA (2018)

1.2 Problem Statement

The salience of electricity as the most desirable form of energy forms the basis for our hypothesis; besides its contribution to economic growth, it has come to be viewed as a basic need to human society; pricing of electricity became a subject of dichotomy as cheaper prices could lead to over-consumption and wastage and over-pricing could deprive the vulnerable sections of society of the most convenient form of energy.

The discussions so far bring out that investor-owned ESIs in the U.S evolved as the most profitable industry – technology provided scalable efficiency, and business tapped this efficiency incrementally to sustain the industry on a declining cost trend for over hundred years, enabling phenomenal growth as well as profits; the non-storable nature of electricity helped ESIs to discriminate prices between consumers on the basis of their demand elasticity, to improve load factor thereby reducing costs as well as increasing profits further. Regulatory framework enabled the industry to become the most capital-intensive monopoly industry. Thus, this industry even during its formative phase became a vehicle for transfer of wealth from the electricity consumers to the shareholders.

Plateauing of technology and indiscriminate use of untested technology in conjunction with macroeconomic upheavals led to spiralling factor costs. These developments changed the outlook of this industry. Marginal-principle based pricing systems evolved to provide economic viability for the industry. It provided a steady growing stream of revenues to the State treasury through State-owned ESIs.

PURPA provided an attractive pricing scheme to encourage electricity generation efficiency as well as end-user efficiency. Though PURPA succeeded in introducing low-cost combined-cycle gas turbine technology and significant conservation initiatives, the consequent reduction in electricity generation costs did not result in corresponding decreases in electricity prices.

Pricing systems based on marginal principles ensured economic viability of the ESIs which differentiated prices between consumers according to their elasticities of demand. Households belonged to the inelastic category and had to take on the burden of a larger proportion of the fixed-cost of electricity. This pricing system encouraged social inequity, and caused hardship for the most depressed sections of the society. Improvements in productivity did not reflect in price reductions. Profit to investors and revenue to governments depended on sustaining growing demand. The entire paradigm of pricing hinged on the assumptions of consistently growing demand.

In this scenario, marginal principle for pricing, advocated by neoliberal economists, offered an alluring prospect not only to future investors but also to governments which owned the ESIs then. However, the new pricing paradigm would require ending regulated pricing and introducing free markets for electricity. Harnessing the support of World Bank, IMF and other multilateral agencies, neoliberal think-tanks pushed governments to adopt free-market principle based reforms for the ESIs; they claimed that inefficiencies of regulated pricing system and government protected ESIs can only be overcome by subjecting the industry to competition. They recommended restructuring of the industry into its competitive and in the monopoly segments. Pricing in competitive segments would be market determined and in the monopoly segments would be regulated. It was claimed that markets would veer towards marginal cost based pricing system conducive to maximum allocative efficiency, reduced generation costs and therefore, lower consumer prices. The stage was set for deregulation.

A decade after deregulation, it became evident that the predictions of economists had gone awry. Consumer prices, charged on the basis of marginal principles, have been steadily on the rise. As shown in figures 1-6 to 1-11 electricity prices have stubbornly been on the increase, with the divergence between household and industry prices growing ever wider.

This was further exacerbated by the scope now available to generation companies to exercise market power by engineering artificial shortages. Watts (2001), Dubash and Bouille (2002), Beder (2003), Chick (2006), Sioshansi (2006), Thomas (2006), Beder (2007), Thomas (2007) have observed that this scope was exploited and continues to be exploited. This had adverse implications for capacity additions. Also, price setting for profit rather than innovative cost-reductions became the central focus.

Even as the price impact of reforms deviated from expectations, economists justified staying the course on the plea that these were caused by glitches in implementation that could be fixed through further reforms. The indispensability of electricity, its non-storability and the imperative of real time matching of supply and demand make it uniquely amenable to price manoeuvrings. This was an era which witnessed drastic divergences of prices from costs of supply. Such pricing schemes inevitably lead to social inequity issues and changed the focus of the industry from one of delivering electricity services to one that caters to shareholder profits.

This thesis, therefore, contends that the pricing system that has emerged following deregulation has fundamental issues regarding its suitability to price electricity—the appropriateness of this pricing system is questionable.

The pervasiveness and essentiality of electricity to modern societies impels us to find answers to the following anomalies:

- Can electricity so indispensable to modern life and yet vulnerable to extraordinary price manipulations be left to markets?
- Electricity is not available naturally; it requires conversion from other forms of energy and as such, the conversion warrants utmost diligence. Does leaving it to markets ensure such diligence?

- Implicit in the market paradigm of pricing is the expectation of continuous cost reductions translating into corresponding price reductions. Do price trends witnessed worldwide conform to such expectations?

1.3 Research Objectives

Against the above backdrop, the main objective of this research is to examine the appropriateness of electricity pricing based on marginal-cost principles.

Specific objectives include:

1. Trace the historic origins of pricing with the view to gain insights into the foci of various pricing philosophies.
2. Develop a review of contemporary electricity pricing practices with the view to develop an understanding of their underlying rationale and approaches.
3. Provide a comprehensive description of the circumstances that led to the deregulation and privatisation of ESIs and assess its impacts on allocation of resources, justness, social equity and long-term availability.
4. Based on insights, elaborate on the appropriateness of existing pricing practices.

1.4 Research Methodology

This research is multifaceted in its nature requiring historical information covering the disciplines of socio-politics, economics and engineering. Addressing the above specific objectives calls for a combination of methodologies. Chapter 2, 3, 4 and 5 provide detailed description of the methodology adopted in accordance with their specific objectives. The salient points of these methodologies are provided in this section. The overall methodological schema is presented in section 1.5.

The overall task is multi-disciplinary; the subsections below provide the methodology outline for each of the sub-objectives; more details of the methodology are provided in the respective chapters (as also noted above).

1.4.1 Origins of Pricing Philosophy

Detailed literature review has been undertaken to track the origins of pricing – the review includes economic thinking right from the Aristotelian times to the present day. The review of each period is preceded with a background information on socio, cultural and political contexts that had prevailed in order to capture the factors that influenced economic thinking in each period. The diversities between mainstream and heterodox thinking have been considered in the review while developing the insights. The review of pricing philosophies is as per time line provided below:

a) 4th Century BC to 15th Century AD – Aristotelian and Scholastic economic thinking
b) 1500 – 1750 AD – Mercantilism and Pre-Classical economic thinking
c) 1750 – 1880 AD – Classical economic thinking
d) 1880 – 1930 AD – Neoclassical economic thinking
e) Late-1940 – current – Modern economic thinking

1.4.2 Review of electricity pricing practices

Detailed literature review has been undertaken to gain understanding of the rationale of electricity pricing practices beginning from the origin of the ESIs. The review is as per time line provided below.

a) 1880 – 1930 – Formative Phase
b) 1930 – 1960 – Consolidation Phase
c) 1960 – 1980 – Inflection Phase

1.4.3 Assess appropriateness of market based electricity pricing

Detailed literature review of the rationale for deregulation, deductive analysis of studies that hold conflicting views of the outcomes of deregulation in order to generate hypotheses that ascribe suitability of market-based pricing for electricity; veracity of the hypotheses has been econometrically evaluated utilising long timeline data (1960-2014). The econometric model adopted is 'Analysis of Variance' (ANOVA) provided by Gujarati and Porter (2003). This model regresses the performance variable selected to represent hypotheses against various time periods chosen by the study and provides mean values of regressand for making a comparison and drawing conclusions.

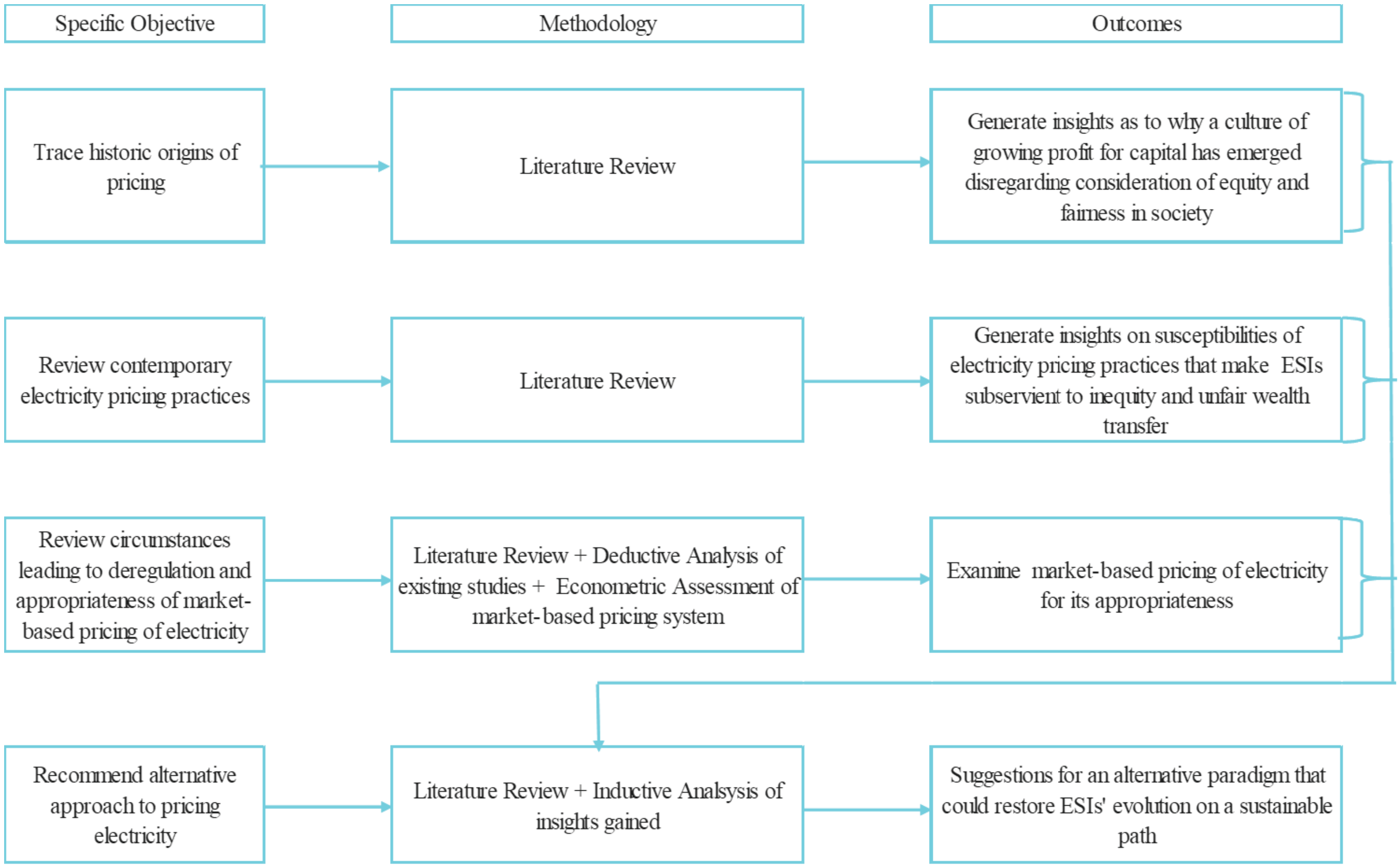
1.4.4 Recommendation for an alternative paradigm

Utilising: (1) deductive analysis of all insights gained from sections 1.4.1, 1.4.2, and 1.4.3, (2) additional quantitative analysis on performance variable identified by section 1.4.3, and (3) inductive analysis of further literature review, recommendations for a sustainable pricing paradigm have been provided.

1.5 Overall methodological approach

The overall methodological approach considered for this research is a combination of different methodologies described above and is shown in the form of a block diagram on the adjacent page.

Figure 1-14 Methodological Approach



1.6 Research Scope

The scope of this research has been largely led by how a particular country/state contributed to establishing the specific objectives. For instance, the United States, Germany and the UK are the chosen countries to explain pricing systems that evolved during the period 1880-1930 as these countries fully explain the patterns of evolution of ESIs worldwide (As pointed out by Hughes (1993), – the US and Germany were the forerunners among ESIs of the world and their pricing strategies (particularly in the US) enabled rapid growth, reduced costs and growing profits for the industry; the UK, though a forerunner in respect of industrialisation using steam turbines and coal power, was slow to adopt electric power, and held a conservative position when it came to promoting ESIs and served as a contrast. Considering its pioneering role in introducing marginal-cost principles for pricing electricity, France was chosen.

Nationalised ESIs were used by some of the countries to generate higher and higher revenue streams for their Treasuries. This thesis, in order to analyse such pricing systems, chose the UK and Australia as they adopted LRMC (long-run marginal-cost) pricing along with growing financial targets for their ESIs.

The UK, the US and Australia are the countries that were committed to electricity reforms and were also responsible for propagating their values and drawing other countries towards adoption. This thesis accordingly has chosen these countries for analysing the impact of market-based electricity pricing.

The time-lines in this research vary and are dictated by the needs of the analysis. For example, where tracing of the origin of pricing was involved this has been undertaken for the period right from 450 BC. The econometric analyses majorly cover the period 1960 – 2014. Some specific analysis however is limited to shorter time periods according to their relevance.

1.7 Data and Data development considerations

The data for electricity price trends and econometric analyses have been largely obtained from the published data of EIA, IEA and DECC and also include data that have been provided by the ESIs through their published reports when they were publicly owned or regulated by the government. Data have also been obtained from reports generated by State regulatory agencies. Where data have been unavailable, the research has generated the data by applying suitable rationale. Data from Frontier Economics (Australia), Mac Donald Mott (UK), IHSCERA (USA) have been utilised for obtaining plant, generation costs and cost indices for power generation equipment.

1.8 Research Significance

This research has tracked the evolution of ESIs and its pricing practices from a global perspective. Improving productivities helped the industry to grow as a declining cost industry. The protean form of electricity not only served to improve living standards for society and vistas for boundless technological advancements, but also (its high susceptibility to pricing strategies), has made it a servient to the profit-motives of its owners.

This research has traced the origins of pricing and showed how technology and improving productivities changed the values of human society from one of concern for fairness and equality to one that sought profit by legitimising inequality.

This research has shown that deregulation and pricing of electricity on market-based principles led to profound changes in the pricing pattern of electricity – the price of electricity has assumed an unrelenting increasing trend largely disconnected from the cost. Growing price divergence between consumers of electricity in favour of industry and large users causing grievous problems to the socially most depressed segments of the society. The ethos of industry does not contribute to allocative efficiency or to the values of environment compliance.

This research also has revealed that benefits accrued both to the society as well as to the owners of the industry whenever there was a pursuit for achieving technological and operational excellence with a zeal to improving services to community.

This research has recommended an alternative paradigm for the industry in which the focus shifts from price for profit – to producing environment compliant electricity benchmarked to improved efficiency norms – apportioning of tariffs between various consumer categories that will ensure meeting equality considerations. At the same the new paradigm suggests revenue flow to maintain economic efficiency.

With electricity prices soaring in different parts of the world, with existing electricity assets reaching their period of usefulness and new investments not forthcoming, it is felt that the findings of this research may help to develop a good policy approach for future.

1.9 Organisation of this thesis

This thesis comprises six chapters. Chapter 2 provides a comprehensive review of pricing philosophies. Chapter 3 provides review of electricity pricing systems commencing from the formative years to the 1980s. Chapter 4 provides review of market-based electricity pricing system. Chapter 5 provides an alternative paradigm to market-based electricity pricing system – it utilises insights gained form Chapters 2, 3 and 4 as well that derived from the analysis of the reform on capacity utilisation – Chapter 5 has added this analysis (post-deregulation) in view of its criticality to fully appreciate the recommendations of this research. Chapter 6 provides conclusions.

2 REVIEW OF PRICING PHILOSOPHIES

2.1 Introduction

In the previous chapter, concerns were raised about the appropriateness of the electricity pricing philosophy set off by the neoliberal proponents in the context of restructured deregulated ESIs.

The choice of large-scale and large-area technology made the ESIs leading among comparable industries for its capital intensiveness. The cyclical nature of demand made ESIs lag quite behind other comparable industries from the point of view of capacity utilisation. However, the non-storable nature of electricity provided rich possibilities for the business to price electricity differentially among consumers to reduce cost of generation, maximise profits, register phenomenal growth of industry and in effect become an industry that is emblematic of profit. The technology adopted provided huge potential for profit from economies of scale which the industry leaders tapped on an incremental basis, and the high profit trends for the industry continued for over a hundred years. The benevolence of electricity to society calls for a pricing system that would measure up not only to economic but to social aspects as well.

The objective of this chapter is to provide a review of pricing philosophies that have evolved under the auspices of different schools of economic thought that are antecedent to the modern-day pricing system with a view to gain insights that can help to carry out an assessment of the appropriateness of deregulated pricing system – its ability to remain consonant with social values while meeting the economic objectives. The insights gained could be utilised to provide useful guidelines.

This review covers the period from the Aristotelian times to the present day economic thinking. The review of each period is preceded with a background information on social, cultural and political aspects that bears relevance to the economic thinking that prevailed. Review also captures the views of such heterodox economists who have contested the mainstream economic thinking when they observed fairness to social values being undermined. The chapter summarises insights gained and provides ideas for assessing the appropriateness of deregulated electricity pricing system.

This chapter is organised as follows. Section 2.2 covers the Aristotelian and Scholastic economic thinking and covers the period from 4th Century BC to 15th Century AD. It reviews the

Aristotelian concepts of value, the conundrums relating to *exchange-value* and the difficulty of achieving fairness in exchange; these aspects are covered in some detail as they provide a deeper understanding of the importance of ethics and fairness in pricing in general. Section 2.3 covers the period 1500-1750, the period when earlier strands of economic literature began to emerge. Section 2.4 reviews the pricing philosophies that emerged during the period of classical economic thinking (1750-1880). Section 2.5 covers the pricing philosophies that emerged during the period of neoclassical economic thinking (1880-1930). Section 2.6 covers the pricing philosophies that emerged during the period of modern economic thinking (from late 1940s). Section 2.7 summarises the insights and perspectives from the previous five sections. Section 2.8 provides a discussion on the usefulness of the findings in the context of the issues of the pricing system of the ESIs.

2.2 Aristotelian and Scholastic Economic Thinking

2.2.1 Aristotelian Economic Thinking

Context

Aristotle (384-322 BC) was a strong proponent of ethical approach in all walks of life. He established a learning institution (Lyceum) which was known for its pursuit of learning every branch of knowledge of the world. Aristotle is widely regarded for his economic contributions through his two books: (1) Nicomachean Ethics (Book V) and (2) Politics (Book I) (McKeon 1974, Meikle 1997). Aristotle's economic thinking was borne out of his unfathomable commitment for fairness, mutuality and strict aegis of ethics. He taught the importance of being virtuous to be happy; he also emphasised the importance of the communal wellbeing. The theme of both the books (referred above) surround the concept of exchange-value which, Aristotle considered as one of the two aspects of *economic-value* of any product, the other being *use-value* of the product (McKeon 1974, Meikle 1997). Aristotle's economic writing was the backbone of medieval thinking in matters pertaining to trade and commerce, and any other which could be considered economic. His writings had analytic intention and offered the rudiments of analysis (Finley 1970). His economic thinking was the forerunner for Islamic Economic thought; it also provided the foundation for Catholic social teaching (Roll 1973, Dalton 2007).

During Aristotelian times, every family produced that which was needed for a living and the produce was within the confines of the family needs. However, occasions for exchange began to arise when the products made were not consumed or when the produced quantity was higher than the expected needs. Even during these early periods, many things were made for exchange and circulated as commodities against money. Conceptualising *exchange-value* always posed a challenge to Aristotle; when exchange was in the form of barter to satisfy natural needs, Aristotle was convinced that such exchanges did not intend economic gain; he was, however, concerned with other forms of exchanges; he had great concern about the likely ill-effects on the society of growing exchange and monetary activities. Emerging signs of a pursuit for economic gain in the society prompted Aristotle to investigate issues relating to exchange activities (Meikle 1997). Aristotle was keen to find out: (1) whether exchange was taking place to satisfy needs or inordinate desires; (2) the understandings relating to formation of *market price*; (3) the tenets that can qualify the fairness *of the exchange* and the fair use *of money in exchange*.

Pricing Philosophy of Aristotle

Aristotle found explaining *market price* without compromising fairness in exchange a very formidable and daunting task. Fairness in exchange was central to Aristotle's theory of exchange value. Aristotle regarded fairness as the binding element of the society. His contribution to economic thinking also concerned the use of money in exchange. Elucidating on the basis for fairness in exchange and explaining the nature of exchange value were the major pursuits of Aristotle's economic inquiries (Meikle 1997).

Aristotle introduced notions about *use-value*, *exchange value*, *need* and *money* to elaborate his theory of exchange-value. He made distinctions between *exchange value and use-value; use-value* when utilized for self-consumption and *use-value* when exchanged. The product of labour was considered as the *use-value*. *Use-value* was referred to something directly useful not only for *self-consumption*, but also because of it being the product of interest for others. *Exchange-value* represented the value of a product in relation to other products as for example a certain amount of money represents certain amount of every kind of product that is made.

As *use values*, products differ in quality, but as *exchange-values*, they differ, not in quality, but only in quantity. *Economic-value*, of a product, is a combination of *use-value* and *exchange-value* (Meikle 1997).

Aristotle contended that for achieving justice in exchange, a form of reciprocity was required and termed this as *commensurability*. Aristotle's metaphysical analysis contended that *exchange-value* cannot be commensurate with *use-value* as they are distinct. Aristotle's quest for *reciprocity* in the context of exchange along with his passion for achieving credible fairness in exchange led him in the pursuit of a '*conceptual-entity*' – a product that could be the subject of exchange and also be the bearer of two quite distinct natures as it would be so as in the case of a "*hypostatic union*". For Aristotle, *money* did not measure up to his metaphysical standards for taking the role of *conceptual-entity*. *Need* lacked the condition of *commensurability*. Aristotle then ingeniously envisioned a combined concept of *need* and *money* to meet his metaphysical norms that he had stipulated for this conceptual entity in *exchange-value*.

Though Aristotle envisioned this combined concept of *need* and *money*, he only reluctantly conceded to *money* representing the conventional role as a measure (the unit) of *need* and *need* performing the role of commensurability, thus transforming of the unit-less *need* commensurable by adopting *money* to play the role of measure of *need*. Aristotle thus developed the notion that *need* inheres the *exchanger* rather than the products. Yet, Aristotle was unsure whether this arrangement would meet his metaphysical standards. He characterised this solution as just about sufficiently acceptable. He emphasised the importance of *holding together* (the hypostatic union) which *need* should be able to uncontestably satisfy.

Aristotle went to greater lengths and introduced more conditions that *need* must satisfy to merit the status of *conceptual entity*. He stressed that *need* must explain: *making equal of the proportions* in which things are exchanged; the *holding together of divided labour* within associations that are part of the *exchange* process as well as within the association of the state/society (Meikle 1997).

Modern economists, despite Aristotle's dilemma and his conditional acceptance to a narrowly defined *exchange value,* have provided an interpretation that Aristotle's economic thinking was supportive of *neoclassical value-theory*.

Aristotle, not being entirely satisfied, with the arrangement that makes products to commensurate only *sufficiently,* furthered his investigations on *exchange-value* based on his *theory of action* and the role of money in the exchange process. Aristotle provided a *theory of action* and postulated that actions are defined by their ends. Aristotle provided a contrast between the pursuit for *exchange value* and the pursuit of *use value* as an end. The use of *money* in exchange was a matter of deep ambivalence in Aristotle's analysis of *exchange*. He held that the end of getting *wealth* as *exchange value* or *money* as bad. He expounded on 'the relation, or lack of it' between *use value* and *exchange value* and provided more ideas for achieving economic good.

Aristotle distinguished four forms of exchange in his deliberations on exchange and usage of money: *C-C'*, *C-M-C'*, *M-C-M'*, and *M-M'*. [*C* represents Commodity and *M* represents Money] Aristotle integrates ethics in his analysis of the end of each form of exchange and provides his views.

C-C' is acceptable because the end is consumption, the bringing together of needs with the use-values that will satisfy them – this is natural. C-M-C' too is acceptable – he judges these as natural because it meets his usual criterion of having *enough*. The end shared by M-C-M' and M-M' is the accumulation of money, and the aim here is not that of having *enough*. Using money in this way is not to use it as a means subordinate to a natural end, but to make money itself the end and to make natural ends a means of making money. According to Aristotle, if M can be advanced to M', and so can M' can be advanced to M" and so on without a limit. A process of end without limit is unacceptable.

According to Aristotle, C-C' evolved with the emergence of villages – confines of need governed the exchange. Money arose next, made exchange easier, enabling C-M-C' to come into being. As *C-M-C'* developed and its operation became sufficiently understood, it gave rise to *M-C-M'* and *M-M'*. Each transition from one form to the next was an evolution process for the *exchange*. However, such a process eventually changed the nature to become something else altogether, between the processes C-M-C' and M-C-M' money ceases to be a means and becomes an end. Aristotle sees the process M-M' very damaging (Roll 1973, Meikle 1997).

Aristotle concludes *exchange-value* as a conundrum. He was just able to formulate the problem of *exchange-value* with clarity, and believed providing a solution for *exchange-value* is elusive.

Aristotle opined that *exchange-value* does not rest content with the form taken by the products of labour – it can assume any form as per the wants and esteem of humans. Aristotle could foresee the type of things that could happen when *exchange-value* latches on with activities – the real end of that activity becomes a means to the end of *exchange value*, so that the real end is compromised or destroyed – *exchange-value* can enter thought, culture, and morals. The nature of everything would become secondary to this universal form of *exchange-value*.

Aristotle believed that private property served a useful function in society – regulation, however, should be made to limit the property in private hands. Aristotle's apparent inconsistency in condemning the pursuit of economic gain while endorsing the right to private property troubled moral philosophers until the sixteenth century (Landreth and Colander 1976). While this being so, Aristotle is also known for holding views that concern with moderation: "scarcity can be addressed by reducing consumption and by changing human attitudes" (Meikle 1997). Josef Soudek (in his book titled *Aristotle's theory of exchange*, 1952) and Joseph A Schumpeter (in his book titled *History of Economic Analysis*, 1954) have likened Aristotle to being supportive of neoclassical theory of value; Soudek even goes to the extent of suggesting that Aristotle had anticipated Jevons' theory of exchange (Soudek 1952, Schumpeter 1954).

2.2.2 Scholastic Economic Thinking

Context

Scholasticism is referred to as a medieval system of Christian thought and was prevalent in whole of Europe and even beyond and lasted for a period of over half a millennium commencing from the fall of Roman Empire to the beginnings of mercantilism in Western Europe (Landreth and Colander 1976). During this period, Church controlled all aspects of life. The pope as the head of the Christian body was regarded supreme. All land belonged to God, who allowed custody of this to either a man who was king by divine right, or to the church. The period was also known as the period of feudalism. The feudal economy consisted of subsistence agriculture in a society that was bound together not by a market, but by tradition, custom, and authority. Religious teachings of the church had a pervasive influence throughout the communities in Europe. Church strictly discouraged pecuniary desires and condemned anything or anyone who was involved in money making. Trade was a taboo and merchants were frowned upon. Possession of private property was considered a sin (Hunt 2002).

The twelfth century marked the emergence of a distinctive era (also known as an era of "discovery of the individual") when the value of individual and individual experience was regarded. People felt inspired and developed a new sense of self-awareness of their abilities and rights (Langholm 1992).

Technology assumed importance and began to show up as improvements in productivity. Agricultural productivity increased dramatically on account of the introduction of 'three-field system' and the introduction of 'horse' as the principal motive power for tilling. These led to emergence of town centres and cities. People became increasingly skilled, made specialized goods of high commercial value (Hunt 2002).

Higher productivity resulted in surpluses and higher skills in specialised products; these combined with transport improvements spurred a zeal among people to engage in economic activities. The society that was under the reins of high scholasticism during this period led by strict religious doctrines and traditions that forbade any form of trade, wealth or economic gain became increasingly confronted by growing economic pressures and problems posed by the *nouveaux rich*. Richness, wealth and money that was equated to covetousness, dishonesty, an acquisition by robbing began to be viewed less aggressively (Hunt 2002, Wood 2002).

Things however, changed when labour tended to become militant and gain upper hand. Complications arose when labour shortage was acute following famines and *Black Death*; this led to labourers gaining upper-hand, seeking higher wages and gaining militancy. This change brought about a less favourable disposition against the *poor class* in general. This change also led the society to view evangelisation of apostolic poverty and abidance to a living enabled by seeking alms and the equation of *poor* with *virtuousness* and *rich* with *evil* and *disdain* (Wood 2002). Scholastics began to allow the pursuit of moderate prosperity and allowed riches that were perceived to serve the cause of virtuousness.

Pricing philosophy during the scholastic period

The struggle to reconcile religious teachings of the Church with the increasing economic activity of the time led to the fusion of religious teachings with the Aristotelian economic thought. In the year 1231, the Pope directed the Dominican Friars to undertake 'Christianising' the works of Aristotle which was accomplished by Albert the Great and Thomas Aquinas (Schumacher 1949, Langholm 1992).

The Christianised version could recommend that private property was not contrary to natural law, and advocated acceptance of a limited form of inequality and unequal distribution of private property. The translation took care to maintain the sanctity of the religion's principle to uphold poverty and communal living as the ideal for deep religious commitment (Schumacher 1949, Langholm 1992).

The increasing level of economic activity brought along with it concerns about fairness of exchange and justness of price. Religious standards that were set were central to determine the economic conduct. Custom, tradition and authority played important roles and educated church men were considered 'higher good' than economic goods (Wood 2002). Aquinas and other scholastics did not engage in analysing the formation of prices in an economy or to understand the role that prices played in the allocation of scarce resources (Wood 2002). They focused on the ethical aspects of prices, raising issues of equity and justice.

Scholastics had differing notions about just price; being unaware of market mechanisms, just price was determined by the criteria of fairness. They were intrigued by the meaning of value and preferred prices determined based on the cost of production. There are some authors who claim that scholastics supported value-based pricing. Watt (1930) mentions about scholastic luminaries St. Thomas Aquinas, St. Augustine supporting utility-based pricing expressing approval to the element of *need*. Despite the differing views about just price, there was a perennial concern about fairness in the pricing system (Schumacher 1949, Langholm 1983, Wood 2002).

The differing notions about pricing led to differing approaches to pricing. For example, just price was linked to the medieval concept of a social hierarchy and corresponded to a reasonable charge which would enable the producer to live and support his family on a scale suitable to his status in life (Wood 2002). Thomas Aquinas equated the current *market price* with *just price*. He also allowed market price to be determined by the forces of both *supply* and *demand* as well as by *labour* and *cost* (Wood 2002).

Scholastic theologians of the likes of Richard of Middleton, Gerald of Abbeville and Bonaventura emphasized the need of providing a price to merchants that protected them from various forms of risks arising from uncertainties like vagaries of demand, business failures, damages to commodities arising from storage, fire etc., (Langholm 1992).

Scholastics focused on ethical aspect of prices. Aquinas combined religious thinking with Aristotle's views. The hallmark of scholastic period was the genuine concern for ensuring fairness. Guiding tenets were provided to address these concerns. Profiting from scarcity, deliberate impeding of the flow of market and manoeuvring to induce scarcity were considered unacceptable and condemnable.

2.3 Mercantilist Economic thinking (1500-1750)

Context

Spanning from around early 15th century to the early 17th century rose a period of 'Renaissance' that was filled with scientific inventions which led to engendering new technologies and ideas; ideas of this kind led to the 'age of explorations' (Hunt 2002). Chartered sea routes enabled long-distance trade between Europe, India and Africa. The international trade was very lucrative, but the merchant traders were impeded from going after higher profits due to the tradition of custom and control imposed by scholasticism (Wood 2002). Over time merchant traders combined and helped strong monarchs to replace nobility and the associated feudalistic structures and made way for the emergence of strong nationalistic states, as they would serve to protect their trade interests. This period marked the beginning of the pursuit for wealth of state as well as for the wealth of the business segment of the society. A pursuit for power and policies for growing wealth ensued (Hunt 2002).

Mercantilism represented a form of economic nationalism encompassing economic ideas such as: (1) the world is embodied with fixed resources; trade would serve to transfer wealth between nations; it is advantageous for countries to have balance of trade as their economic objective; governments should do all within their means to shift wealth from other countries into one's own country; (2) Governments should support their home industry by granting monopolies and provide protection for their trade by sea; (3) Government should allow traders to have advantages over their factor costs by allowing policies that encourage low wages to labour and banning of export of raw materials that are utilised for manufacture of tradable goods (Wood 2002).

Mercantilism proved an enormous success during the mid-17th century; many west European countries were benefitted by large profits during this period. The profit earned by the countries remained in the form of wealth (gold) which was received for the goods traded. Growth of trade promoted increased importance for *monetary factors* rather than for *real factors*; *monetary* *factors* began to be regarded as the chief determinants of economic activity and growth (Hunt 2002).

Pricing philosophy of mercantilists

Mercantilists abandoned the cost-of-production approach that was prevalent during the scholastic period. They focused on the point of sale. Profit was the motive. Mercantilists' value theory professed that *natural-value* of commodities was simply their actual market price. *Use-value* as a factor was most important for determining demand and the indicator of market value; the forces of supply and demand determined the market value (Landreth and Colander 1994). Merchants regulated the supply to remain always at a level lower than the demand to generate higher prices. The merchant companies went to great lengths through the support of their monarchs to exclude competitors and to maintain their monopolistic privileges and lower the supply costs by paying low wages to the labour. Government support, intervention and policies favouring trade were key elements during this period. Merchants also went to great lengths to favour governments that provided them with monopoly privileges. Profit motive stimulated the economy during this period.

Hume's economic thinking

David Hume (1711-1776) held views that differentiated him from those of his fellow mercantilists. Hume did not subscribe to the ideas of favourable trade balance. He considered this an impossibility. According to Hume a country that benefited from a favourable trade balance will experience inflationary trends due to the inflow of gold, whereas a country that paid gold will experience a kind of recession with falling prices. The imbalances in price levels set off oppositely in the two countries involved in this trade exchange will create forces to reverse the trade exchange. These forces ultimately lead to a self-correction of the trade balances. Hume also expounded on how general level of prices depended on the quantity of money and the velocity of its circulation (Landreth and Colander 1994). He held that the economy of a nation improves not on account of absolute level of money or wealth but upon gradual rate of increase of money.

2.4 Precursors of Classical thought (1650-1750)

The later periods of mercantilism were witness to *enclosure movement*, *putting out system*, international *trading*, *colonization, wars, and large flows of precious metals from the Americas,* *and high rates of inflation.* Merchant traders during this period reaped large profits. This period of prosperity for the mercantilists, however, began to plateau from the early eighteenth century (Hunt 2002). Despite the efforts of the great trading companies to maintain their monopolies and their spread of trade and commerce, competition could not be prevented. Growth of competition continuously reduced the relative magnitude of price differences among different regions and nations. The decline in the profit led to the waning of mercantilism (Landreth and Colander 1994).

Emergence of Individualism

Relevance of mercantilism began to decline with reducing profits. A new creed of capitalists whose origins had been in the craft guilds and had been inhibited during the celebrated period of mercantilists began to surface. A philosophy of *individualism* emerged during this period. Thomas Hobbes (1588-1679) considered as 'founder of modern political philosophy' in his book 'Leviathan' published in the year 1651, emphasised on how self-interest (which may remain disguised) dominated all human motives. He also believed that such individualistic and ego driven thoughts tended to dominate economic thinking. Other philosophers, for example, Sir Dudley North (1641-1691) insisted that human behaviour of selfishness, greed and acquisitiveness contribute to industriousness (Hunt 2002). From around the middle of seventeenth century an activist movement of *individualism* supported by the inhibited capitalists emerged; they condemned state granted monopolies, and other forms of protection and favouritism prevailing in the internal economy. This *individualists' activism* received a fillip due to the emergence of various productivity improving factory technologies. The arrival of *division of labour* techniques, steam turbine driven manufacturing machines and mechanisation of factories made economists to see things differently. North spearheaded the individualists' movement and advanced the view that "*men motivated by self-interest should be left alone to compete in a free market if the public welfare was to be maximized*" (Hunt 2002). During this period, there were some other thinkers, for example, Bernard Mandeville (1670-1733) about whom, a distinction needs to be drawn; Mandeville argued that selfishness and self-interest was a moral vice, but that social good could result from such acts if these actions were properly channelled by the government (Landreth and Colander 1994). However, by and large, mainstream thinkers of the time began to support the movement of *individualism* advanced by

North. For example, Francois Quesnay, Richard Cantillon became staunch supporters of the view that competitive markets automatically provided harmonious solutions and that government should not interfere in the economy (Landreth and Colander 1994). This new wave of thinking represented a departure from those of reconciling economic activity with spiritual values and States having to deal with the economic affairs, and paved way for a greater belief in the role of competitive market in economic development. The self-regulating market-based system that pursued for profit was considered superior to produce results better than what could be with government regulation. Protestant theology provided the much-needed reprieve for the *individualists/entrepreneurs* from the moral opprobrium heaped on them about their selfish motives by the Catholic Church.

Physiocracy, dawn of Laissez Faire

Improvements in productivity by resorting to division of labour techniques resulted in substantial labour cost reductions; the possibility of reduced costs contributing to profits became increasingly plausible. Prices and profits which were considered solely determinable by forces of supply and demand began to devolve on to conditions of production, and profits began to originate from the production process. Precursors of free market theory, e.g., Richard Cantillon (1680-1734) and Francois Quesnay (1694-1774) provided ideas of how competitive market forces could rein the economy. Cantillon perceived about the working of competitive forces both in the factor markets as well as in the final goods market. He also provided ideas on pricing – about *short-run* and *long-run* equilibrium prices. Quesnay and his followers provided a new economic thinking called *Physiocracy* that had a brief existence during the 1750s in France. Physiocrats believed that *natural laws* governed the working of the economy; they identified key economic variables and developed theoretical models. The physiocrats regarded agricultural productivity as paramount for the economy of their nation and emphasised on productive work as the source of national wealth. They termed the net surplus that was created by agriculture as the *net product*. This contrasts with the mercantilists who regarded favourable balance of trade or accumulation of gold as the biggest contribution to the national wealth.

Physiocrats provided a macroeconomic model which showed the inter-relatedness of macroeconomic sectors with clarity. Their model represented three sectors of society: farmers, landowners, artisans and servants. Physiocrats regarded land as the surplus generator (its output was greater than its costs); artisans and labour do not generate surplus.

Physiocrats believed in *laissez-faire*; they believed that markets automatically provide harmonious solution to the conflicts flowing from relative scarcity. They also conceived of an economy that was largely self-regulating, and rejected the controls imposed by the mercantilist system. Physiocrats recognized the function of prices in integrating the activities of the various factors of the economy. Though they did not succeed in evolving a coherent theory or price, physiocrats held the view that free competition would lead to the best price and that society would benefit if individuals followed their self-interest. *Laissez-faire*, will enhance productivity and economic growth.

2.5 Classical Economic thinking (1750-1850)

The major contributors to classical economic thinking were mainly British. The important mainstream contributors were Adam Smith, David Ricardo and John Stuart Mill; Karl Marx represents heterodox thinking of this period; Thomas Robert Malthus represents part of both the streams of thinking.

Context

In the UK and other industrialized European countries, the period 1700-1770 was one of high production of manufactured goods, and much of the produce was sold outside of the countries. The output of industries that served for foreign markets increased dramatically in comparison to those industries that served for the domestic economy. Rising foreign demand spurred the mechanisation of the industry. This rapidly growing foreign demand and the accompanying changes in the economic outlook were among the important reasons for the economic disparities in the society as well as the causes for the spate of industrial revolutions that happened during the period between mid-18th and mid-19th centuries (Hunt 2002). Only the strong hand of the governments of the time could overcome the ensuing social upheavals that took place and institutionalised the capitalistic ideologies promoted by the classical economists of the period.

The zeal for productivity improvements led to a virtual explosion of technological innovations in the late eighteenth and early nineteenth centuries. Inventions led to mechanisation of the manufacturing industries and also to rapid expansion of iron and coal mining industries to provide basic materials for manufacturing machines (the capital good) for the industry. Industrial steam engine designed by James Watt provided steam power and this produced profound economic and social changes. Larger quantities of manufactured goods were produced at lower costs, and matched with increasing demand, made profits to soar for the capitalists. In all the European cities, the political atmosphere changed – producers received more importance and more freedom (Hunt 2002). New producer-capitalists backed up by a large segment of philosophers, economists and other thinkers paved way for a new economic order and a new economic philosophy. Industrial evolution and strong capitalistic thinking became intertwined. Economic thinkers of the early eighteenth century began to see important principles at work in this increased productivity; they strived to integrate the thinking of scholastics, mercantilists and physiocrats in a more harmonious way (Landreth and Colander 1994).

2.5.1 Adam Smith

Context

Adam Smith (1723-1790) was known for his brilliance in the development of economic ideas. He drew his central ideas from scholastics, physiocrats and later mercantilists, brought them together in the form of a book which significantly contributed to the development of modern economic theory (Landreth and Colander 1994). Smith resented mercantilism and considered the mercantilist argument for government intervention as self-serving and did not contribute to social good.

During the 1770s technological innovations improved the productivities of textile and weaving machines in the UK in dramatic proportions. Mechanisation transformed cottage industries into large scale factories. Large scale production of Watt's steam engine rapidly replaced the source of power in manufacturing industries. Also during this period, the economic clash between the capitalists and the labourers led to a spate of industrial revolutions. The strong hand of the governments of the time could overcome these social upheavals and establish capitalistic ideologies in the western world.

Smith was enormously impressed by the *specialization* and *division of labour* and the emerging new technologies that promoted mechanisations leading to vast improvements in the productivity of labour through the capital good. Smith examined the economy and the potential of human capability of individual self-interest to unleash itself in competitive markets to produce harmony, and social improvement. He contended that there existed a natural process at work in the economy that can resolve the conflicts in society more effectively than arrangements devised by human beings. He subscribed to the ideas of economic thinkers of the likes of Cantillon and Quesnay, and advocated *laissez faire* as the best policy.

Even though Smith professed *laissez faire*, his thinking was influenced more by the overwhelming economic growth during this period. Classical economists sought for a price system that would lead to economic growth. Smith was keener on developing economic policies that would promote economic growth. Smith's *laissez faire* policy position was contextual, it rationalized with the activities of the rising capitalist class of his time, but it was not on account of its efficiency in allocating resources – it was more based on the beneficial effects it produced on the economic growth during that period.

He was successful in introducing *laissez faire* as an economic policy in England, and it is to his credit this became a worldwide phenomenon for all times to come.

Smith's pricing theory

The cornerstone of Smith's economic theory was the belief: (1) that competition among producers will result in goods being sold at prices that are just sufficient to pay for the opportunity cost of the factors of production; (2) the producers will bid for various factors of production in such a way that the best allocative efficiency is achieved; (3) consumers will contribute to the economy by rationally making their choice of purchase.

Smith in his analysis of price formation and resource allocation considered two types of prices – *short-run* prices *market price* and *long-run* prices *natural-price*. Short-run prices will be dictated by the *supply-demand* interaction. Smith contended that prices reached by competition in the *long-run* will settle at a value equal to the cost of production. However, this contention appeared to depend upon the nature of the economic sector and the elasticity of the *supply curve*. *Long-run* prices showed an ascending trend in the case of agricultural sector; a constant trend in the case of certain manufacturing sectors and a declining trend in some other sectors. Smith, despite these contradictions to his theory, in his analysis of long-run price preferred to assume universality of constant costs. He did not engage in the development of the demand side of price analysis but preferred to focus on labour theory of value, which also encountered problems. He was unable to relate costs of accumulated capital and appropriated land in labour terms.

During this period Smith saw the emergence of entrepreneur capitalists possessing potential to ramp up economic growth; he admired the productivities of the machineries created by these capitalists and considered them as important contributors to the society. Accordingly, his *cost of production theory* and *income distribution theory* assigned greater importance to the capitalist entrepreneurs especially while determining the relative benefits.

The *cost of production theory* related to payments to all the factors of production of the modern economy of Smith's time; it was the sum of capital, land and labour costs. Smith arrived at his factor costs based on his *distribution theory*. He considered a distribution of income for the factors of production that included *profit* for the capital, *wages* at *subsistence* level for the labour and *rent* for the landlord.

Among the factors of production, Smith considered *capital* and *capital accumulation* as paramount for economic development. He provided wages for labour, at subsistence level only, as he considered that this section of the society did not contribute to any capital accumulation. He presented a version of the *wages fund doctrine* that served as an important tool for the classical economists. This fund essentially provided a formula for determining the cost of providing labour to meet their requirements at subsistence level. The wage fund was the capital intended for payment to labour during the time of construction of any given firm. The wage rate was determined as the ratio of wages fund over the labour force deployed. The overall principle of wage rate was to provide a rate of payment to the labour that will meet the requirement of the labour to be at subsistence level over a long-run. Smith had a natural dislike for landlords as he regarded them as engaging in desires for high living and not contributing towards economic growth even though they had sufficient incomes; but he still conceded to provide a rent for the land.

Smith, thus favoured an unequal distribution of income in favour of the capitalists as they were, according to him, of tremendous social importance. He also came to a conclusion that without an unequal distribution of income, economic growth was not possible. According to him, the factors that contribute to good of a nation are productivity of labour, degree of engagement of available labour in productive works, capital accumulation and the largeness of the market.

2.5.2 Thomas Robert Malthus and David Ricardo

Ricardo and Malthus lived through a period of intense class conflicts including conflicts between land lords and the new industrial capitalist class, and industrial revolution. Both Malthus and Ricardo were consistent defenders of capitalist class which had been sanctified by Smith. Smith and Ricardo had laid emphasis on economic progress by capital accumulation, and productivity of labour. Ricardo, unlike Smith was non-contextual in his approach – he was a theoretical policy maker and his theories were abstract in nature.

Contributions of Malthus (1766-1834)

Population Thesis

Malthus's population thesis surrounds the food requirement for the existence of mankind and the rate of rise in population particularly among the labour class. Malthus contended that the population particularly, among the labour class, rises in geometrical proportions, whereas the food supplies increase only in arithmetical proportion. Malthus attributed the decrease in food supply to limitation of land, and rising population to the indiscretion of the labour class. Smith developed the wages fund doctrine which was further improved by Ricardo utilizing Malthus's population theory (Landreth and Colander 1994).

Macroeconomic perspectives of Malthus

Malthus feared that capitalist economy will experience over production and under consumption which will lead to gluts. He described his apprehensions on the basis of the following possibilities (Landreth and Colander 1994): (1) Labour may have the will to purchase goods, but may lack the purchasing power because of poor wages; (2) Capitalists possess purchasing power but lack the will to consume; (3) Capitalists in their zeal for achieving high capital accumulation may land up in a situation of over-supply leading to a condition of gluts and (4) Capitalists may resort to more savings and under-investment. Malthus thus argued that the possibilities for gluts in capitalists' economy are more likely.

Malthus insisted that to achieve full utilization of resources in a capitalistic economy, both output and consumption must keep expanding. He asserted that only greater consumption can sustain economic activity and saving on the contrary would result in recession and unemployment (Landreth and Colander 1994). On the contrary classical economists, argued, that in the process of producing goods, full employment is assured, thus sufficient purchasing power gets generated to take these goods off the market at satisfactory prices. Profits will be reinvested in capital and businesses will sustain without recession (Landreth and Colander 1994).

Malthus' views on pricing

Malthus did not agree with Smith's cost of production theory of value as well as with his concept of natural-price. He contended that market forces of supply and demand do not automatically push the market price towards the natural-price; the worth of a commodity is its market price and not its natural-price (Landreth and Colander 1994).

Contributions of Ricardo (1772-1823)

Context

Ricardo was moved by the economic problems of his time. UK was going through a period of rising population, rising grain prices, relative decline in productivity of agriculture segment, and rapid industrial growth. Ricardo like Smith was impressed by the progress made by the capitalist industrialists. Ricardo considered land-lords as absentee owners of land, claiming rent for their possession and made no contribution towards the economy. He was keen to develop a *distribution theory of income* that could reflect the contribution of segments of the society to the economy(Hunt 2002).

During his times, increases in population led to increased demand for grain; availability of limited fertile land led to cultivation of relatively unfertile lands, together all these factors led to increased price of grains. Landlords lobbied with the government and prevented import of cheaper grains from France to sustain higher prices as it helped them with higher rents for their land. Ricardo who favoured the capitalist' industrialists, argued for an appropriate policy of rent to ensure that landlords who reap the benefits of efforts of others just by virtue of their ownership of land do not get away with an irrationally high rent. Ricardo developed a *theory of rent* to resolve this problem; this effort also led him to develop *labour theory of value* (Hunt 2002).

Ricardo's Economic theories

Ricardo developed *theory of distribution of income* to explain changes in the shares of income received by the three classes of the society of his time, the capitalists, the landlords, and the labourers, over time. He was primarily concerned about the impact of increasing agricultural prices on the rate of capital accumulation and economic growth. He provided a graphical method for explaining his rationale of distribution of income among the segments of the society (Hunt 2002).

Ricardo modified the *wages fund doctrine* formula evolved by Smith to explain his view about what labour was entitled to as real wage of labour. He provided a rationale of *wages fund* which represented the *capital accumulation* that was provided by the capitalists through their savings for setting up their prospective firms. To determine wages, Ricardo divided this *wage fund* among the number of labourers available for deployment for the project and called this amount the *real wage* for the labour. The number of labourers engaged depended upon the availability of labour in the market. The value of wages paid determined in this manner always worked out to fall in a range that would secure a level just about what would be required for subsistence. This method came to be known as *wage fund doctrine* evolved by Ricardo (Landreth and Colander 1994).

Theory of Rent was Ricardo's important economic theory. This theory was based on several assumptions: important among them are appropriateness of Ricardo's *labour cost theory*; *constant returns* in the manufacturing sector, *diminishing returns* in agriculture sector, perfect market competition, and the validity of Malthus's *population theory* (this meant that with increasing population increasingly unfertile lands will come under cultivation) (Landreth and Colander 1994). He assumed that the land available for agriculture was fixed, but differed in fertility, and the choice of land for agriculture becoming progressively inferior in fertility. To justify a payment to the landlord he developed a rationale of *rent* and obtained a value to it by considering the differing fertilities. Ricardo held that the marginal returns of agricultural produce diminished as the land was more intensively farmed (Landreth and Colander 1994). He explained it thus: (1) marginal cost of agriculture produce increased as the land was more intensively farmed; (2) marginal cost of agricultural produce would increase as the demand rose as this warranted increasingly less fertile land to be brought under cultivation; (3) which naturally leads to the rationale that market price should be determined on the basis of the highest marginal cost and the rent for the land should be computed on the basis of the marginal cost differential between the lands (Landreth and Colander 1994). The most fertile land will receive the maximum differential, meaning the *maximum rent*. The land at the margin will not receive any rent. Ricardo was thus successful in developing a very important economic tool though it was meant for a limited application of providing a notion of *rent* for the landlords. Ricardo's explanation of diminishing returns of agricultural sector formed the basis for the *marginal productivity theory* that came to be discovered much later.

Ricardo's labour cost theory of value

Even though Ricardo determined the wages for labour according to his *wages fund doctrine* he provided a *labour cost theory* to explain relative prices over time. He held that the value of a commodity, or the quantity of any other commodity for which it will exchange, depends on the relative quantity of labour which is necessary for its production (Landreth and Colander 1994). He did not base his premises on the level of compensation paid for labour according to their levels of skill. He held that *use-value* is essential for the existence of the *exchange-value* and excluded those scarce, not freely reproducible commodities from his labour theory of value. He recommended that the quantity of labour be measured by the amount of time involved in producing a good. He considered that wage level assigned to labourers be used as a measure of their relative productivities.

For determining the *value of capital* assets in labour terms, Ricardo developed a *labour theory of value*. He regarded capital assets as *stored-up labour*, a labour that has been applied during a previous period (Landreth and Colander 1994). He computed the labour value of a commodity by adding the stored-up labour value utilized in the capital assets as well as the labour value that was utilized to actually produce the said commodity. He also provided considerations to make his theory more realistic by providing for the accounting practices that were followed: (1) allowance for *depreciation* (which is an accountant's measure of the capital destroyed in the production process); (2) the present value of capital determined by the labour portion that is still embodied in the final goods. Ricardo faced difficulty while assigning profit for capital – the amount of capital per unit of final output varied from one industry to the other. Profit will be the largest element of final prices in industries that are *capital-intensive* than in industries that are *labour-intensive*. He set aside this matter by arguing that *rate of profit* was not an important matter.

Smith and Ricardo had opined rate of profit in a capitalist-economy will fall over time but the two differed on the reasons for this phenomenon. Smith attributed falling of profit over time to competitive commodity, labour and investment markets. Ricardo attributed falling of profit over time to occur on account of population increases, increases in costs and rent in the agriculture sector and the belief that long-run equilibrium rate of profits must equalise throughout the economy. According to Ricardo the problem of population and increasing costs in the agricultural sector leads to reducing *capital accumulation*, the driver of the economy (Landreth and Colander 1994). Ricardo, thus concluded, that if any sector of the economy had diminishing returns, this will eventually lead to the falling rate of profit in all the sectors of the economy (Landreth and Colander 1994).

2.5.3 John Stuart Mill (1806-1873)

Context

John Stuart Mill (Mill) was a gifted thinker and contributed significantly to economics. At the time of his entry into the field of economics, classical economics was going through a period of severe criticism for being unrealistically pessimistic and for subjecting the labour class to extreme hardships. Mill had faith in classical economics even though he did not entirely agree with the views of his predecessors; he took upon himself the uphill task of saving the credibility of classical economics. Ricardo’s economic thinking came under intense criticism from the year 1817. His projections about diminishing agricultural productivities on account of increasing population, decreasing availability of fertile land, and increasing agricultural costs and increasing compensation to landlords turned out to be unrealistic and could not be sustained empirically. On the contrary agricultural productivities had considerably improved with passage of time. Many economists including heterodox economist Karl Marx held that Ricardo’s wage doctrine as very harsh. Also, they questioned Ricardo as well as his predecessors’ contention about the certainty of full employment at all times for its appropriateness. Ricardo’s labour theory of value was also criticised for not being able to provide a satisfactory explanation about the differing rates of profit arising from the differing capital investment among industries (Hunt 2002). Mill took upon himself to rescue the essential tenets of Ricardo's economic principles. He carried out a full revision of classical economic theory.

Mill rejected 'the harsh' Ricardo's *wages fund doctrine* as well as his *labour theory of value*. He did not favour admonishing the land-lords as non-contributors; he chose to justify appropriate compensations to them; he argued that *opportunity cost of land* is not always zero and that *rent* is a social cost of production in cases when there are alternative uses of land. Mill preferred institutionally and culturally determined laws of distribution—he wanted humanism to moderate the harsh conclusions of conservative classical economists (Landreth and Colander 1994). Mill did not subscribe to Jeremy Bentham's views that the pleasure-pain calculus of hedonism could be used to analyse human behaviour (Landreth and Colander 1994). Mill preferred a mid-path between classical liberalism and socialism; *laissez faire* according to him did not provide adequate social justice.

Mill agreed with Nassau Senior who developed an *abstinence theory* to explain profit. Nassau Senior emphasised *disutility* as a real cost of production to produce capital goods. Capitalists by their abstinence to their comfortable life, save and contribute to capital accumulation which in turn drives the productivity of the economy. He, therefore, justified that capitalists are entitled to suitable rewards for their sacrifices in the form of profit (Landreth and Colander 1994). Senior also developed a *cost of production theory of value* with *wages* being the return to *labour*, and *profits* being the return to the *providers of capital*.

Mill's value theory

Mill presented a *cost-of production theory of value* in which money costs fundamentally represent the real costs of *labour* and *abstinence costs* of *capitalists* which was in line with Senior's *abstinence theory of interest* (Landreth and Colander 1994).

Mill's value theory recognized the importance of both supply and demand to explain the formation of price. He provided his views on value of a good (Landreth and Colander 1994): (1) the price of a good will generally depend on its cost of production; (2) a good derives its *exchange-value* on the basis of its *usefulness and difficulty in obtaining*: (3) the forces that determine prices of a final good are closely connected with the forces that determine the prices of the various *factors of production*.

Mill provided different examples to explain how prices are dependent upon both supply as well as demand conditions (Landreth and Colander 1994): (1) prices will depend upon cost of production under conditions of constant costs; (2) when supply is limited (inelastic), the price gets dictated by demand; and (3) in the case of certain commodities (such as those produced by agriculture) costs increase with increasing quantities as price is determined by cost of production in the most unfavourable circumstances (implying marginal cost). Mill did not cover the case of decreasing costs in his example.

On matters pertaining to distribution of income, Mill's concern with social reform led him to seek a departure from the *laws of production* – he showed an inclination towards institutionally and culturally determined laws for governing the distribution of personal income. Mill did not make any changes about the rent for landlords. He agreed with the notion of profit for the capitalists (Landreth and Colander 1994).

2.5.4 Karl Marx

Context

Marx was a great heterodox thinker, a philosopher, and a socialist whose ideas had phenomenal potential for transforming society. Marx dedicated himself to the study of *capitalism*, the dynamic process of changes that occur in capitalism, and the implications of growing returns of capitalist industries of his time. Marx made clear his philosophical objection to capitalism – he was of the firm opinion that capitalism alienates human beings from themselves (Hunt 2002). Marx held that markets undermine people's ability to achieve true happiness. He was opposed to private property, separation of labour, capital, monopoly and competition.

Marx, adhering to Aristotelian theory of action, held that actions are to be identified and discriminated by their ends; he described the differing kinds of labours as distinct and incommensurable, because they have different *ends*. Marx distinguished labour embodied in commodities into two kinds – *useful labour* which produce natural things that have *use-value* – and the other as *abstract labour* – non-natural, which produces *exchange-value*. Being a quantity, *exchange-value*, lacks any attribute other than magnitude, hence it does not possess the ability to be commensurate with any other (Hunt 2002). Marx considered *use-value* and *exchange-value* as distinct – all the classical economists Smith, Ricardo and Mill, however, did not see this distinction.

Marx's economic theories

Marx observed the distinctions made between the owners of the means of production (capitalists) and those people who sell their labour in the market (the proletariat). He went on to examine the earnings to the capitalists who sold the commodities produced by the labour and the price that labour received as payment for their productive efforts. According to Marx the advent of capitalism shifted the focus from *use-value* to *exchange-value* (Hunt 2002).

Capitalism along with it brought changes that did not remain only in the confines of the commodity exchange realm but also proliferated to affect qualitative social relationships among individuals in the economy. The outcome of this was in the form of a profound class discrimination in the society which resulted in a stark income inequality as well as a distinct difference in the level of importance between the two classes. Marx engagement on aspects of pricing was primarily to determine the disparities in the social relationships between the two classes.

Marx's labour theory of value

According to Marx, the only social cost of producing commodities was *labour*. He introduced the notion of *abstract labour* to explain *exchange value*. He provided a labour version of the notions that were close to Aristotle (Hunt 2002). Marx maintained that it is the *labour* that created the *surplus-value* and not the *capital accumulation* as was being argued by the classical economists (Hunt 2002).

Surplus value (Profit)

Marx showed how surplus value gets generated through certain capitalist strategies involving labour market and technology. Introduction of new technologies leads to improved productivity and corresponding displacement of labour. This displacement of labour has its ramifications. The loss of employment of the labour, forces the dependents of the labour to go in the fray for employment. Eventually this process generates a reserve army of unemployed which has the natural effect of bringing down the wages in the competitive market (Hunt 2002).

Falling rate of profit

Marx attributed falling rate of profit to expanding capital accumulation. He described this as arising from the capitalists' pursuit for productivity improvements for the sake of keeping wages of labour down; this pursuit eventually expands the capital accumulation and consequent competition in commodity markets and causes lowering of prices and profits. Marx concluded that competition in labour and commodity markets eventually leads to falling rate of profit (Landreth and Colander 1994).

Business cycles

Marx contended that one of the major contradictions between the forces and relations of production under capitalism is the periodic depressions that are inherent in capitalist economy. This was, however, refuted by classical economists consistently; they argued against this possibility and maintained that barring minor fluctuations the capitalist economy will operate satisfactorily with full employment (Landreth and Colander 1994). Marx, however, viewed this differently. In a simple barter economy production and consumption are perfectly synchronized. The entire motive behind economic activity of production was to obtain *use values* (Landreth and Colander 1994). In this type of economy there can be no overproduction as goods are produced only when needed. Even introduction of money does not change this synchronism as long as money serves only for the purpose of acting as a means for facilitating exchange. Capitalism represents a change in the orientation of economic activity – from production of *use-values* to the production of *exchange-values*. The main objective of the capitalists is profit and the growth of money that businesses can produce over time. Thus, with objectives firmly entrenched on exchange-values and profits, over production becomes a distinct possibility. This explains the vulnerability of capitalistic economy to the occurrences of business cycles as viewed by Marx.

Monopolisation of businesses

Marx had the vision to predict possibility of concentration and centralization of capital. He based this prediction on the premise that capital accumulation, economies of scale, growth of credit markets will lead to severe competition and the risk of business failures. Marx could perceive the possibility of firms growing in size, the consequent weakening of competition, and the growth of monopoly power. His predictions were prophetic as large corporations and monopolies became a reality in subsequent times (Landreth and Colander 1994).

2.6 Neoclassical Economic Thinking

In the Western World, the period from mid1840s to 1873 was one of rapid economic expansion. Fierce competition led to elimination of small firms. Large corporations in important spheres of industry, finance and transportation emerged. The prudence of adoption of *laissez faire* as a government policy began to arise. Classical economics also came under close scrutiny; the cost of production theory continued to be considered inadequate to explain pricing of commodities.

Neoclassical economic theory took birth during the final decades of nineteenth century. Belief in marginal principles took centre stage and transformed classical economics into neoclassical economics. Beginning 1870s witnessed the emergence of three economists W. S. Jevons, Carl Menger, and Leon Walras who were committed to marginal principles; they applied marginal analysis to demand theory and developed the concept of marginal utility. These economists undermined classical economics to promote marginal principles. They rejected the labour theory of value for its limitation to explain market value in terms of labour value and also on account of its weakness to explain satisfactorily the behaviour of rate of profit under conditions of differing capital intensity.

2.6.1 Marginal Principles

Jevons, Menger and Walras working independent of one another came to the view that value of commodity depends upon their utility. They argued that commodity receives its value only from its utility and the factors that lead to the production of the commodity receive their values in turn from the price that the commodity is able to fetch for itself. In other words, the price of a final good depends upon its *marginal utility*, and the prices of factors of production depend upon the utility of the produced final good (Landreth and Colander 1994). The trio assumed the principle of *diminishing marginal utility* that is *marginal utility* decreasing with increasing consumption. Utility was considered a psychological phenomenon with unspecified units of measurement. Marginal utility was considered as measurable and cardinal measurability was assumed.

Marginal utility theorists completely ignored the theory of supply and took supply as given; they did not realise that both supply and demand are independent variables and mutually determine each other's values which Mill had elucidated. They, however, succeeded in providing an important economic tool that served to analyse more effectively various economic theories.

Marginal productivity theory

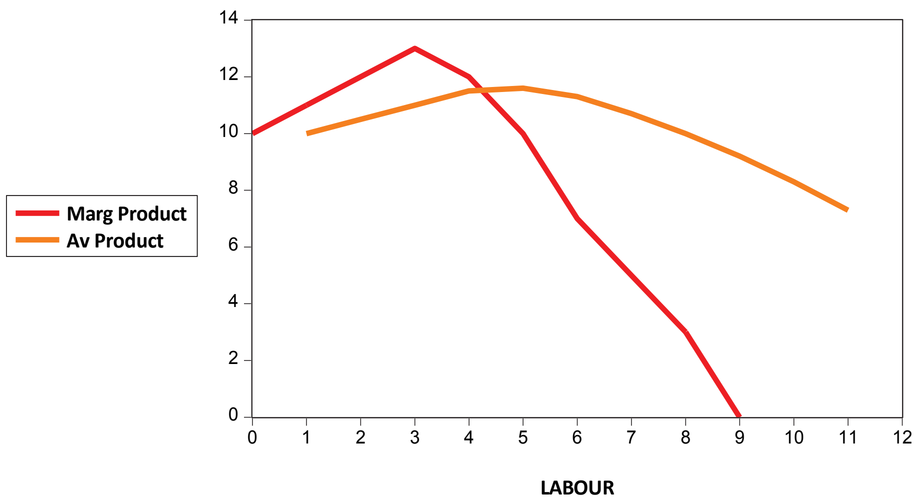
Combined effort of many economists resulted in the application of marginal principles to the theories of both demand and supply in a broader manner. The scope of their work went on to include analysis of the forces that determined the distribution of income as well as develop the concept of marginal productivity of factors. Some of the works of these economists concerned costs and factors of production imputed from the value of the final goods which contrasted with the works of classical economists who had maintained that values of factors were determining the price of the final good. These economists who extended the marginal principles and worked out the elements of marginal productivity theory of distribution are called second generation marginalists.

The evolution of marginal principles was greatly facilitated by the introduction of *the principle of diminishing returns* and was regarded by the mainstream economists as the corner stone of mainstream neoclassical economic thinking. It explains, how, when one of the two factors of production is held constant and other input is varied – the resulting output will often increase at an increasing rate initially – then increase at a decreasing rate – and finally decrease. The shapes of the short-run supply curves of firms and the shapes of the firms' demand curves for factors of production get explained with the help of *principle of diminishing returns*. Please see Figures 2-1 and 2-2.

Figure 2-1 Total Product

Source: Landreth and Colander (1994)

Figure 2-2 Marginal Product and Average Product



Source: Landreth and Colander (1994)

Marginal Product is the output that results from one additional unit of input factor of production. Insights from figure 2-2 have helped in development of demand curves for the different factors to optimise production. Marginal productivity theory (MPT) provides useful insights for optimizing production process involving several inputs. MPT provides the insight that input factors are most optimally utilized when the last dollar spent on the purchase of each input yields the same marginal product. This also implies that when firms are optimally hiring inputs all inputs will receive a price equal to the value of their marginal products. MPT also helps to derive demand curves for input factors. The demand for an input is defined as the quantities the firm would hire at various prices. If it is assumed that a firm is hiring inputs optimally, that is the ratios of marginal physical products to the prices of inputs are equal and if we were to lower the price of an input, the firm would use more of that input until the last dollar spent on the input gave the same marginal physical product as the last dollar spent for all other inputs.

Product exhaustion

MPT provides understanding of product exhaustion concepts. For instance, for total product to be exhausted by payments to each factor equal its marginal product, the production function must have the property that a given proportionate increase in all inputs will increase output or total product by the same proportion. When this condition is met, product exhaustion takes place and the production function is mathematically termed as *homogeneous to the degree one*. If production function that is *homogenous to a degree less than one*, as per MPT, a proportionate increase in all the inputs leads to a less proportionate increase in the output. If the production function is *homogenous to a degree greater than one*, a proportionate increase in all inputs leads to a more than proportionate increase in the output. Economists also use the phrase *returns to scale*[3] to describe the way output or costs behave in response to proportionate increases in factor inputs.

Some economists of the likes of J. B. Clark and E. H. Wicksteed held the view that when conditions of *competitive market* existed *constant returns to scale* will invariably be achieved. Other marginal theory economists for example A. W. Flux and Leonhard Euler held the view that product exhaustion will result only when production functions had certain mathematical properties. Wicksell, a Swedish economist, who was an independent discoverer of marginal productivity theory contended that a firm could pass through all three phases of returns to scale. Wicksell believed, that, the three phases of a firm include – expanding output phase, when the firm experiences increasing returns to scale initially, a plateau phase, when the firm experiences

[3] If all inputs are increased proportionately and total output increases by the same proportion, average costs do not change this result is called *constant returns to scale*
If all inputs are increased proportionately and total output increases by a smaller proportion, this result is called *decreasing returns to scale* and increasing average costs
If all inputs are increased proportionately and total output increases by a greater proportion, this result is called *increasing returns to scale* and decreasing average costs

constant returns to scale and thereafter sooner or later the firm encounters decreasing returns to scale.

Ethical implications of marginal productivity theory

John Bates Clark (1847-1938) is considered as the first American to make important contributions to economic theory. His contributions to marginal analysis and marginal productivity theory are well acclaimed. Clark was very particular to maintain that the return that accrued to capital and land did not contain any element of profit. Clark was keen to provide a justified distribution of wealth argument utilising MPT. He maintained that under perfectly competitive market each factor of production would receive a return equal to the value of its marginal product. He utilised MPT to justify higher returns to capital as fair as they are the outcomes of competitive market conditions. Clark also argued that existence of any profit may only occur if the competitive markets are not in their long-run equilibrium or due to dynamic changes in the economy or changes in technology. He disregarded the monopoly powers of the firms and asserted that any deviations from the competitive market conditions were quantitatively unimportant and ruled out the possibility of any exploitation.

Clark's marginal productivity theory also led to a macroeconomic policy conclusion that depressions and unemployment could be eliminated by permitting wages to fall. This view was opposed by John Maynard Keynes (1883-1946), who pointed out that lower wages will result in lower disposable income for the labour and result in lowering of the demand for final goods. Clark did not agree to see this point of view that aggregate supply and aggregate demand would have to remain balanced. There was a zeal to promote a strong *laissez faire* orientation and increasingly higher profits for capital and land.

2.6.2 Alfred Marshall

Alfred Marshall (1842-1924), a man of immense scholarship and wisdom, improved the works of classical economists and went on to expound his principles of supply-and-demand. Marshall found economic studies complex as they depended on many factors and these factors in turn were themselves interdependent. He developed the *ceteris paribus* technique of keeping most variables constant which helps to break up complex problems for easier analysis – a technique also known as partial equilibrium analysis. Application of *ceteris paribus* technique helped him to simplify economic analysis where causes take time to work out their effects – to address problems caused by time. Marshall introduced different time periods in his analysis: (1) market period – during this period supply is considered fixed/inelastic; (2) short-run period – during this period the firm is in position to change supply within limits of its capacity; and (3) long-run period – during this period supply can make full adjustment to changing prices by altering plant capacity. Marshall elucidated on the pricing controversy between the classical economist Mill's production theory of value and the neoclassical economists Jevons, Menger, and Walras's marginal utility theory. Marshall acknowledged the relative importance of demand and supply, but his belief that demands are actually outgrowths of human activities, made him inclined to giving more emphasis towards supply. Marshall formulated the concepts of *price elasticity of demand*, *consumer surplus, the demand curve* and *diminishing utility*. He made a very important contribution by way of introducing the notion of *quasi-rent* in the analysis of cost and supply.

Marshall's pricing philosophy

Marshall's pricing philosophy is mainly related to application of *ceteris paribus* technique to elucidate the controversy concerning the relative importance of demand and supply in price or value theory. The Marginal-utility theorists stressed that value depends entirely upon demand. Marshall stressed on the understanding of the influence of time and an awareness of the interdependence of economic variables.

Marshall rejected the idea of value at the margin representing the value of the whole – just *marginal utility* or *marginal cost* cannot determine the *price*. He provided the following basic understanding to elucidate his pricing philosophy: (1) *marginal-utility*, *cost of production*, and *price* interact with one another at the margin and mutually determine their respective values; (2) demand curve for final good slopes downward and to the right – purchase quantity increases with lowering of prices; (3) shape of the supply curve depends upon the time period – the shorter the period – the more important the role of demand in determining the price – the longer the period – the more important the role of supply; and (4) in the long-run, if the firm is a constant cost type price will depend solely on cost of production.

Marshall perceived the shapes of firm's supply curves for the different periods – the market period, the short run, and the long run. After considering how forces are at work, he expounded on to the realistic domain to explain how choices are made by firms to make their businesses viable. For explaining a realistic operation of a firm in the short-run period, Marshall made the assumptions that the firm is operating in a perfectly competitive market and that its short-run supply curve will follow the principle of diminishing returns and also segregated the supply costs into its fixed and variable components. Basing on these assumptions he further provides insights into the nature of relationship between the marginal cost curve and the average variable cost curve (representative illustration given in figures 2-1- 2-2) explains, how, any operating firm will make choice of the output in the marginal cost curve to minimize its losses – the firm will operate on that portion of the marginal cost curve that is above the average variable cost curve – this meant that the firm in the short-run makes the choice of at least minimizing its fixed cost losses by operating in output sections that fetch a marginal cost that is above the average variable cost. By providing this explanation Marshall also plays down the view of critiques that capitalists always make huge profits when they sell at high opportunity costs.

The long-run forces, according to Marshall, determine the shape and position of the firm's cost and supply curves – as the size of the firm increases internal economies of scale lead to decreasing costs and internal diseconomies lead to increasing costs. Long-run supply curves slope downwards – larger quantities will be supplied at lower prices.

Marshall's quasi-rent

Marshall through his concept of *quasi-rent*, provided insights into the workings of a market based pricing system. With this concept, he could draw a distinction between his pricing system and that of Mill's. Mill's pricing system held that wages, profits and interest were price-determining – and did not recognize a rent potential at the margin. Marshall, however, could show rents coming up for the factor payments from the elasticity of the supply curves of the factors during market- and short-run periods. He could thus bring forth a different perspective that factor payments that are generally price-determining tend to become price-determined during market- and short-run periods

Marshall considered that wages, profits, and interest have the characteristics of rent; in the long-run wages are price determining; in the short-run wages are price determined and therefore behave like rent. He extended the concept of *quasi rent* for capital and argued that profits like wages can be either price-determining or price-determined depending upon the period under examination. Marshall opined that in the long-run equilibrium, each firm will earn only a normal rate of profit.

General equilibrium perspective of Walras

General equilibrium theory is an analysis of the economy in which all sectors are considered simultaneously. Formalizing the interrelatedness of economy was a formidable challenge to the economists. A Cournot (1801-1877) was inspired to undertake this challenge, he did make some advances in the year 1838; he developed a premise using calculus that profits maximized when marginal cost became equal to marginal revenue. Utilising this premise, he went on to comprehend the dynamics of the economy but had to give up when the enormity of the task overwhelmed him. Walras defied the awe surrounding this task and succeeded in formulating a model of an economy. He perceived interrelatedness of households, firms, prices of final goods, prices of factors of production, quantities supplied, and quantities demanded of goods and developed his general equilibrium theory using a system of simultaneous equations to show how prices in an economy get evolved. He utilized the basic premise that individuals strive to achieve maximum utility, his focus was on marginal utility. Walras demonstrated with his mathematical model that when the equilibrium is disturbed – repercussion takes place in the entire system – consumers change their spending patterns and firms change their demand for inputs – thereby bringing a new constellation of input prices and a different distribution of income. His model comprised of two-sectors: firms and households. He made assumptions such as – firms do not buy intermediate goods – level of technology as fixed – existence of full employment. His work is considered revolutionary because it is the first mathematically (calculus) based analysis to determine the uniqueness of prices and quantities in the system. Walras made no attempt to validate the concepts of this model empirically. This was a theory without empirical application.

2.6.3 Thorstein Veblen (1857-1929)

Veblen is regarded as the father of American heterodoxy. He had scientific and ethical disagreements with classical/neoclassical economic theories which according to him were teleological, and pre-Darwinian. Veblen found ameliorative tendency of classical and neoclassical economists which he expounded by showing how from Smith to Marshal the notions such as natural-price, unrestrained competition, and beliefs about the working of the invisible hand were sustained even though these could not be established or proven (Harris 1934, Landreth and Colander 1994). Veblen was highly critical of Clark's conclusion that long-run competitive equilibrium produces equitable distribution of income and argued about the farfetchedness of such claims. He contended that the objectives of business were only for pecuniary gain and pursuit of profit which were often achieved through creation of shortages by adopting clandestine methods. He also alleged that larger corporations that were set up on the pretext of efficiency were only for acquiring monopoly control over setting prices. Veblen disavowed the claims of the mainstream economists about the existence of competitive markets, hedonistic households and the implicit assumption of harmony in the economic system and insisted that these should have been empirically established before making claims (Landreth and Colander 1976, Hunt 2002).

2.6.4 Other economic thinking during neoclassical time

Socialists Economic thinking

Capability of socialistic economies were always viewed by the mainstream economists with scepticism as they felt that the conditions such as community ownership of production facilities, nonexistence of property rights, absence of market institutions would prevent achieving of economic efficiency (Landreth and Colander 1976). For the mainstream economists, absence of rights to private property, independent owners of factors of production, democracy, and democratic institutions meant a total impossibility of achieving any economic efficiency or being anywhere near reaching conditions of allocating resources with efficiency.

Economists of the likes of Vilfredo Pareto, Enrico Barone, and F. M. Taylor however, held that allocating resources rationally under socialism is possible. Taylor held that while income to household could be distributed by the state – the household could be permitted to spend its income in free markets – state-owned firms would plan production to meet consumer demand so that price equalled cost of production – trial and error would disclose to the planners equilibrium prices for the factors – hence resource-allocation problem is non-existent under socialism (Landreth and Colander 1994, Peters 2015). Enrico Barone held that state will set prices so that they are equal to the cost of production and if costs of production are at a minimum – an optimum allocation of resources exists and maximum welfare is achieved.

Oskar Lange (1904-1965) who was an eminent socialist from the United States, brought a close to this subject of whether socialism can efficiently allocate resources or not.

According to Lange, even, under capitalism, the households who sell factors and the firms that buy the factors, hold no real knowledge of the forces that drive the prices – and their knowledge is not influencing their actions. And, in a similar way, the planners in the socialist economies, find the prices by trial and error that will make quantity supplied equal to quantity demanded and thus clear the markets. Lange explained the process thus:

"*Under planned socialism (the equilibrium condition of producer maximizing profit is not called for) – state-owned firms do not seek profit. Under socialism Lange suggested that they follow two rules – first, that they produce at the lowest possible cost; second, they choose the scale of output so that price equals marginal cost. Lange contended that the clearing of markets under socialism would be brought about by state planners by adjusting prices on a trial and error basis. A price that is too high would bring about surpluses and indicate to the planners the necessity of lowering prices. Too low a price would result in shortages. Under socialism there would be no profits*" (Landreth and Colander 1994)

Thus Pareto-Barone-Taylor-Lange's arguments convey unequivocally that a socialist economy could allocate resources efficiently, and by proper planning and direction this could bring about the same results as would exist under perfectly competitive markets.

2.7 Contributions of Modern Economic Thinking

2.7.1 Microeconomic theory

The evolution of modern microeconomics could be attributed to the outcome of the factional fights between two groups of economists in the United States – the *institutionalist* and the *formalists* over the continuation of Marshallian economic theory. *Institutionalists* considered Marshallian economic theory inadequate and insisted that this theory should be discarded. *Formalists* were also critics of Marshallian economic theory. They believed that economics should be regarded as a science, and held the view that economic theory should be adopted only after establishing the *how and why* of the theory. *Formalists* preferred a more rigorous general equilibrium foundation that could adequately answer more complicated questions and thereafter they emerged successful and gained control. The transition away from *neoclassical economics* toward *modern microeconomics* began strongly from late 1950s. This transition also marked the beginning of an era which considered applications of economics less important than logical consistency (Landreth and Colander 1994).

Pricing theory in the Modern Economic Period

The transitioning from neoclassical era into the modern modelling era also brought changes in the method of determining prices. The pricing methods moved away from partial equilibrium and began to be based on general equilibrium modelling approach. In the modelling approach, the essence of the economic premise is captured using mathematics to develop the model, and then econometric techniques are used to test those models. Arrow and Debreu produced a precise formulation which was an improvement over Walras's general equilibrium theory. They also are acclaimed for achieving the distinction of establishing the veracity of Adam Smith's notion about the *working of the invisible hand in the economy*. Further, mathematical economists came closer to answering the question of whether prices were inherent in the economic system; they could show that prices occurred *naturally* through a *maximization* process. They developed methods which could, even in the absence of markets, be able to determine *shadow price* (also known as *Lagrangian multipliers*) through a mathematical process of *constrained maximization*. Using shadow prices, economists, could gain greater insights on businesses from a pricing angle (Landreth and Colander 1994).

Progressively, mathematical techniques began to advance, and complexity of calculus increased, theories such as *set theory* and *game theory* evolved. The advancement of mathematics made it more esoteric and users had to be highly competent to be able to learn and grasp highly abstract and non-contextual argumentation.

Application of mathematical models to policy

Consequent to accomplishment of gaining competency over general equilibrium techniques, economists turned once again to applied work. The applied work now chose mathematical modelling approach rather than the conventional Marshall's economic engine approach. This modelling approach began to engage in the economic policy area from around the 1980s. Simple mathematical models captured the essence of policy prescriptions and econometric techniques were deployed to empirically test the veracity of these models. The initial works carried out in this manner turned out to be successful and increasingly this method was adopted and became very popular. Over application of this method led to gradual erosion of quality of this work. A switch from the more difficult general equilibrium approach to partial equilibrium model approach gradually emerged with the eagerness to providing basis for policy arguments

(Landreth and Colander 1994). A disconnection with the theoretical core became the order of the day; modern applied economics became more of an exercise of data mining and depicted semblance of 'scientific empirical testing' and thus the outcome of such works became unreliable. Modern economics became more eclectic and less genuine (Landreth and Colander 1994).

2.7.2 Chicago Economists-Neoliberalism

As modern modelling approach became increasingly unreliable and questionable, economists of the likes of Milton Friedman who championed the Chicago movement began to counter formalist economists who were evangelists of mathematical economics. The Chicago brand of Marshallian economics emerged from the 1970s; they advocated an economic ideology generally known by the name *neoliberalism*; the cornerstone of this economic ideology was free-market (Landreth and Colander 1994). Neoliberalism, from an economic perspective underpins the efficiency of free market and upholds the welfare consequences of market exchange as sacrosanct. Neoliberalism also had a version to attract and engage the political leadership into its ideology which portrayed the superiority of market. This version elaborated the advantages of neoliberalism which appealed to the political leadership. They claimed and insisted: (1) market can make better allocation of goods over that achievable by State; (2) adoption of policy measures such as tax reductions for the top bracket: (3) disempowering of labour unions; (4) deregulation of businesses: and (5) reduction of public spending for achieving improved economic growth. Proponents of this ideological movement were able to receive support of top business leaders and influence policy changes (Wikipedia 2015).

The neoliberalism ideology was spread far and wide by its proponents who were financed by big industry groups. Think tanks and other organizations developed theories with finesse and erudition that bespoke the ability of markets to allocate efficiently and achieve improved productivity. They succeeded in influencing leaders of powerful and industrial western democracies to adopt policies such as privatization of public enterprises as well as deregulation of major industries (Wikipedia 2015). Institutions such as World Bank, IMF, Asian Development Bank (ADB), etc., were made to adopt neoliberal ideologies. At the IMF, the conditionality of 'Washington Consensus' included conditions representing a strongly market based approach for approving monetary loans sought by the underdeveloped countries to overcome the worldwide financial crises of the 1980s. The Washington consensus actually meant: fiscal policy norms (avoidance of large fiscal deficits relative to GDP); redirection of public spending from subsidies (such as provision of pro-poor services); adoption of tax reforms – broadening the tax base and lowering of the tax rates; competitive exchange rates; trade liberalization (uniform tariffs); privatization of state enterprises; and deregulation and legal securing of property rights (Beder 2003). These proponents also raised scepticism about Keynesian form of governmental intervention and blamed the role of money for spreading inflation and disavowed the suitability of Keynesian macroeconomic approach. Neoliberalism ideology was not an outcome of technology or economic forces; this ideology served business interests who stood to gain the most from its introduction (Landreth and Colander 1994).

2.7.3 Modern Macroeconomics

Classical and neoclassical economists believed that competitive market forces and profit motives of private entrepreneurs led by *invisible hand* would produce resources sufficient for full employment and any serious upheavals to macro-economy was an impossibility. Classical economists, however, feared the possibility of a shrinking economy. Marshall also held the view of a shrinking economy though he had hopes on technological progresses impeding the economic decline to some extent (Landreth and Colander 1994).

The concern for macroeconomics arose only after the occurrence of major depression, which had engulfed the entire industrialized world in the 1930s. This depression changed the context within which society and economists viewed the market. The credibility of laissez faire came under scrutiny. Marx saw depressions as a manifestation of the contradictions in the system that lead to its ultimate collapse.

Schumpeter held views like that of Marx, but had differing arguments. He believed that economic growth is fostered by the institutional structure of the society that encourages innovation and entrepreneurship. According to Schumpeter entrepreneurs are risk takers and stoke the economy by introducing innovative products and technology. Schumpeter who wished to see the continuation of this process of economic growth, found that entrepreneurs after achieving their initial success tend to become less risk taking and engage in consolidating their business into larger corporates for eliminating competition. Emergence of large corporates eventually eliminates the culture of entrepreneurship. Managers of large corporates cannot defend the concept of private property. Schumpeter did not support the Keynesian way of shoring up capitalism by injecting money into the economy; he felt that this would eventually wreck capitalism (Landreth and Colander 1994).

Tugan Baranowsky held views like that of Marx. According to him economic fluctuations are inherent in the capitalistic system. The major causes of the business cycle are attributable to the forces that determine investment spending.

2.7.4 Keynesian economic thinking

J. M. Keynes (1883-1946) in the year 1936 developed his *General Theory of Employment, Interest and* Money. Keynes championed the role of overall demand and the importance of its adequacy to prevent unemployment; he totally disagreed with the view that competitive markets in the long-run ensure full employment. He contended that aggregate demand (the sum of spending of household, businesses, and the government) was the most important driving force in an economy (Jahan, Mahmud et al. 2014). He provided the *notion of income multiplier effect*. He explained the possibility of an injection of investment in an economy getting multiplied: an injection of extra income leads to more spending, which in turn creates more income; the size of the multiplier he went on to explain would depend on the *marginal propensity to consume*. The approach of Keynes ushered in a new phase of orthodox macroeconomic thinking. His thinking was well received by other economists of his time and they were known as Keynesian economists. Keynesian economists explored and furthered his theories for applications to economic policies. Keynes's multiplier model was also explored in greater detail; and the importance of aggregate demand and its significant impact on employment and real output of the economy in the short-run was made more explicit (Landreth and Colander 1994). Abba Lerner (1903-1982) was an influential force in promotion of Keynesian economic thinking. Lerner did not favour a policy of *sound finance* (balancing the budget), instead he recommended a policy of *functional finance* (countercyclical *fiscal policies*) – that could act counter to the direction of the business cycle, and be able to provide the necessary *drive* to the economy. Lerner emphasised the need for quick and prompt actions to prevent macroeconomic upheavals. He contended that fiscal and monetary policies were the tools that government should use to achieve its macroeconomic goals of high employment, high growth and price stability (Landreth and Colander 1994, Jahan, Mahmud et al. 2014).

Keynesian economics dominated economic theory and policy after World War II until the 1970s. In the 1970s, when many advanced economies suffered *stagflation*, Keynesian theory came under question, because, it had no appropriate policy for stagflation. Monetarist economists critiqued the government's approach of regulating the business cycle with fiscal policy only; they recommended judicious use of monetary policy (Jahan, Mahmud et al. 2014). Keynesian economists revamped their system by integrating the new suggestions of the monetarists as well as other newly acquired knowledge on monetary influences. Keynesian models were fitted into the neoclassical general equilibrium model. This was done to achieve theoretical completeness and also for being able to make the model to address inflation into the analysis.

In the mid-1970s, *hypothesis of rational expectations* caught on with macroeconomics; these evolving rational expectations came to be known as *new classical economics*. The *rational expectation hypothesis* disavowed the joint works that were being carried on by the Keynesian economists and monetarists economists. The *New Classical Economic thinking* asserted the efforts of policy makers are rendered ineffective because individual market participants can anticipate the changes from a policy and act in advance to counteract them. This view, however, remained a subject of debate as new emerging views cast doubts on the efficacy of aggregate markets to respond in an instantaneous manner to the moves of market participants (Jahan, Mahmud et al. 2014).

The tenets of Keynesian economics proved its mettle by handling the worldwide financial crisis of 2007-08 in a swift and effective manner and re-established the continuing relevance of Keynesian economic thinking (Jahan, Mahmud et al. 2014).

2.7.5 Emergence of New Classical Economics

In the 1950s Harrod-Domar (H-D) model sought to explain: (1) the requirements to maintain steady rate of growth of full employment income without inflation or deflation; (2) whether long-run full employment equilibrium of a developed economy is possible without secular stagnation or secular inflation. As H-D model did not project a positive picture of growth, Solow model emerged as a response. The Solow growth model (developed by Robert Solow and Trevor Swan in the year 1956), also called the neoclassical growth model, focused completely on supply; demand played no role in determining output (Landreth and Colander 1994).

New classicals found Solow model to their liking and developed it further to push their macroeconomic movement away from demand and towards growth which was supply oriented. A new endogenous growth theory supported the new classicals which posited that technological changes were endogenous and occurred as a natural result of investment in research and development. Endogenous growth theory allowed increasing returns to overwhelm diminishing marginal returns, and the result of this could be continual growth and no eventual movement to the stationary state. It brought the mainstream macroeconomics back to the optimist, rather than the pessimist fold.

2.8 Evolution of perspectives

Aristotelian Economic Thinking

- Equivalence in *Exchange value* is difficult to achieve and often a conundrum; a just exchange would warrant achieving an uncontestably genuine *need* between the exchangers and the *need* thus achieved should merit unquestionably justifiable *commensurability* with the determined *exchange-value*.
- Unreined *exchange-value* can unleash a culture of pursuit for unlimited gains. When *exchange-value* latches on with activities with money as the end objective, real things of value in life get compromised.
- Virtuous living, holding of community in harmony, and social equity are sacrosanct. *Exchange value* tends to seek individual profits, undermine communities and erode social values.

Scholastic Economic Thinking

- Scholasticism marked a gradual unshackling of the western society from the burdens of guilt of forsaking the virtues of poorness and equality and seeking to favour a life of riches, by providing arguments that this transition was appropriate and served the objectives of greater virtues.
- Scholastics adapted to the changing situation by allowing fusion of religious teachings with the writings of Aristotle. During the period of scholasticism, the transition to economic thinking was marked by differing notions about fair and just price.

- The hallmark of scholastic period was the genuine concern for ensuring fairness. Guiding tenets were provided to address these concerns. Profiting from scarcity, deliberate impeding of the flow of market, and manoeuvring to induce scarcity were considered unacceptable and condemnable.

- The transition to economic ideals, however, was gradual, it commenced within the strict aegis of ethics, fairness and justice.

Mercantilism

- Profit motive dominated and stimulated the economy. Merchant companies won the support of their monarchy to obtain monopolistic privileges to exclude competitors. Merchants in return provided strong support to their governments.
- Use-value determined the demand. Forces of supply and demand determined the market value. Supply was regulated to maintain higher prices.
- Social justice was undermined. Wages to labourers were curtailed to reduce costs.
- Concentration of State and individual wealth became the new norm. *Mone*y began to assume the roles of both means and end-objective characterising an endless pursuit for *money*.

Pre-classical economic thinking

- Increased competition impeded mercantilism and caused reduction in profits. Highly skilled craftsmen who had been suppressed during the period of mercantilism resurrected themselves as the new capitalists and challenged mercantilist businessmen. This new movement condemned State interference in the economy and the institutions that promoted mercantilism. Protestant theologians provided moral fillip. Diligence and thrift assumed importance.
- New *capitalists*, armed with division of labour techniques, steam-turbine driven manufacturing machines and mechanisation ideas demonstrated their prowess to improve factory productivities.
- Profit seeking by the new entrepreneur capitalists was not considered as ungraceful. Economists of the likes of Cantillon and Quesnay provided ideas of how competitive market forces could bolster the economy. Capital accumulation, productivity initiatives and competition became the new bywords for economic growth and social welfare.

Classical Economic Thinking

- Mid-18th to mid-19th century represented a period of profound economic changes and social upheavals in the UK and several other European countries following industrial revolution. Technological innovations transformed cottage industries into large-scale factories. Economic disparities between the capitalists and the labourers led to a spate of societal upheavals. The strong hand of the governments of the time could overcome these upheavals and establish capitalistic ideologies in the western world.

Adam Smith

- Smith was profoundly impressed by the technological improvements by entrepreneur *capitalists*, opposed mercantilism and favoured a *laissez faire* approach. He envisioned an economic system fostered by market forces, unhindered by the restrictions of the government, to enable entrepreneur *capitalists* to unleash their potential and contribute to strong economic growth.
- He provided an ideology that recognized the role of capitalists and capital accumulation as imperative for successful economic growth of any country and favoured a disproportionate compensation for the capitalists. He believed that competition in factor markets will result in optimising allocative efficiency and maximising social welfare.
- *Income distribution theory* allowing wage for labourers at just about *subsistence* level in order to provide a very favourable compensation to *capitalists* was justified.
- Smith maintained that *capitalistic ideology* will ensure full deployment of resources & employment for the people. He provided a *cost of production theory* to explain formation of prices and a concept of *natural price* which he believed, results from unfettered competition and overtime will produce the best allocative efficiency and maximum social welfare.

Thomas Robert Malthus

- Malthus held the view that prices are determined by the interaction of supply and demand; he rejected the notion of *natural pri*ce as well as Smith's *cost of production theory*. Wage fund doctrines that limited labour wages at subsistence level evolved by Smith and Ricardo was justified based on Malthus's *population thesis* which blamed high fertility rates among labour class as impediments to the economy.

David Ricardo

- Ricardo strongly supported capitalism, and preferred *an income distribution theory* that provided a stricter dispensation of compensation for the landlords who he considered were non-contributors to the society. *Rent-theory of income* based on marginal principles developed by Ricardo to determine the compensation to landlords was unique.
- *Wage-fund doctrine* developed by him for labour was considered harsh. He developed a *labour theory of value* which could not assign a *profit* to capital. His views about *diminishing returns* in agricultural sector and fall in rate of profits could not be sustained.

John Stuart Mill

- Mill considered Malthusian *population thesis* and Ricardo's *wage fund doctrine* as exploitative of labour; he preferred to depart from the leanings on *laissez faire* approach towards a more socially benevolent government directed economy. He also rejected Ricardo's *labour theory of value*. He was keen to bring in social reforms.
- Mill adopted Nassau *Senior's abstinence theory* for justifying compensation for the capitalists
- He provided a *production theory of value* that related prices of final goods to both supply and demand forces that determined the factor prices.
- He was keen to bring about favourable *distribution of income* by allowing institutionally determined laws to modify prices

Karl Marx (heterodox thinker)

- Marx held that capitalism was responsible for separating labour from the ownership of the means of production and that capitalism produced commodities only for their *exchange value*. According to him, capitalists emphasised on increasing *exchange value* and underpaying labour to enlarge *profits*.
- He developed a *labour theory of value* only for exposing exploitation of labour by the capitalists. He was moved by the suffering of labour during the period of industrial revolution and maintained that it was labour which produced the *capital-accumulation* and not the capitalists.

- The ideology of capitalism, according to him, was not sustainable as he could foresee serious inevitable economic recessions.

Neoclassical Economic Thinking

Marginalist Economists

- The declining relevance of *labour theory of value* prompted interest among economists to explore *utility principles* for determining the *value*.
- Marginalist economists provided greater importance to *scarcity* and introduced a pricing system in which *market price* would correspond to the highest *marginal cost*.
- Clark's *Marginal productivity theory of distribution of income* reinforced the legitimacy of profit for *capital*; *land rent* was also merged to capital and together they represented earnings that characterised their *productivit*y. Their relatively higher earnings were justified based on their *marginal product*. Commodity prices based on *value-of-service* and monopoly pricing strategies increased *profits* and this practice became increasingly prevalent unleashing a culture of *profit*.
- With the advent of marginal principles mathematics entered the field of economics.

Walras's general equilibrium theory

- Walras perceived interrelatedness of households, firms, prices of final goods, prices of factors of production, quantities supplied and quantities demanded of goods and developed his *general equilibrium theory*. Based on the premise that individuals strive to achieve maximum utility, he developed a system of simultaneous equations and by solving it showed how prices in an economy evolve. Utilising his mathematical model he could demonstrate that when equilibrium is disturbed repercussions take place in the entire system, bringing a new constellation of input prices and a different distribution of income. Walras did not pursue to establish his theory empirically.

Marshallian economics

- Marshall developed the *ceteris paribus* technique of keeping most variables constant which helps to break up complex problems for easier analysis also known as partial equilibrium analysis.

- Marshall rejected the idea of *value at the margin* representing the *value of the whole*; he contended that just *marginal utility* or *marginal cost* cannot determine the *price* and elucidated that marginal-utility, cost of production and price interact with one another at the margin and mutually determine their respective *values*.
- Marshall through his concept of *quasi-rent*, provided insights into the workings of a market based pricing system.
- He justified *profit* for *capital* and endorsed the concept that capitalist economy will achieve deployment of full resources as well as employment for all.

Thorstein Veblen (heterodox thinker)

- Veblen contended that the objectives of business was pecuniary gain and profit was often achieved by restricting output. Larger corporations that were being formed were not for increasing efficiency, but to acquire monopoly power and set monopoly prices. Veblen was highly critical of Clark's *marginal productivity theory* and its conclusion that long-run competitive equilibrium produces equitable *distribution of income*.

Modern Economic Thinking

- Formalists who believed that economics should be treated as a science introduced a more mathematical general equilibrium-based foundation to evolve economic theories.
- Pricing theory transitioned to a mathematical modelling era. These models utilised the premise that prices occurred naturally through a maximisation process. Constrained maximization could generate information on *shadow price* without the need of an actual market.
- Extensive usage of modelling techniques for proving policy matters led to adoption of unethical practices like partial equilibrium in lieu of general equilibrium and acceptance of ad hoc data to facilitate favourable results—the credibility of this system increasingly came under question overtime.

Chicago Approach – Neoliberalism

- Unreliable modelling approach and deterioration of the overall economic conditions during the 1970s led to the emergence of Chicago economists who developed a new economic ideology known as *neoliberalism*. Neoliberalism extolled the advantages of free market principles and advocated against any kind of State involvement in the economy. Businesses took active interests in furthering this ideology. *Think Tanks* were engaged by businesses to propagate this ideology among governments, educational institutions, and public. Advent of neoliberalism led to globalisation of economy, significant increase in wealth concentration among super rich and greater inequality in the society.

- Neoliberal ideology discouraged government debt for funding utility companies and insisted on spending cuts by government and recommended:
    - privatisation of public utility companies
    - broad lowering of taxes and more specifically encouraged higher tax benefits to the larger income groups
    - to be open to foreign investments and allow repatriation of profits
    - pricing based on marginal principles.

2.9 Summary and Insights

The purpose of this chapter was to review pricing philosophies that have evolved under the auspices of different schools of economic thought. The main insights from the review are as follows:

- Economic thinking of 2000 years ago emphasised ethical issues such as virtuous living, community harmony and social equity and raised concerns about the damages that unreined *exchange-value* can inflict on the fabric of the society.
- Agrarian capitalism, mercantilism and industrial capitalism emerged as a response to growing economic and commercial activities which were propelled by improvements in agricultural productivities and technological advancements.
- Mainstream economic theories ramped up the profit theme progressively. Capitalism was accorded a formal foundation based on the principles of *laissez faire*. Profit and unequal society became the new norm.
- Neoclassical economists combined capital accumulation and rent for land under one category and termed it as *capital*. *Marginal productivity theory of income distribution* developed by the neoclassical economists characterised profit for capital and wages for labour as being representative of their respective marginal products and therefore the respective earnings are fully justified.

- *Value-of-service based pricing* arising from *elasticities of demand* increased the profit potential that accrued to the capital. Marshallian economics provided notions of short-run marginal prices to justify profit.
- Adoption of marginal principles also facilitated introduction of mathematics into the field of economics. Formalists laid emphasis on discovering prices on the premises of maximizing utility and minimizing factor costs based on marginal principles. Esoteric mathematics and mathematical modelling techniques overtime tended to produce works that were unreliable and less genuine.
- *Neoliberalism* laid emphasis on privatisation, *free-market* principles, and market discovered prices based on the principles of *value-of-service*.
- Heterodox economists (Karl Marx and Thorstein Veblen) raised concerns about the inequality arising from depression of wages to the labour. Veblen opposed Clark's assertion about capitalism producing equitable distribution of income and held capitalists accountable for the growing profits and consequent inequality in the society.
- The track record overtime has adduced to the views of the heterodox economists.
- OECD (2011) has raised concerns over the rising income inequality in the Western world and in particular, countries like Italy, the United Kingdom, the United States and the Nordic countries. They fear that this could breed social resentment and political instability.
- Piketty (2014) and Foster and Yates (2014) join this view and express concern over growing inequality. Their views elaborate on the weaknesses of mainstream economic theories which contribute to the growing profit at the cost of growing inequality.
- As brought out by Economist (2014), Piketty subscribes to the following points: inequality became a pattern of society from the times of industrial revolution; only exigencies of First and Second World Wars could disrupt this pattern. High taxes, inflation, bankruptcies, and the growth of sprawling welfare states caused wealth to shrink dramatically and ushered in an egalitarian period (1945-1970) when income and wealth were more equitably distributed. From the 1970s, however, wealth has begun to grow back due to shifts in economic policies leading to very serious distributional concerns. Wealth is growing faster than the economic output.
- Foster and Yates (2014) point to the alarming inequality divide between the top 1% and the remaining 99% and cite the example of how in the United States the average mean worth of

the wealthiest 1 percent in 2010 was US$ 16.4 million as against that for the least wealthy 40 percent was USD (-) 10,600 (a negative amount). They question the veracity of the core assumptions of economic theories for example – Say's notion of natural tendency in capitalism to a full-employment equilibrium – Kuznet's assumption about growing equality in developed capitalist economies which is so unreal. They also contrast growth of productivity to the changes in incomes that come about – they cite reference from a publication of Economic Policy which brings out that an increased growth of productivity at 64.9 % resulted in 80 percent of private-sector workforce getting an improvement in compensation only to an extent of 8.0 %.

- The track record of profits of the investor-owned ESIs in the United States strikes a resonating chord with the enthusiasm of the mainstream economists in legitimizing profit for the capital; investor-owned ESIs of the US have stood out as exemplars. Incrementally improving scale efficiencies, pricing strategies based on value of service and monopoly pricing techniques have complemented the industry in its goal to achieve a perennial flow of profit for almost a hundred years concentrating the industry to become giant monopolies with an incredible capacity to amass wealth.
- The extreme usefulness of electricity and its technical nature to allow prices to be discriminated between consumers with ease have provided an abetting support for the ESIs to extract profit. These profits have affected the most vulnerable section of the society in the developed world; the increased cost of electricity generating equipment and the price of electricity have resulted in denial of access to electricity to over 1 billion people living in the less developed economies representing 50 percent of the world's rural population.
- This study of pricing philosophies that have evolved under the auspices of different schools of economic thought, that are antecedents to the modern-day pricing system, has revealed the profound importance of fairness, justness of pricing system to the human society and its great relevance in the context of ESIs. It has also revealed about the difficulties in achieving equivalence in *exchange-value*.
- This thesis will utilise the important findings of this chapter to assess the appropriateness of deregulated electricity pricing system and provide suggestions for equitable availability of electricity services without compromising the economics of providing this service.

3 REVIEW OF ELECTRICITY PRICING SYSTEMS

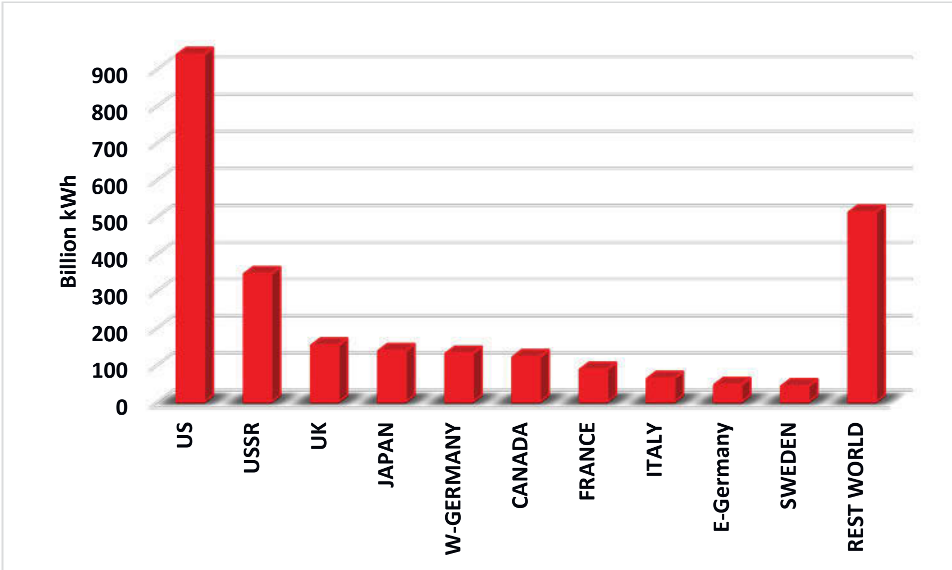
3.1 Introduction

The previous chapter provided a historic overview of major philosophies, emphasising how consideration of ethics, fairness, and justice were integral to pricing in the earlier times, and how, over time these considerations assumed a dormant place to be replaced by profits as a sole consideration in pricing. The previous chapter also discussed how this replacement resulted in subordination of social values – growing profits were glorified, and growing inequality was considered inevitable for achieving overall economic welfare. Neoclassical economists provided marginal utility and marginal productivity theories, and promoted 'value-of-service' rationale to discriminate prices between consumers. Their attempts were aimed at removing the 'unethical' stigma surrounding profit motives.

ESIs began evolving in the 1880s around the same time when neoclassical economic ideologies were evolving. The ESIs, as they evolved, embodied a culture that was clearly capitalistic; profits determined the prices of goods and services. The capitalistic culture of the industry was regardless of the form of ownership – private, public, or mixed private and public, particularly in the western countries (Hughes 1993).The growth of ESIs was also influenced by the 'progressivism ideology' that was predominant in the US during the late nineteenth century. Progressives were keen to promote utilities by according them a natural monopoly status and a pricing system which enabled financial credibility as they provided a useful service to the society.

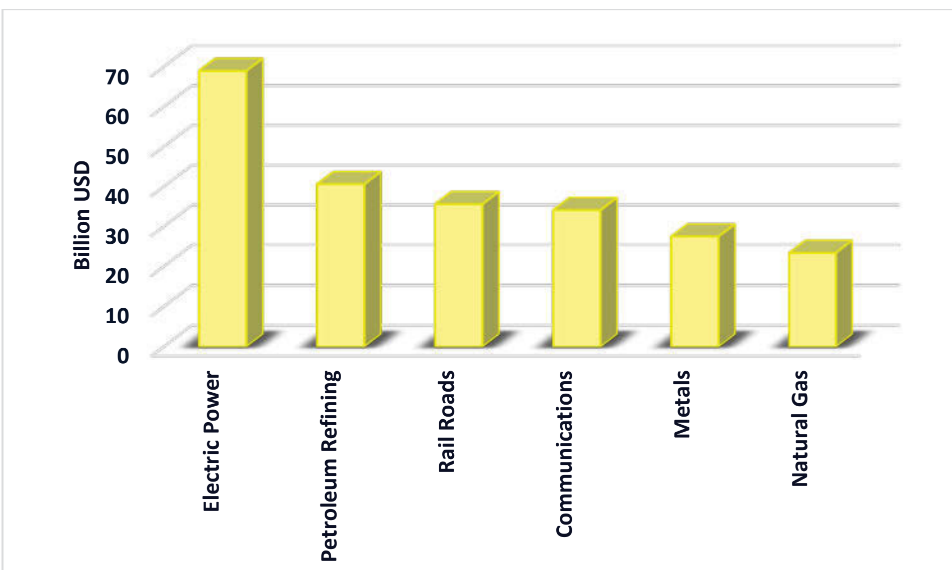
Much of the earlier growth of ESIs took place in the United States. The US ESIs adopted large-scale and large-area technology which made the industry highly capital intensive; pricing strategies and technology together helped the industry to reap growing profits. The growth of US ESIs was phenomenal; a strong correlation between energy consumption and gross national product emerged – ideology of growth became sacrosanct for the ESIs. The US companies also held a global primacy in the manufacturing of electrical equipment, followed by Germany.

Figure 3-1 World Electricity Generation (1962)



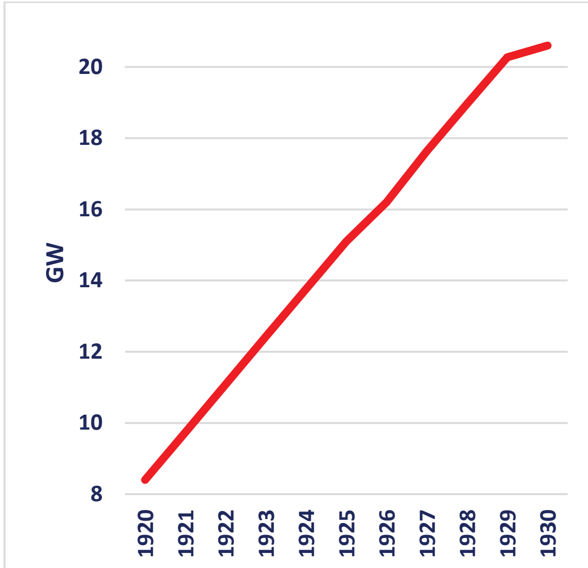
Source: FPC (1964)

Figure 3-2 US industries – Asset value (1962)



Source: FPC (1964)

Figure 3-3 US Electricity Capacity Growth



Source: FPC (1964)

Figure 3-1 shows that US energy consumption was highest in the world in 1962 and Figure 3-2 indicates that capital investments were also the highest in the US electricity sector as compared to other sectors of the U.S economy. Figure 3-3 shows the rate of growth of US ESIs in their formative years.

High capital costs of ESIs comprising generation, transmission and distributions costs generates a high fixed cost element that must be recovered from the consumers of electricity. Fixed cost allocation between consumers therefore often assumes complexity because of the difficulties associated in determining the respective contribution of consumers to this cost; recovery of these costs from consumers often tends to become arbitrary and subjective. The high fixed cost alongside the cyclic and varying nature of consumption of electricity significantly impairs the economic utilization of ESIs. Underutilization results in increased cost of each unit of electricity on average, and demands over existing capacity calls for setting up of additional capacity involving high capital costs. The owners of ESIs often resort to discriminatory allocation of fixed costs between consumers driven by commercial considerations.

This chapter provides a comprehensive review of the evolution of the pricing system for the ESIs, analyses the rationale for the evolution, and provides a deeper understanding about how considerations of justness and equity were dealt with in the process.

3.1.1 Methodology

As discussed earlier, socio-political factors, economic thinking, technology and electricity pricing strategies have been largely responsible for shaping the evolving ESIs. Technology generally provided the scope for expansion as well as productivity improvements, both of which drove down costs while pricing strategies enhanced profits.

This chapter considers three distinct phases of evolution of ESIs, namely, the ESI formative phase (1880-1930), the consolidation phase in Europe (1930-1960s), the inflection phase (1960s-1980s). Post 1980 represents an important phase for the ESIs when deregulation and market pricing system was introduced. This phase is discussed in Chapter 4.

During the formative phase, the ESIs came into their own and entrenched themselves in the modern way of life. Much of this development was led by the U.S, closely followed by Germany. However, elsewhere in the developed world, the industry did not follow the same trajectory. According to historian Thomas Hughes, the industry developed in three different patterns – the U.S in one category, Germany in the second and the UK and the rest of the world charting a third pattern (Hughes 1993). War exigencies provided the impetus to accelerate the growth of both large-scale and large-area technologies in the US and Germany whereas in the UK war unshackled the industry from its conservative foundations. This section seeks to understand how pricing of electricity responded in consonance with its evolution pattern. The countries chosen for analysis are the United States, Germany and the United Kingdom.

The consolidation phase in Europe coincided with the introduction of PUHCA in the US and is significant for the following reasons.

- Financial ingenuity marked the governance of ESIs in the US. The economic crash that followed set in motion the enactment of PUHCA which had financial implications.
- In the UK, electricity came to be recognised for its economic benefits; it also augured well for military superiority; electricity reforms followed establishing the national grid, the induction of large-scale and large-area technologies and subsequently, nationalisation.
- The reverberations of the above developments on the French and other European ESIs.

The evolution of pricing in these three countries followed different trajectories yet all of this converged to entrench ESIs in a commercial framework. This section analyses the manner in which the pricing system was manipulated in jurisdictions on both sides of the Atlantic. The countries covered in this phase are the US, the UK and France.

The inflection phase (1960s – 1980s) marked the end of declining cost phase and the beginning of increasing cost phase; it is significant also for the following reasons.

- The U.S ESIs witnessed the onset of plateauing of its technology – incrementally improving fuel productivity was the first casualty, followed by scalability. Macroeconomic upheavals compounded by Middle-East oil crises also impacted ESIs severely.
- Following nationalisation, UK and Australia launched an accelerated capacity enhancement program with attendant consequences for pricing.

This section tracks the changes to the electricity pricing system as a sequel to the developments outlined above. The countries covered in this phase are the US, the UK and Australia.

Comprehensive literature review has been carried out in this chapter to highlight the salience of socio-political contexts, prevailing economic philosophies, and the extant technology to the pricing of electricity. The review seeks to provide an understanding of how these factors had a bearing on the emerging pricing philosophies.

This chapter comprises five sections. Section 3.2 provides the review of pricing systems during the formative period (1880-1930). Section 3.3 discusses at pricing during the consolidation phase, the three decades following 1930. Section 3.4 examines the changes to pricing during the inflection phase (1960–1980s) prompting the introduction of deregulation post-1980s. Section 3.5 consolidates the insights from the previous sections to weave a coherent story on the evolution of pricing in ESIs worldwide.

3.2 The Formative Phase (1880-1930)

3.2.1 United States ESI (technology-led and state-supported)

ESIs took birth in the US, with the successful establishment of Edison Electric Illuminating Company of New York in the year 1882. It started with a generating station and its distribution network. Edison's invention, the 'incandescent lamp' was the most critical component of his company. The company's success depended upon providing a cheaper lighting option to attract consumers (Hausman and Neufeld 1984). Edison set electricity price based on the cost of gas lighting, not on the cost incurred by him. By 1886, he had successfully established 410 ESIs in the US. By 1900, improvements in the efficiency of incandescent bulb brought the cost of the electric bulb to just 17 percent of its cost in 1882 (Hausman and Neufeld 1984, Faruqui and Eakin 2012). Supplying electricity only for part of the day, however, produced limited revenue as the plants remained idle during the other times of the day. The search for more applications for the usage of electricity as well as enhancing the scope of the industry led to greater technological innovations.

The development of alternating current (AC) type of electricity expanded the scope of ESIs; transformers allowed long-distance transmission of electricity and introduction of three-phase-AC – this resulted in phenomenal growth in the spread of electricity. The expansion of ESIs reached to such an extent that they could be classed along with rail-road companies as public necessities. The adoption of electricity for transport and for factory power greatly reduced costs, and the virtues of electricity began to increase (Hirsh 2002).

During the early years, Edison's ESIs faced only primitive competition from gas light industry. ESIs could improve their utilisation with the advent of electric motor loads, but over time the ESIs faced stiff competition from 'Isolated Facilities (IFs)'. IFs essentially represented self-generation facilities that supplied electricity for their own industrial plant/factory requirements. Even as early as in 1902, there were 3,620 ESIs and over 50,000 isolated plants. Self-generated electricity by IFs was very economical for the industry, as it avoided the transmission and distribution costs of the ESIs, and in some cases these electricity generation plants could utilize the plant's own waste heat for generating electricity (Neufeld 1987, Faruqui and Eakin 2012).

The pioneers of ESIs had a vision of centrally supplying electricity and went for large scale and large area technologies. This made their investments very capital intensive. The variable nature of demand of electricity and the need to set up plant sizes according to peak demand posed a problem of lower capacity utilization and consequent higher price of electricity. ESIs felt the need to attract industrial load which was self-supplied by IFs and whose load generally was not coincident in time with the peak demand period. It thus became imperative for the ESIs with high capacity to offer attractive rates to these industrial consumers and swamp competition by discouraging the need for IFs. The issue of how electricity should be priced, thus, came about right from the infancy of ESIs particularly in the US where the industry faced increased levels of competition (Neufeld 1987, Faruqui and Eakin 2012).

Value-based Electricity Pricing – profit by price discrimination

As discussed above, the variable nature of demand of electricity posed challenges to the industry's earnings and viability; high fixed costs meant high electricity prices when the capacity utilization factors were low. British Electrical Engineer John Hopkinson (1849-1898), an astute economic thinker, is credited for being able to show (in the year 1892) a way for pricing electricity which despite the high fixed cost could still make electricity business viable. Hopkinson proposed a fixed charge that was commensurate with the maximum demand the consumer will take regardless of whether this maximum demand is coincident with the system peak demand, and a separate charge for the actual consumption of energy which was read off by an energy meter (Neufeld 1987, Faruqui and Eakin 2012). Hopkinson however did not take into consideration the probability of maximum load occurring at different times. The rationale of Hopkinson to lay emphasis on the consumer's load factor presumably was that "ESIs were obligated to be ready to give a rate of electricity supply based on the total which each consumer might demand" and hence the fixed costs should be divided among consumers on the basis of the individual peak load demanded by them (Byatt 1963). Hopkinson held that it was proper to charge electricity users on the basis of their individual peaks rather than their consumption during system peaks (Neufeld 1987, Faruqui and Eakin 2012). Hopkinson rate structure suited the ESIs.

With a rate-structure based on demand, and with the unlikeliness that all consumers will demand maximum rate of supply at the same moment, Hopkinson opined that allocation of fixed cost between consumers could be differentiated by allowing somewhat lower prices for attracting existing and potential consumers (of the IFs) and by increasing prices for certain 'must-take' consumers for making profit for the business. Arthur Wright, manager of an electric utility in England, who supported Hopkinson's logic of rate structure, developed the first practical demand meter capable of measuring an electricity consumer's maximum power consumption.

The Hopkinson and Wright's method of electricity pricing structure came under criticism. The critics characterised this type of pricing, on the basis of 'unlikeliness of peaks', as flawed, very opportunistic and solely favouring ESI's business interests (Neufeld 1987, Faruqui and Eakin 2012). They suggested that peak pricing should be applied to actual peak usage and not on any conceptual basis.

Gisbert Kapp regarded as the "father of time-of-day pricing", advocated two prices for electricity, namely an estimated higher price during the time of day when the ESI experienced maximum system demand, and an estimated lower price during other times to encourage utilization of capacity. The investor-owned ESIs in the US however did not allow Kapp's idea to the applied in the US (Neufeld 1987).

Wright provided a counter argument, as given below:

Theoretically it might be said that the standing charges ought to be divided into amounts proportionate to the maximum demand of each customer, at the day and at the very time the maximum demand occurred on the mains each year. This is obviously impossible to determine in practice, and would not be, moreover, necessarily equitable to the consumers who might or might not have used their maximum demands at the moment in question. (Byatt 1963)

Wright went on to insist that the value-of-service based pricing system advocated by him and Hopkinson clearly improved the load factor of the ESIs and hence was desirable.

Insull, the pioneer and founding father of ESIs in the US, collaborated with Wright and utilized Wright's maximum demand meter and his demand-charge rate structure to develop a sophisticated mechanism which institutionalized profit-maximizing price discrimination. Insull could track the costs of competition – the costs of operating an isolated plant and set a price which was high enough to cover his costs but low enough to be attractive to the industry user. In this manner Insull was able to swamp out competition to his ESIs. The role of Wright's demand-charge rate structure as an instrument of price discrimination became more important to its widespread adoption in the US (Neufeld 1987).

Incremental release of scalable efficiency to maximise profit

Insull did not confine his interests to just innovative pricing strategies. He also took the lead in the technological and economic realms. Insull's rich ESI experience gained through his association right from the industry's infancy enabled him to take bold decisions in matters pertaining to the choice of technology for his ESIs. He went on to adopt relatively unproven technologies that had the potential to provide a competitive edge. Leaguing with manufacturers he was able to secure, on exclusivity basis, generators with larger capacities and higher efficiencies that were yet to be manufactured at any given point in time. The equipment manufacturers who were fully aware of the productivity potential of the technology set a strategy of incrementally releasing the productivities so that this can enable a cost reducing trend spanning over long periods, thereby enabling the business larger and larger profits (Hirsh 1999, Beder 2003). The collaboration between the investors of ESIs and the equipment manufacturers also enabled a smooth transitioning of technology with maximum productivity benefits. Insull also fully exploited large area technology involving high voltage transmission systems to optimize economic mix as well as for achieving increased customer base, diversity of load and consequent improvement of his ESIs utilization factor (Hirsh 2002).

Emergence of Regulatory Pricing System

Adoption of large-scale and large-area technology made ESIs highly capital intensive. The cost of construction for ESIs quadrupled within a period ten years to a staggering $2 billion in the year 1912 (Hirsh 2002). With increase in the capital intensiveness of the industry, a permanency of business was critically dependent on reduction of costs of raising capital as well as for provisions for protecting high capital investments. To achieve this, Insull forged a consensus with 'Progressive Reformers' of his time and through their influence, obtained natural monopoly status with agreement for a regulatory oversight of ESIs. Progressives sought to promote the emerging new economic forces for society's good and believed that competition among large public utility companies will result in poor service; they therefore favoured monopolization with regulatory oversight. They enabled a very generous pricing formula to the ESIs which allowed for all prudently incurred expenses and provided a return on allowed asset base which was high enough to guarantee the financial viability of the ESIs. Regulatory oversight provided legitimacy to the ESI business. Scale-economies provided by technology also meant that ESIs could grow unlimitedly. What was required was only the corresponding growth in customer base to increase demand. In order to promote demand and customer base, Insull sought the permission of regulatory authorities to allow ESIs to exercise price discrimination between consumers on the basis of value-of-service. This request for change was met with opposition from economists of the time, manufacturers of equipment for IFs, and eminent independent observers like Louis D Brandeis (1856-1941) – an associate justice on the Supreme Court of US who had come in defence of the manufacturers of IFs plants. Brandeis asserted that price differential based solely on characteristics of demand was illegal (Neufeld 1987, Faruqui and Eakin 2012). Economists

James C Bonbright and Ralph K Davidson argued that rate-differentials developed on the basis of value-of-service were no different from monopolistic pricing; they also objected to promotional pricing strategies of selling electricity below cost to promote growth of demand (they argued that such pricing strategies will cause wastage of resources and also will entail social inequity). Both these economists argued for a rate structure that would correctly reflect costs, they recommended time-of-day pricing as this would correctly reflect costs and will be non-discriminatory (Davidson 1955, Bonbright 1961). Insull, however using his influence mobilised support from the industry trade group "National Electric Light Association (NELA)" – the forerunner of the modern Edison Electric Institute, for his demand-charge rate method for discriminating electricity price between users according to the value-of-electricity to the consumer. NELA strongly advocated value-of-service as the primary basis for structuring rates and this was accepted by the regulators (Neufeld 1987, Faruqui and Eakin 2012).

The value-of-service based rate-structure which allowed price-discrimination between consumers earned the ESIs much higher returns than the allowed 'Rate-of-Return' structure. The reducing cost feature of technology provided ESIs with reducing fixed costs and this meant a window of opportunities for growing profits as was also discussed in Chapter 1(Beder 2003).

This regulatory pricing formula (i.e., based on value of service) was attractive for equipment manufacturers as it provided them opportunities to make high profits by selling their equipment at inflated prices during periods of supply shortages (Hirsh 2002, Beder 2003). The regulatory oversight which was meant to prevent such monopoly abuses was therefore beginning to become ineffectual from about the late 1910s. The regulators felt obliged to the owners of ESIs for upholding the continuance of their regulatory commissions. The 'holding company way' came in handy to claim the revenues that were in excess of allowed revenue – the excesses that came about by not sharing the benefits of scale economies with the consumers could be hidden by increasing the value of investments through reappraisals. The ESIs/holding companies could earn profits much in excess of allowed returns. Holding companies could conceal returns as high as 40%, and on occasions, these methods could conceal returns as high as 600%. These excess amounts, as was discovered by federal investigating authorities (Federal Trade Commission) were found to be close to one billion dollars in the 1930s (Buchanan 1936, Hirsh 1999, Beder 2003).

Regulatory pricing formula alongside weak upholders of regulatory obligations served investor interests in every possible way; the benefits of scale economies could be overwhelmingly reaped (as profits), by the investors; with price discrimination, the business could be expanded by sponsoring promotional pricing schemes thus enabling high profits through monopoly pricing for 'must take' consumers.

Altogether, this represented an ideal combination – a beacon for the activists of capitalistic ideology. However, this also meant that many conditions such as the extremely desirable service 'that electricity provided', a technology that could be tweaked to deliver incrementally incrementing productivities which meant continuously reducing costs (the reducing costs against the reference of price set by the Isolated Plant meant growing profits for the ESIs), a state that allowed assured market and weak regulatory framework were available as enablers to sustain this poise of ESI business.

The overwhelming business success of the investor-owned ESIs in the US also had its detractors and they represented a popular movement for public controlled power stations. While supernormal profits underpinned the rationale of the investor-owned ESIs, there were others who were seeking to raise the standard of living of people living in rural areas by providing them access to cheap electricity in increasing quantities. Gifford Pinchot, governor of Pennsylvania and his technical assistance Morris Cooke advocated a giant mine mouthed power plant that could produce cheap electricity. The objectives of this power project were to get electricity to rural areas, and also enable farmers to set up their voluntary distribution companies. Pinchot and Cooke considered the existing practice of very favourable electricity prices to rich industrial users, by charging the costs on to moderate and small users as very unjustifiable. The ESIs were however able to thwart this movement; they argued that Pinchot and Cooke's efforts were unrealistic, and followed the ways of communist world (Hughes 1993, Beder 2003).

In summary, in the US, during the period 1880-1930, electricity endeared the domestic and industrial consumer alike and the increased attractiveness of its service made electricity business prospects look very natural. Edison's incandescent lamp system competed with gas lights and centralised ESIs competed with IFs for assured markets as well as for establishing their viability during the early periods. Large scale steam turbine technology, with incrementally improving scale efficiency, offered reducing costs as well as potential for expansion of capacity, price discrimination strategies facilitated by electricity's unique technical characteristics enabled expansion of electricity demand for ESIs. Regulatory pricing scheme provided permanency of assured market, and with a weakened regulatory oversight allowed profits more than allowed rate of return. Price discrimination strategies fetched supernormal profits to ESIs, caused inequality in the society and promoted a culture that enshrined profit as the main rationale of the industry. Since electricity technologies originated in the Western World, developing countries which had to acquire technology, equipment and skills from the West found the costs of providing electricity to their citizens prohibitively expensive. This is evidenced by the fact that even today 1.4 billion people in the less developed world are without access to electricity (Dubash and Bouille 2002, WEA 2010).

3.2.2 German ESI (State-industry collaboration)

The context and the electricity pricing system

In Germany, national interests governed the determination of electricity price. The government also played an active role in promoting mutually beneficial price solutions for electricity consumers. The government recognized the need for ESIs to achieve higher capacity utilization factors and therefore allowed introduction of differential rates that will promote higher utilization factors. These differential rates spurred rapid industrialization in Germany. The structure of German ESIs was reflective of the federal structure of the country; there were three major sub-sectors: (1) ESIs that were dedicated for regional-public industrial plants; (2) ESIs that were dedicated for federal industrial plants and federal railways; and (3) ESIs that were dedicated for households and small businesses. The ownership was mixed – public and private. The German law differentiated between consumer groups by two rate structures. Households and small businesses represented one group and were subject to 'standard tariff'. The second group consisted of the so-called 'special customers', essentially large firms. Standard tariffs were significantly higher than the special tariffs (Klingenberger 1992, Hughes 1993).

In summary, the pricing system in Germany was supportive to the industrial consumers of electricity; it also supported the profitability of ESIs. This pricing system also contributed to social inequity. However, the ESIs did not reap extraordinary benefits as witnessed in the US.

3.2.3 UK ESIs (hostage to political conservatism)

The primacy of politics and conservatism shaped the evolution of the ESIs in the UK. The governing framework and administrative control of the ESIs were defined by parliamentary legislation. The 1882 legislation provided for a ceiling on prices and stipulated the condition that privately owned ESIs could be repurchased by the government after 21 years upon demand by the local authority. The 1888 Act later modified this period to 42 years. The legislation also favoured municipal ownership which, in turn, constrained the size of units and the technologies used (Hughes 1993). As a result, ESIs of this period were fragmented, and confined within the boundaries local governmental jurisdictions. They adopted small-scale technology, and because of spatial dispersion, their utilization factors were low. The franchises, to both private and municipal undertakings, protected them from competition and encouraged them to act slowly and cautiously. ESIs tended to preserve the status quo; existing profit levels with a protected local monopoly and low output were seen as more attractive. The absence of close links between equipment manufacturers and supply companies encouraged British engineers to set up differing systems and differing standards. Attempts to unify supply systems were opposed regardless of the form of ownership. Large-scale interconnected operations were opposed by political lobbying (Hughes 1993).

World War I brought to attention the inferior position of the UK in its war-preparedness, in comparison to Germany; this was attributed to the superiority of the large-scale German ESIs. The UK government consulted Insull and engaged Charles Merz (considered as ‘Edison of the UK’), a leading executive of an important ESI (Newcastle upon Tyne Electric Supply Company (NESC)), to modernize the UK ESIs. A consensus emerged to set up a ‘National Grid’ to interconnect different power plants in the country, build large scale power plants, and establish direct control over the operations of the best privately and municipally-owned power plants. The royal ascent was accorded for the formation of Central Electricity Board (CEB) in the year 1926. With the introduction of CEB, a commercial approach to management of the electricity business emerged—growth and enhanced profitability gained importance. Standardization of frequency, voltage, and phase took place (Leslie 1979, Hughes 1993).

Electricity pricing system

Electricity pricing system in the UK during this period was similar to that in the US. Hopkinson's rationale was adopted; fixed cost on the basis of consumer's load factor was justified. Gispert Kapp who was regarded as the original proponent of 'time-of-day pricing' raised questions and objections about the appropriateness of Hopkinson's rationale; he argued that pricing arrived in this manner will not add up to the cost of the peak capacity of the system. Despite Kasp's objection "Hopkinson" rate structure was widely accepted in the UK. As only lighting load prevailed in the early periods, adoption of Hopkinson rate did not create any major issue. Arthur Wright introduced, in the year 1897, a maximum demand meter, to assess the maximum demand of each consumer. With the introduction of Wright's maximum demand indicator, many ESIs began adopting Wright's system of pricing which was essentially based on Hopkinson's rationale and provided the convenience of actual measurement of maximum demand instead of estimation which was practised before its introduction.

From 1910 onwards both municipally and privately owned ESIs began selling power to factories, industries and tramways on the basis of Hopkinson's rationale. The industry consumers opposed Hopkinson-Wright tariffs on the grounds that they were, in fact, benefiting the ESIs by improving the diversity of peaks and thereby improving ESI profits. The ESIs had to relent and agree to charge lower prices when these consumers threatened to have their own captive generating equipment. However, ESIs continued to price electricity on the basis of the 'Hopkinson' rationale (Byatt 1963).

By the early 1900s, 66 percent of the UK ESIs were publicly owned; legislation limited the tenure of privately-owned ESIs. In contrast, in the US, during this period, privately owned ESIs were dominant and they campaigned against any government ownership on the ground that government-owned ESIs promoted social goals rather than produce and sell electricity efficiently. The main threat for the privately owned ESIs came from self-generation plants – the IFs (Beder 2003).

Despite the adoption of pricing system on the basis of Hopkinson rationale, the municipal-owned ESIs could supply electricity at prices nearly 30 percent lower as compared to privately-owned ESIs; the municipal-owned ESIs were not profit seeking. During this period, while there was no specific regulation, price caps did exist. However, actual prices remained well below the caps (Leslie 1979, Beder 2003).

The advent of CEB and the establishment of 132 kV transmission Grid brought significant improvements in the operation of ESIs as well as increase in electricity generating capacity. Grid interconnection vastly improved load diversity and the load factor. The reserve capacity could be reduced to 10 percent in the 1930s; it was 43 percent in 1925. Value-based pricing utilizing monopolistic price discrimination techniques emerged – similar to the US. Electricity prices tended to reduce because of the improved utilization factor, and scale-economies arising from the introduction of higher-sized new power plants. Per-capita consumption of electricity improved significantly (Leslie 1979, Hughes 1993, Beder 2003).

In summary, in the UK, during the period 1880-1930, the price of electricity was not regulated as in the US. The size of the electricity generating units were relatively small. Municipal-owned ESIs were able to supply electricity at significantly lower prices. The formation of CEB and the introduction of grid improved security, efficiency and enabled electricity price reductions. The advent of grid however, made the pricing system of electricity more commercially oriented.

3.3 The consolidation phase (1930-1965)

3.3.1 ESIs' commercial approach challenged (United States)

As was brought out in chapter 1:

Investigations into the Stock-market crash of 1929 exposed the implicitness ESI holding companies and their abuses. In the year 1935, PUHCA was passed to break up the holding companies – reintegrate the companies to ensure better scale economies and easier regulation. TVA, government-owned ESI was set up – this ESI demonstrated that government-run ESI could sell electricity at lower rates, stimulate demand and contribute to raise the standard of living of rural residents and provide electricity service to agricultural farm customers who had been ignored by investor-owned ESIs. Investor-owned ESIs survived the stock-market crash episode, due mainly to abundant availability of electricity and continuing reducing costs (provided by technology) and supportive regulators. The boom economy that followed World War II reinforced this trend.

Investor-owned ESIs maintained their tradition of taking over rival firms and during this period they resorted to taking over of municipal and rural electric cooperatives trend. ESIs also resorted to regular public campaigns to sustain public support for their industry (the expenditure towards these public campaigns was being allowed by regulatory pricing formula as prudently incurred expenses). ESIs deployed think-tanks which spread the view that the income earned by utilities in the competitive market place was being distributed by the governments to the public just as what was being done by communist countries. An impression that investor-owned ESIs were supplying electricity at rates cheaper than public/municipal-owned ESIs was being spread even though the investor-owned ESIs on average sold electricity at rates nearly 30 percent higher. ESIs during the 1960s, as brought out in chapter 1, earned a profit of 2.3 times on average over that earned by firms of all other sectors of the economy. There was no change to the electricity pricing system during this period (Hirsh 1999, Beder 2003).

3.3.2 ESIs as benefactors of society (United Kingdom)

Following the establishment of CEB and setting up of the national grid, there was a movement in the UK to spread the usage of electricity. Most of the urban residences were newly wired and most families living in urban places could use electricity. CEB also encouraged rural electrification. Domestic electricity consumption in the UK began to increase with the introduction of domestic electricity appliances such as electric cookers, electric irons, electric kettles, etc. Space and water heating began to pick up from the 1930s. The CEB found the need to increase domestic load to improve diversity of load. Electricity began to be offered at much lower prices for domestic consumption for purposes other than lighting. This approach led to improved diversity of load (Leslie 1979). The ESIs, therefore, began to expand as was happening in the US. Promotional tariffs for domestic heating became increasingly justified. Municipal-owned ESIs also realized the political appeal of low electricity prices for domestic consumers. Moreover, the municipal-owned ESIs also had the advantage of access to low cost Treasury capital, and profit was not their prime rationale (Leslie 1979).

During Second World War the ESIs faced significant problems. Coal supplies were a major constraint, and there was a general shortage of qualified staff to operate power plants (a significant number of staff were engaged in dealing with the exigencies of the War). Consequently, electricity generation had to be limited to conserve coal. Plant outages increased during the war. Productivities of power plants reduced significantly. The demand for electricity (including domestic demand), was expected to grow rapidly after the war (Leslie 1979). Sir William Jowitt (Pay Master General) was appointed in 1942 to take charge of the reconstruction of the ESIs. Jowitt's report which was released in the same year recommended nationalization of ESIs, with CEB taking over of the generating stations from the existing operating undertakings (Chick 2007).

The post-war years were marked by gloom and people yearning better life and better living conditions. The government of the time favoured nationalisation of the utilities including electric utilities. Labour party which had pledged nationalisation of ESIs was elected in 1945 with a large majority. The legislation for nationalisation of ESI was passed in 1947 and came into effect in 1948. The British Electricity Authority was established. All the municipal and private ESIs were taken over. The previous owners were compensated at the market rates (Hannah 1979, Hughes 1993, Beder 2003).

Electricity Pricing System

Introduction of CEB had ushered in a commercial approach for pricing electricity; CEB impressed upon its managers of the ESIs the importance of achieving growth and enhanced profitability. There was no direct regulation of electricity prices; ESIs were free to price electricity as they wished. Municipal-owned ESIs adopted the expansionist line – they took over the private-owned ESIs when they came in for renewal of franchise. They also lowered electricity prices to promote electricity sales. Private ESIs stuck to profit ideals; they increased electricity prices, taking advantage their monopoly position. Private ESIs were also linked to holding companies. Holding companies thrived during this period as was also the case in the US. Some US based holding companies also operated in the UK and made huge profits. Edmundsons Group an American holding company was considered the worst of the holding companies as it made huge profits and transferred them to the parent holding company. Price discrimination to take advantage of elasticity of demand resorted to by privately-owned ESIs generally kept prices high, tempered only by public opinion. Diversity of load was influenced by domestic consumption. Promotion of sale of domestic appliances, promotional pricing of electricity were resorted to (Leslie 1979, Beder 2003).

The post Second World War conditions were bad for ESIs; aerial bombings had left many power plants damaged. The nationalization of ESIs from the beginning of 1948 brought in changes in the structure and ownership. The electricity pricing system that was to be adopted post-nationalisation became a subject of debate. Economists, for example, James Meade (who was also the Director of the Cabinet in the UK Government) who was a staunch proponent of marginal principles, persuaded the government to adopt marginal-cost based approach for pricing electricity (Leslie 1979, Chick 2007). The government instead favoured average-cost based prices, with a provision to cross-subsidise in favour of domestic and rural consumers. This was based on the Jowitt Committee report released in August 1942, which recommended that electricity be treated as a basic necessity similar to water and sewage service. The Energy department of the government preferred a centralised organisation to facilitate cross-subsidisation in favour of domestic consumers. However, the Treasury department prevailed and split the ESI structure in two: generation and bulk supply transmission which was entrusted to Central Electricity Generating Board (CEGB) and sales and distribution which was entrusted to Regional Electricity Boards. CEGB fixed the Bulk Supply Tariff (BST) and the area boards set their own area tariffs. The BST was split from area tariffs which resulted in the non-reflection of generation costs to the customers (Chick 2007).

Between the years 1948 and 1958, the domestic consumer base increased from 9.7 million to 14.3 million. The initial track record of nationalized of ESI was one of success. Over the period 1948-1971 the ESI registered an accumulated profit of £783 million (Leslie 1979). During this period, electricity prices continually declined (can be seen in Figure 1-7).

In summary, electricity pricing during this period became more commercially oriented. Municipally-owned ESIs focused on expansions supported by lower prices, their private counter parts focused exclusively on profit. The UK holding companies made supernormal profits like in those in the US. The UK ESIs resorted to value-based pricing as was done by investor-owned ESIs in the US.

3.3.3 ESIs as revitaliser of economy (France)

The political mood during the late 1940s, in the war devastated France, was one of seeking national security and economic modernization. The centrality of electricity to the modernization of French industry was considered paramount. The Marshall Plan, that was initiated by the U.S to provide recovery to the war impacted countries of Europe, provided most of the funds for the modernization of the French electricity industry (Chick 2007).

The French Franc had lost 99 percent of its value relative to the dollar during the period 1914-1959. The fixed charges for electricity had not been changed since the year 1935; the price level and price structure of electricity were untenable (Nelson 1964). In order to repay the loans taken under the Marshall Plan to build new high-fixed cost plants, French economists favoured marginal-cost based pricing of electricity. The government, recognizing the acute financial condition of the ESIs, decided to nationalize and engage the services of the most eminent economists to set the ESI on track to stoke the economy back to health.

The French ESIs were nationalized in 1946, and brought under the umbrella of a single entity, namely EDF. The nationalized ESI was placed under the stewardship of Gabriel Dessus, an eminent tariff designer and advocate of marginal principles. Marcel Boiteux, another advocate of marginal principles, working under Dessus, went on to devise a very pragmatic marginal-cost based tariff known as the *Tarif Vert* for EDF in 1956.

Tarif-Vert comprised a schedule of electricity rates, as well as policy guidelines for investments in EDF on the basis of marginal-cost based pricing. The first version of *Green Tarif* derived from *Tarif-Vert* was introduced in 1958 exclusively for industrial customers (Chick 2007).

In post-war France, electricity demand rose rapidly and several new power plants, funded by the Marshall Scheme came into operation. The imperative to industrialize and modernize the French economy necessitated favourable electricity price for industry users, which was achieved through cross-subsidization, from residential users, to the industry users. Average electricity prices in France were very low during this as much of the electricity came from hydroelectric power plants and the French currency had undergone devaluation. The upcoming new power plants were much higher in costs and the marginal cost of electricity was significantly higher than the average electricity price. The annual investment costs of EDF were around 5.5 percent of the national investment during this period (Nelson 1964).

Boiteux favoured of applying marginal principles for pricing electricity; he was of the strong belief that this type of pricing system will make the society to appreciate the cost while choosing to increase electricity consumption and recognize the advantages to the economy when electricity consumption is reduced. Boiteux published a paper on peak-load pricing theory in which he provided an understanding of the notions he developed to make marginal cost based pricing address the fixed cost issue of electricity pricing; this work of his is singular and widely acclaimed.

Marginal costs, strictly defined, represent the cost of the next unit produced. This interpretation creates the impression that, in the context of ESIs, marginal costs exclude all fixed charges. But prices must equal marginal cost for price to reflect accurately the cost of producing that additional unit of output and to provide an accurate resource signal to the consumers. Though this sounded paradoxical, Boiteux asserted that under conditions of perfect competition, with sale at marginal cost of the marginal firm, maximization of profit and budgetary equilibrium are achievable. He insisted that application of marginal principles to industries with high fixed costs involves a certain amount of abstraction and requires understanding of additional notions such as differential cost, partial operating cost, and development cost.

Boiteux provided examples of cost of electricity transmission service to explain about the notion of optimum capacity, and about how the fixed costs of transmission system could be covered while preserving the marginalistic features of pricing. Transmission services, he held, could be sold at a price equal to the cost of losses while transmitting the marginal kW.

To explain this rationale, he considered two cases of sale (1) in a lightly loaded transmission line, and another (2) in an inadequate transmission line.

In the case of lightly loaded transmission line marginal losses are low – sale at marginal cost will recover more than total losses; however, it will not be sufficient to recover the fixed charges of the line. In the case where the line is inadequate, marginal losses will be considerable, marginal cost of transmission will be very high – the sale of transmission services will insure receipts that will be much higher than the total cost of losses and of fixed charges of line as well (Nelson 1964).

Sale at marginal cost involves deficits when the firm is over-equipped relative to demand, but it is profitable when the enterprise is under-equipped. When capacity is optimum, sale at marginal cost of the service rendered by the marginal plant exactly covers the costs of this marginal equipment, so that sale at marginal cost is equivalent to sale at average cost of the marginal plant (Boiteux 1960).

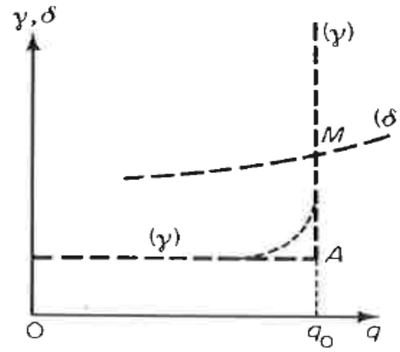
Boiteux extended his concepts of transmission services to electricity generating units notwithstanding the fact that generating unit capacity are inelastic – they cannot be overloaded as in the case of transmission lines.

Boiteux therefore introduced more concepts for explaining the case of bringing fixed cost of generator units into the gamut of marginal cost principles by considering an example of constant load and single unit.

These concepts included: 1) *Differential cost* – the rate of variation of total expenditure with output; 2) *Optimal Capacity* – the designed capacity of the generating plant when the performance is optimal, which in the case of generating plants is the maximum capacity of the generating unit (electricity generating plants are optimised at their maximum capacity to achieve maximum benefits; they strive to achieve maximum utilisation) and 3) *Development cost* – the total development cost per unit of output.

At *optimised condition*, *differential cost* and *development cost* become equal – *differential cost* pricing not only covers working but also that of plant assessed at its *development cost*. Put differently, *development costs* are fix rates equivalent to what the differential costs would be if the plant were constantly at correct capacity (optimized capacity). The above concepts have been illustrated in the figures 3-4 and 3-5.

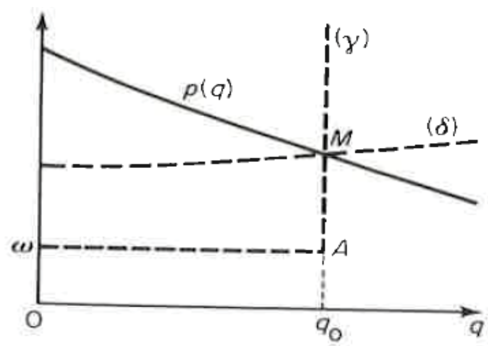
Figure 3-4 Rigid Plant



Source: Boiteux (1960)

Symbol	Description
γ	Differential cost
ω	Partial operating cost
δ	Development cost
q0	Optimum capacity
0- q	Capacity
p(q)	Demand Curve

Figure 3-5 Development cost



Source: Boiteux (1960)

Boiteux illustrated the relationships between partial operating cost, differential cost, development cost, optimum capacity, and demand through curves taking the example of a rigid plant. The cardinal principle was that each demand must pay for its relevant energy cost and the peak demand must absorb the complete plant's costs. He argued that when *capacity is at its optimum*, sale at marginal price for the service rendered by the marginal plant exactly covers the costs of this marginal equipment, implying sale at marginal cost is equivalent to sale at average cost of the marginal plant. Differential cost and development costs are equal – differential cost covers both running costs (energy costs) as well as the plant cost assessed at its development cost (Boiteux 1960).

The cost per unit time of *a slight permanent overloading* of the plant is then equal to the cost per unit time of adapting the plant to the new permanent output (as industrial power plants are very rigid – the option of overloading does not exist – hence there is no question of equating the development cost to the cost of over-loading the plant). Plants could be perfectly adapted to the quantity demanded, modified in step with demand, so that optimum capacity is constantly maintained for the load demanded.

For a rigid capacity plant working slightly under its maximum rating, the differential cost is always less than the total average cost. Plant development is only justified when demand reaches the point M, that is to say, when the differential rate also pays for this development.

Boiteux also provided guidelines for determining the optimum plant capacity, the pricing policy which can help to improve the utilization of ESI capacity under differing intermittent load conditions based on marginal principles.

When the daily load is intermittent (say, at two levels x and y), the optimum capacity is defined by the condition that will minimize the sum of the expenditure due to x and y. This is achieved by pricing each demand period at its differential cost. Arithmetical mean of the prices so fixed should be equal to the development cost. If it is not, the plant should be modified.

Pricing policy should aim to make the collective load curve take the form of producible energy, without allowing price to fall below the marginal cost. Electricity rates should be high enough at the times when consumption would tend to rise above the level of capacity, so as to bring the corresponding portion of the curve down the optimum capacity of the plant. Low rates should be encouraged to fill in any dips of load below the plant capacity, and when level of load picks up enough higher rates will be charged to peg the consumption.

Green Tariff introduced by Boiteux for industrial customers provided a dual incentive to reduce peak consumption: (1) fixed charge reductions was offered to consumers that subscribe to a higher level of maximum demand during other than peak times; (2) (the other) was actually a disincentive by way of an increased kWh rate for discouraging usage at peak times. EDF claimed that significant flattening of the load curve was achieved after the introduction of Green Tariff. It was estimated that EDF saved a quarter of a billion dollars through its tariff structure in capacity costs alone (Nelson 1964).

Universal Tariff was introduced by the EDF in the year 1965. This tariff was applied to domestic and commercial customers. The principles of this tariff are similar to Green Tariff, but the characteristics of this customer group necessitated imposing certain variations to make it workable. This tariff was of two types: (1) tariff, called 'simple tariff' did not incorporate time-of-day or seasonal differentials – this was meant to serve small scale consumers like residential users, and (2) 'double tariff'; provided the features of time-of-day tariff as well as had provision to meter the night consumption separately for which charges were very low. Additionally, this tariff also provided for varying rates for energy charges based on season. To enable such facilities, separate metering arrangements were provided for separate charges which were levied (Nelson 1964).

Boiteux had his own views about tariffs that were based on *value-of-service*. He was particularly critical of the version of tariff which favoured domestic consumers. Boiteux was against selling above cost to those who are able to pay, in order to sell at a loss to those who cannot repay production costs; according to him, this served egalitarian causes and was populistic. Boiteux however, was not against investor-owned ESIs seeking monopoly profits by charging on the 'value-of-service' principles (Nelson 1964).

Boiteux successfully introduced economic discipline in the management of EDF. EDF generally remained in good financial health, and the government provided considerable commercial freedom to EDF, while setting limits on the tariff increases. EDF showed improving trends in TFP; TFP increased from 3.08 in 1960-79, to 4.17 percent in 1979-89.

Marginal approach also contributed to a shift from coal to oil when Middle-East supplied at lower prices. France shifted its fuel base from coal to oil when the prices went lower. This resulted in fuel poverty and increased fuel dependency. This, together with the price increases following the Middle-East oil crises, provided the backdrop for the decisive shift towards nuclear power from mid-1970s.

Higher prices arising from the marginal approach led to relatively lower per-capita domestic consumption – the ratio of domestic to industry price in France was over 2.3, as compared to 1.16 in Britain, 1.65 in West Germany and 1.83 in the U.S around the late 1960s (Chick 2007).

Summary for the period (1930s-1960s)

The period from 1930s to mid-1960s represented a period of consolidation of investor-owned ESIs in the US. There was a brief uprising against the investor-owned ESIs, and a push for the introduction of publicly owned/controlled ESIs in the US with an objective of providing affordable prices to the rural and vulnerable consumers. This push was however met with stiff opposition from the investor-owned ESIs. In response, they resorted to a publicity campaign against such moves by deploying think-tanks and magazines with far-right ideologies; they considered support for public ownership as an indication of the emergence of socialistic/communistic leanings. After the war, most of the European countries nationalized their industries with a view to reinvigorate their economies. While the UK favoured a pricing system that would enable affordability of electricity to the less privileged and rural section of the society, France preferred a marginal-cost based pricing system which served to favour industrial growth. France succeeded in establishing EDF despite the capital intensiveness of ESI and high funding costs, but this was, by making the vulnerable consumers to bear the financial burden. The UK led by Jowitt report nationalized ESIs and favoured an electricity pricing system that allowed cross-subsidization from industrial users to the not so privileged and rural consumers. In the UK, before nationalization, the municipal owned ESIs provided electricity at prices that were around 30 percent lower than the prices that were charged by privately owned ESIs. Privately owned ESIs and holding companies, like in the US, made phenomenal profits post installation of national grid in the UK, by resorting to value based pricing; the scale of profits in the UK were however still significantly lower as compared to that of the US.

3.4 The inflection phase (mid1960s-1980s)

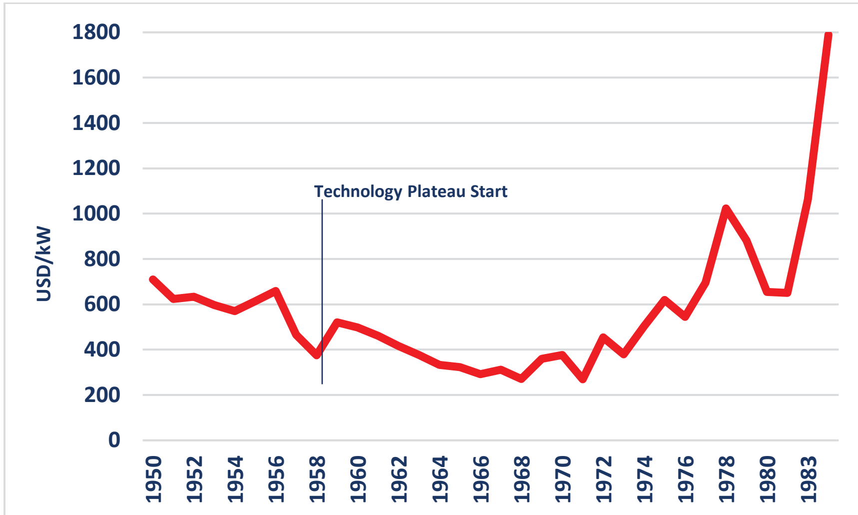
3.4.1 PURPA and its impacts (United States)

The poise and stability of the investor owned ESIs in the US was contingent upon their ability to sustain growth of demand and decreasing costs. Decreasing costs were contingent upon technology providing a perennial incrementally reducing factor costs and stable macroeconomic conditions. Growth of demand was contingent upon an unchanging structure of the economy and reducing factor costs (Hirsh 1999).

Beginning mid-1950s, incrementally improving productivity features provided by technology began to plateau. Fuel-efficiency plateauing was the first to occur – though this phenomenon began from the early 1950s, it began to show up as an increasing factor cost only from the 1960s; a declining fuel price trend occurring during this time masked the onset. The scale economies of steam turbine technology continued till the mid-1960s. As the nuclear technology could offer better scale-economies, ESIs switched to building nuclear power plants (Hirsh 1999, Hirsh 2002). The "Three Mile Island" accident and rising environmental activism however dampened this enthusiasm for nuclear, and with it any further possibilities of scale-economies (Beder 2003). In addition to the plateauing technological productivity, the macroeconomic conditions worsened during the 1970s. The Korean and Vietnam Wars, as well as aggressive welfare policies of the Johnson years caused unprecedented hyperinflation. Middle-East oil shocks produced oil prices, and caused ripple effects for other fuel prices as well (Hirsh 2002). The increased energy price and worsening economic conditions contributed to stagflation in the US economy. The onset of plateauing of industrial electricity consumption can be seen in Figure 3-7 below. Environmental activism of the times, resulted in stricter environmental norms for the ESIs, contributing to reduced efficiencies and delays in project construction, and big implications of significantly increasing costs (Hirsh 1999).

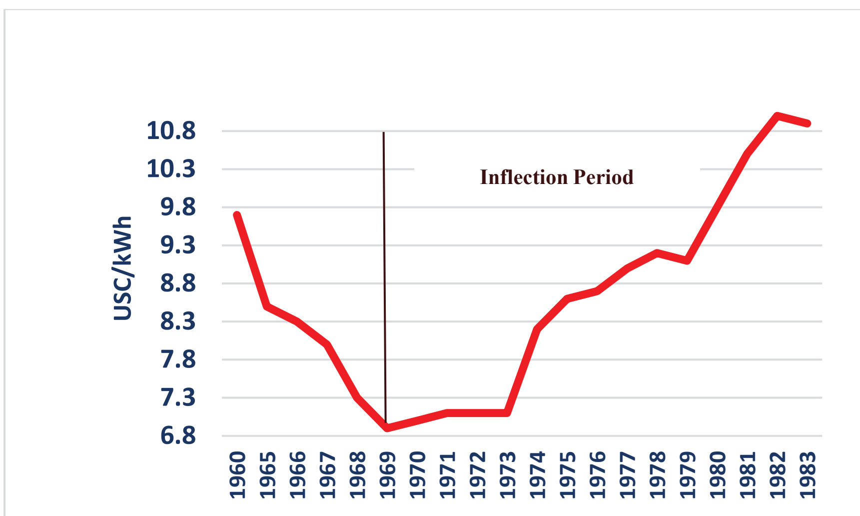
The confluence of hyper-inflation, environmental activism and Middle-East oil crises meant increased factor costs for ESIs. This, together with the plateauing of scale economies constituted a turning point in the history of ESIs when the ever-declining cost of producing electricity reversed trends and began to increase instead. The ESIs and equipment manufacturers, in order to deal with this challenge, and to continue to benefit from sudden surge of demand (see Fig 3.8) that occurred during this period, resorted to a short-sighted approach – of manufacturing new scaled-up units, by geometrical extrapolation, without scientific design verifications. This caused serious problems for the ESIs, resulting in costly outages and losses on account of unfulfilled demand. Further, the electricity equipment manufacturers took advantage of the demand rush and priced their equipment on an opportunistic basis (see Figure 3-6). Consequently, electricity prices nearly doubled during the period from the late 1960s to the late 1970s (see Figure 3-7).

Figure 3-6 Electricity Plant Cost (Steam Technology) (US)



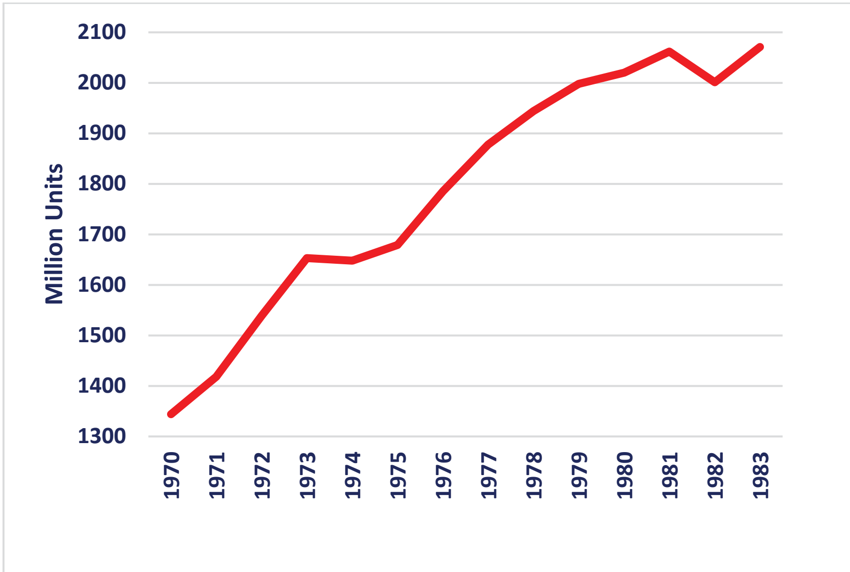
Source: FPC (1964)

Figure 3-7 Average retail electricity price (US)



Source: EIA (2011)

Figure 3-8 Changes to electricity consumption (US)



Source: (EIA 2011)

The sharply increasing electricity prices, and the unresponsiveness of ESIs to environmental issues, united disparate and disenchanted environmental activists. They began to mobilize public opinion against the ESIs. The ESIs, bereft of the technological prowess and overwhelmed by rising factor costs, suddenly came under public scrutiny. The consumers, with the active support of the environmentalists, set up establishments such as the "Citizens' utility boards." Consumer groups strongly rallied against capital expansion projects.

The economists in the US were also intrigued by the unprecedented electricity price increases. Serious concerns about the appropriateness of regulatory form of pricing emerged. Eminent economists like Horace Gray and William Demestz, began to question the rationale of regulatory pricing and the natural monopoly status of ESIs (Hirsh 1999). Averch and Johnson (Averch and Leland 1962) insisted that rate-of-regulation (adopted by ESIs in the U.S) incentivised inefficiencies. Alfred Kahn, a Cornell University Professor, and a strong proponent of marginal principles and marginal cost based pricing was highly critical of the prevailing regulatory electricity pricing. Kahn (1970), criticised the regulatory pricing system for encouraging price discrimination methods that only served to promote capacity growth and supernormal profits for the ESIs. Kahn, an avid admirer of the French electricity tariff system, *Tarif Vert*, (based on marginal principles), campaigned the adoption of similar pricing system in the US.

As the ESIs suddenly became encumbered with problems from all around, the regulators who had always looked upon the ESIs with admiration for their ability to keep electricity prices on the decline, now turned their backs to ESIs as they were faced with the unpleasant task of approving the price increases sought by the ESIs.

The Carter administration, in response to the energy crisis of 1973, began to engage in formulating a national energy policy to prevent such vulnerabilities and regain control over their country's economic future. In the year 1977, President Carter announced a national energy plan that emphasised energy conservation, a rate structure for electricity based on marginal principles, and encouragement of more efficient alternative electricity generation technologies utilizing renewable resources and other non-conventional resources. This was followed by the passage of the Public Utility Regulatory Policies Act (PURPA) in the year 1978. PURPA was the first major electricity reform to be introduced in the US (Hirsh 1999).

PURPA emphasised conservation of energy, marginal-cost pricing of electricity for rate-reform, and eliminated 'promotional rate structure' (which incentivised higher rate of consumption).

Section 210 of PURPA provided major encouragement (through a promotional pricing system) to non-traditional generation technologies. It also envisioned strict eligibility criteria (in the form of efficiency norms and fuel types) for the electricity generating companies to receive PURPA support. PURPA Qualified Facilities (QF) also known as Independent Power Producers (IPP) were entitled to (1) access to grid and guaranteed market for their electricity; (2) a generous pricing approach for the QF/IPP based on 'marginal avoided cost' principle (i.e., cost avoided by the incumbent ESI); (3) exemption by the Federal Energy Regulatory Commission (FERC), from laws and regulation that burdened the ESIs- this enabled QFs to avail low-cost project financing schemes (Hirsh 1999). PURPA was a watershed for the IPPs. In the early 1980s, regulators of California introduced more innovative methods, such as 'standard offers' – these provided the IPPs a generous pricing scheme known as long-run avoided costs that extended benefits over longer periods. This pricing scheme extended liberal estimations of capital and fuel costs of plants into distant future.

PURPA thus provided a very generous environment for manufacturing companies and IPPs to engage in ushering new technologies that are cost-efficient and serve as a superior alternative to the traditional ESIs (Hirsh 1999).

Some of the manufacturing companies embarked upon producing gas turbines with higher efficiencies. A breed of relatively cheaper (capital cost) "aero-derivative" gas turbines with an efficiency rating above 34 % began to be manufactured in the early 1990s. Manufacturers provided heat recovery generators, which enabled efficiencies to reach levels above 40%, even as high as 52% in some cases. These plants operated on natural gas, which was not an allowed fuel at the time of PURPA enactment. In the year 1987, the Fuel Use Act was repealed, which enabled the use of gas for electricity production. During the early 1990s, gas prices went low enough and IPPs began to introduce the Combine Cycle Gas Turbine cogeneration plants. This introduction was met with great success. IPPs greatly benefitted from the generous pricing, assured markets and innovative financing scheme for their projects. Many of these IPPs accrued supernormal profits. Realizing that supernormal profits could be made under PURPA rules, some ESIs created 'QF-subsidiaries' to take advantage of the provisions of PURPA (Hirsh 1999).

PURPA's emphasis on energy conservation also challenged conventional thinking that economic prosperity depends upon increasing energy usage. Proponents of energy conservation (David Freeman, Amory Lovins, Roger Sant, Arthur Rosenfield) campaigned for energy conservation. They argued that by curbing the acceleration of demand, the need to build expensive new power plants could be avoided. They made a distinction between the role of energy consumption and efficient maintenance of energy services, in ensuring standard of living and industrial output. Their initial efforts showed encouraging results, for example, industries like Union Carbide reduced energy consumption to the tune of 20 percent per unit of their finished product; in the high energy-intensive sectors, that included steel, aluminium, and chemical products, outputs increased to the tune of 20 percent while energy consumption reduced by 2.2 percent. Viewed on the whole, from a national point of view, the energy per dollar GNP came down from a level of 55,000 to 45,000 British Thermal Units (BTU) (Hirsh 1999).

The continuing efforts of conservation activists produced important concepts of energy conservation: (1) energy conservation techniques involving efficient utilization of energy, broadly termed as 'Energy Efficiency' evolved into a concept termed as DSM; (2) DSM subsequently, metamorphosed to becoming part of 'Least-Cost Planning (LCP)'. LCP represented an economic concept whose primary goal was to provide energy services at lowest cost while fully complying with the goals of conservation and renewable energy strategy. LCP concept regarded customer demand as controllable and created a system wherein response to rising demand would spur installation of energy-efficient technologies in a way that would be faster than building new conventional power plants. Additionally, for dealing with increased demand, ESIs could quickly construct cogeneration and renewable energy facilities, in modestly sized increments; and (3) Integrated Resource Planning (IRP), a concept that combined the essentials of DSM and LCP and provided unique planning advantages (Hirsh 1999).

The conservation initiatives were implemented by state-owned ESIs, for example, Tennessee Valley Authority (TVA), Municipal utility Osage, Iowa, and Bonneville Power Administration (BPA) (Pacific Northwest region). The success of these initiatives prompted the regulators to encourage their uptake in other states – to meet the objectives of conservation laid out by PURPA (Hirsh 1999).

The ESIs, overwhelmed by environmental and consumer activism of the times, resorted to curtailing investment programs. Regulators feared that continued financial and regulatory constraints on the ESIs could lead to capacity shortages. They considered aggressive conservation efforts as the answer; aligning with conservation activists appeared a more plausible option. Successful regulatory activism and promotion of energy efficiency began to go hand in hand from the 1980s. Using DSM, LCP and IRP as novel tools to help resolve ESI problems, regulators gained increasing political and economic power at the expense of ESI managers (Hirsh 1999).

Over time, regulators realized that the approach of limiting rate hikes to customers and passing on of construction costs to stockholders threatened the economic wellbeing of the ESIs. Traditional regulation rewarded increased sale of power, but conservation meant reduced sales and hence loss of revenues for the ESIs. Schemes such as electric Revenue Adjustment Mechanism were conceived to overcome ESI disincentives. Conservation activists favoured continuance of regulation and advocated to the regulators to tweak rates of return to attractive levels for the ESIs – to incentivise them to aggressively implement of DSM programs (Hirsh 1999).

The economic tools provided by the conservationists for the purposes quantifying benefits from conservation efforts were deployed by some of the regulators to determine a competitive price for dispatching the vying IPPs. Some of the regulators free-market principles to determine the price at which the vying IPPs would be allowed to dispatch their generated electricity.

In summary, PURPA provided 'Marginal Avoided Cost' – a generous promotion pricing approach along with assured market for dispatch of low capital cost and low variable cost PURPA technologies as alternative to steam turbine and nuclear power technologies. Gas and wind turbine technologies that emerged as alternatives, called into question the rationale of dependence on scale-economies. Conservation techniques brought to the fore new concepts for providing electricity services more efficiently. Regulatory pricing continued, despite the PURPA-promoted marginal-avoided cost based pricing. IPPs reaped the benefits of generous pricing and assured markets. Overall, regulated prices tended to increase, to provide revenue for the implementation of energy conservation measures.

3.4.2 Economic Pricing of electricity (United Kingdom)

The Nationalized ESI (i.e., CEGB) in the UK, began conservatively, chose unit sizes based on of proven performance, in the range 30-60 MW in contrast to the US which always chose technologies at the higher end with unit sizes in the range of 300-400 MW. The CEGB initially underestimated electricity demand; economic recovery accompanied by a housing boom, consequently electricity demand increased substantially, surpassing the pace of growth of electricity supply (Surrey 1996, Hirsh 1999).

In the 1960s, the UK government embarked upon an ambitious national economic program. The ESIs, after the problems faced during the acute power shortage period, became overcautious and set rather generous capacity growth targets to meet economic growth projections. The planning margins increased from 15 percent in 1964 to around 28 percent in the mid-1970s. The ESI also opted for rapid increase in unit sizes and capacity, for example over the period 1966-1982, fifty one 500 MW units were built, and a total of 46 GW generating capacity was added (Surrey 1996).

The CEGB also faced technology issues for mostly similarly reasons as was faced by the ESIs in the US. The nationalistic approach adopted by the political governments by successive governments promoted indigenous electricity generating equipment, indigenous coal, and indigenously developed nuclear technology. The government segregated the equipment manufacturing industry to generate competition. The presence of too many manufacturers, and absence of turnkey contractors, prompted the CEGB to take up the role of technology coordination, construction engineering and plant civil designs (Surrey 1996).

Indigenisation of design, manufacture and construction did not augur well with the rapid capacity addition program. Serious design faults of large size boilers, large size generators and Magnox and Advanced Gas-cooled Reactor (AGR) nuclear technologies bogged the CEGB. Step-jump increases in set sizes, with little time to incorporate learning from earlier operation, led to reduced availability and delays in plant commissioning and huge losses. The optimistic of electricity demand forecasts led to substantial surplus capacity despite delays in plant commissioning. From 1970 the growth in electricity demand fell sharply, due to substantial structural changes in the UK economy, away from heavy industry, and rapid market penetration of natural gas. Consequently, CEGB's reserve margin increased from 21% in 1970-71 to 42% in the period 1973-76 (Surrey 1996).

Review of changes to pricing system

The accelerated growth of electricity of capacity from the 1960s resulted in the manufacturing of highly unreliable large-scale units. The CEGB from around the mid-1970s, began to face huge cost overruns and huge losses following introduction of unreliable large size units. As was the case in the US, the economists in the UK (Ronal Edwards, Professor of Economics at the London School of Economics) began to vehemently advocate electricity pricing on the basis of marginal principles (Surrey 1996).

The successive UK governments applied varying degrees of financial controls over the industry. In 1961, government introduced a range of financial objectives and set financial targets for the ESI. These targets were increased on regular basis by successive governments. In 1967, a test discount rate was introduced to apply on all new project investments. This was set 8 percent real in 1967 and raised to 10 percent real in 1969. Government also stipulated that pricing policies should be based on long-run marginal costs (LRMC). Increased revenue requirements for the ESI obviously meant increased electricity prices to consumers (see Figure 1-7). Marginal pricing progressively made domestic electricity significantly pricier in comparison to what was being charged to industry and large users.

During the Thatcher years financial controls over CEGB became significantly stricter; performance targets and ad hoc audits were introduced to rein the industry. A 1.7 per cent rate of return target set in the 1980s rose to a level of 4.9 per cent by 1989.

UK Treasury department recommended for CEGB economic pricing principles – these sought high increases in electricity prices to catch up with inflation as well as the LRMCs. As LRMCs were difficult to determine, increasingly the prices were set to increase the pace of debt repayment. Government introduced the concept of 'the external financing limit' (EFL). Negative EFL was the public-sector equivalent of a dividend for an industry with no outstanding debt.

From the early 1980s there was increased pressure from the governments to meet more demanding financial targets – CEGB was brought under pressure to liquidate its debt that stood at UKP 4.3 billion during 1983/84 by year 1988/89 (Surrey 1996).

Nigel Lawson, Secretary of State for Energy in Thatcher's government, a key architect and advocate of privatization, was highly critical of the nationalized ESI. In a move to liberalize the vertically integrated ESI, Lawson secured the passage of "The Energy Act of 1983". This law allowed private producers to sell electricity to consumers through the Area Boards. Though this act had objectives like that of PURPA of the US, it did not, like PURPA provide the generous support for the private producers. This act therefore did not lead to any significant results (Pearson 2012).

The UK government thereafter increased pressure on the management of ESI, by for example introducing performance targets for reducing generation costs; this was set at 4.25% over two financial years (1983/84-1984/85) and by 6.1% for financial year 1987/88. CEGB was subjected to ad hoc audits by Monopolies and Mergers Commission, and annual performance reviews by various government departments. All the above actions resulted in reduction of electricity generating costs, but the high financial targets meant higher and higher electricity prices much to the detriment of the most vulnerable section of the society.

In summary, the objectives of nationalization following the Second World War was to expand electricity supply capacity; provide affordable electricity to the vulnerable sections of the society and help economic recovery of the country. The performance of the ESIs during the first two decades was generally good – access to electricity, affordable rates to the vulnerable section of society increased significantly. However, during the period of accelerated demand, and in accord with the policy to promote the use of indigenous electricity equipment and coal, the ESI experienced serious design flaws, construction delays, forced outages and huge financial losses. Successive governments however, enforced strict financial targets to recover not only the losses but also to gain handsome returns. The electricity pricing system, that began as average-cost-based, switched to marginal-cost based, from the late 1960s. The Thatcher government, with antipathy for public ownership exerted considerable pressure on the management for reducing generation costs and making them accountable for the losses that had taken place on during the period of accelerated capacity addition in accord with indigenous policies imposed by the government. Though the ESI remained under public ownership, progressively pricing system changed to a radicalised form of marginal-cost based pricing.

3.4.3 Economic pricing of Electricity (Australia)

The ESIs came under the ownership of the State Governments during the period 1930-1950. Electricity supply in Australia during the 1960s and 1970s was the responsibility of the state governments. ESIs belonging to Victoria and New South Wales faced technological problems as was experienced by the ESIs of the UK and the US (Beder 2003).

Anticipating a mineral boom, in the early 1980s, encouraged various stand expand their capacity. The Commonwealth government also approved a new category of borrowings for the states, to support the states with funds at low rates for building infrastructure. The State ESIs consequently embarked on ambitious expansion programs (Beder 2003, Booth and Booth 2003).

The NSW ESI, till year 1970, had a stable performance, with electricity prices declining at the rate of 4 percent. The launching of accelerated capacity addition program changed this all too-good status. Project Liddell comprising of four 500MW units was overtaken by problems right from the inception – all the units of this project were affected by a fundamental design problem relating to its electrical generators. The failure of this station to take off had serious consequential problems; electricity prices rose by over 43 % in 1982 owing to electricity shortages, the state was forced to invest huge sums of money for setting up alternative power plants (Beder 2003).

Investigations following this debacle revealed that the ESI of NSW, besides project Liddell, had multitudes of other problems – many newly constructed power stations had serious availability issues; also, as the expected mineral boom did not take place the NSW ESI was burdened with an almost 70 percent excess capacity. The poor availability of the power plants was traced to a general pattern of the policy followed in Australia to source its electricity generating equipment from manufacturers in the UK. These equipment that were manufactured in the UK during that period was unreliable (Booth and Booth 2003).

Victoria was the bellwether state that influenced electrification in Australia. Attempts to grow at a rapid rate from the early 1960s caused continuous problems for this ESI. Higher sized units that were built to go along with brown coal had serious boiler operational problems and resulted in very poor availabilities. Selection of wrong fuel types, overdesigned equipment also resulted in higher costs. Building a 500 MW (Newport power plant) based steam-turbine technology utilising natural gas in the 1970s was a major controversy – inordinate delays, high costs and wasteful burning of natural gas were glaring.

ESI of Victoria like NSW also went for accelerated capacity additions in the 1980s. Loy Yang A was completed with 4 X 500 MW units and Loy Yang B was completed with 2 X 500 MW units. Both these power projects had significant cost overruns. Loy Yang B Power station had resulted in cost overruns to the tune of AUD 2,800 million, as well as discontinuance of partially built power plant comprising 2X660 MW at Mt Piper which could have substituted the power that was to be generated by the Loy Yang B Power Station in Victoria (Beder 2003, Booth and Booth 2003).

Review of electricity pricing

Review of electricity prices (see figures 1-8 to 1-11) during the 1980s clearly show significant increase in electricity prices in Victoria, NSW and South Australia. The reasons are attributable to the flawed procurement and project implementation that occurred while implementing accelerated capacity addition programs intended to meet the requirements of a purported mining boom. Heavy financial losses occurred on account of long-drawn outages, and poor availabilities. In addition to these problems the ESIs were trapped with excess capacity margins as the intended mining boom did not take place. Australia followed the footsteps of UK in handling the cost overruns and financial losses. The government of Victoria and New South Wales introduced stringent financial controls and conducted frequent management audits. The pricing system as was the case in the UK was changed to be based on marginal principles. The strict financial targets set by the governments led to significant increase in prices of electricity. This was very prominent in the State of Victoria. Introduction of marginal principles led to the less affordable section taking the brunt of the price of electricity price increases.

The ESIs were subject to management and performance audits by the Industries Commission. ESIs were brought under pressure to reduce costs. ESIs responded and brought in significant reduction in costs. The ESIs were corporatized, unbundled into three segments generation, transmission and distribution.

3.5 Summary

This chapter analysed the electricity pricing systems in the different phases of evolution of the industry. The objective was to determine to what extent the underlying philosophies aligned with the canons of equity and justness within an economic framework. The main findings are summarised below.

***Formative Phase* (1880 – 1930)**

The evolution and consolidation of ESIs largely took place in the US, closely followed by Germany. Electricity pricing systems played a significant role in shaping this evolution. Traditional governments in other developed parts of the world more specifically in Europe prevented the upsurge of this industry – the industry structure remained small-scale in these countries.

- ESIs evolved as a provider of electric light service by overcoming the price challenge posed by the gas light – through more efficient electric bulbs. The cost of production of electric power by IFs was the next price challenge for the ESIs which also served as its benchmark price for a long period.
- To overcome this price challenge, ESIs ingeniously chose large-scale and large-area technology that had large productivity potential. They strategically allowed productivities to be incrementally released, bestowing the industry with a declining cost prowess for over a hundred years. Technology bequeathed capital intensiveness to the ESIs. Electricity became entrenched as driver of the economy and raised living standards.
- Cyclical nature of electricity demand made the capital utilisation of the industry distinctly lower than other comparable industries. Investor-owned ESIs converted this challenge into an

opportunity. Price discrimination based on value-of-service in conjunction with diverse customer base helped to achieve improved load factors, reduced costs; essentiality of electricity, incrementally improving productivity trends produced perennial profit stream and an expansive growth trajectory.

- With support from Progressive reformers, the industry could forge a regulatory pricing framework that allowed sound economic base and a credible return for the capital base and a natural monopoly status.
- Large-scale and large-area technology implied high capital intensity which in turn ensured high returns under a regulatory pricing regime; eventually this industry became a classic case of Averch Johnson syndrome. Equipment manufacturers, for their part also skimmed a part of this cream by increasing their profit margins.
- The regulatory model of pricing also enabled manipulation of prices (at less than cost) to generate demands even during peak periods compromising allocative efficiencies. Price-discrimination between consumers based on value-of-service provided excessive revenues.
- Industry engaged in financial innovations to legitimise excess revenues. The potential for price discrimination earned the investors supernormal profits – electricity industry became iconic for its profit potential. In the process, considerations of equity and fairness were compromised. Weak regulation and vulnerability of electricity entrenched price discrimination strategies.
- ESIs in the US, thus became the fastest growing, most profitable, and the most capital-intensive of all industries, vindicating mainstream economic thinking of the time.

***Consolidation Phase* (1930 – 1965)**

War imperatives had the effect of breaking the crust of conservatism in the UK. Reorganisation of the ESI was recognised and the Electricity Act of 1926 was the first major step to reform this industry. This phase witnessed the spreading of large-scale and large-area technology on a worldwide scale, more specifically in the industrialised western countries. World War I also had heightened the need for greater supply of electricity in the US and Germany – this had led these countries to unleash technology advancement in quantum leaps; larger sized units and larger area transmission systems were built. The 1929 Wall Street crash implicated the US ESIs for their holding company abuses. The PUHCA was legislated to rein in the ESIs. A departure from economic approach to pricing of electricity was attempted in the US to provide affordable electricity to rural consumers – government owned ESI of the like of TVA emerged. Post Second World War witnessed nationalisation of the ESIs in the UK and other European countries. The gloom of war had set a resolve in these countries to resurrect their economies and nationalisation of the ESIs was considered paramount. Post-nationalisation electricity pricing system was shaped by the political ideology of the government in power.

- The Electricity Act of 1926 led to the formation of CEB in the UK. CEB provided the national grid and encouraged the setting up of large sized power plants. This consolidation led to improved performance of both the municipal as well as investor owned ESIs. Improved load factors reduced generation costs and provided the profit potential for the ESIs. From this time on commercialisation of electricity sale began to show up in the UK. Electricity pricing systems was not regulated by the state; they evolved according to the vested interests of the ownership – municipal ESIs favoured lower prices and increased sale whereas investor-owned ESIs resorted to value-of-service based pricing to enhance their profits. Municipally-owned ESIs lowered electricity prices to enlarge sale and favour domestic users; privately owned-ESIs priced electricity for profit. Value-based pricing utilizing monopolistic price discrimination practices began to increase from post 1930s in the UK. Foreign based holding companies earned very high profits and repatriated their earnings.
- World War II brought in austerity in the usage of electricity and productivities of power plants had been impacted significantly in the UK. British government nationalized its ESIs and brought them in the fold of CEGB. Provision of electricity was considered as a basic necessity. Electricity was priced on the basis of average-cost – domestic and rural consumers were cross subsidised from industry price. This led to dramatic increase in domestic consumer base.
- Electricity assumed national importance in the war-torn France because of its centrality to industry and economic growth. Prevailing electricity prices were very low, the currency had undergone devaluation and the upcoming new plants were very capital intensive and there was a need to generate funds that could measure up to the high capacity costs and the intended growth rate of ESIs. France also was keen to promote a pricing system of electricity that would provide a favourable electricity price for its industry users as it would help its

industrial growth and economy. The adoption of pricing system based on marginal principles appeared to satisfy these conditions.

- French economist Boiteux introduced notions of *differential cost*, *optimal capacity* and *development cost* to develop a pragmatic marginal-cost based pricing system *Tarif Vert* for pricing electricity. This tariff system provided favourable prices for industrial users but peak electricity consumers were charged at high rates. French ESI, (EDF) which was nationalised adopted electricity pricing based on marginal principles right from the beginning. Relatively lower per-capita consumption by households in France was distinct and could be attributed to the adoption of the pricing system based on marginal principles. The burden of setting up the ESIs in France was borne, to a very large extent, by the household and rural consumers of electricity.

***The Inflection Phase* (1965 – 1985)**

This phase marked the end of a golden era of ESIs worldwide. ESIs transformed from a declining cost industry to a rapidly increasing cost industry; this was a major inflection point that caused serious concerns to the governments.

- In the US, stable macroeconomic conditions, continuing incrementally productivities and increasing demand for electricity ensured growing profitability for the industry up until the 1960s. Adverse macroeconomic conditions, plateauing of scalable efficiencies, increasing of all factor costs in the 1970s broke the myth of declining cost that had prevailed for over a hundred years. Environmental activism and forced outages on account of tinkering with technologies exacerbated the problems of ESIs. Electricity prices that had always been on the decline began to soar at unbelievable rates.
- Regulatory pricing system was blamed for abetting uneconomic practices. Pricing based on marginal principles was recommended claiming that this would provide the right price signals and help achieve allocative efficiency.
- Bereft of support from improving productivities, the stability of ESIs came under question. To find a way forward, the US government introduced PURPA reforms during the year 1978. This sought to introduce alternative technology that was lower in capital and variable costs, switching to renewable resources to reduce reliance on oil fuels and emphasised conservation to reduce consumption.

- PURPA introduced the notion of IFs and stipulated criteria of efficiency and technologies that must be met. It provided IFs access to grid, assured markets, generous pricing and innovative project financing schemes. It mandated electricity regulators to extend support to the energy conservation initiatives.
- PURPA was successful in introducing gas-turbine and wind-turbine technologies very rapidly as alternative to steam turbine and nuclear power technologies. IFs benefited enormously from the generous schemes of PURPA.
- Conservation of energy techniques brought into fore new concepts such as DSM, LCP and IRP for providing electricity services more efficiently. Traditional ESIs were used to introduce these initiatives for which they were compensated through higher returns. PURPA pushed up electricity prices.
- In the UK, CEGB began conservatively and projected capacity additions accordingly. These projections went awry as a housing boom occurring around the same period spurred up the demand. Failure to cope with the surge in demand depicted ESIs in a poor light. This marked beginning of a new culture, CEGB became cautious and began to keep more than generous margins in planning capacity. CEGB accelerated capacity addition programs to keep pace with the government's ambitious economic targets – generous planning margins led to overcapacity problems subsequently. Between 1966 and 1982, 46 GW of new electricity generating capacities was added comprising of large sized units that were largely unproven for reliable performance. This accelerated capacity enhancement accompanied by reliance on indigenous manufacturing capabilities as well as indigenous coal and nuclear technologies resulted in mistakes and led to major failures of generating units and heavy losses. The scale of this industry meant that outages extracted a huge cost. The situation was no different to that which occurred in the US during the 1970s and early 1980s. Even though government directed the manner of growth of ESI and its indigenisation, the blame for the failures devolved on the ESI itself.
- In order, to overcome the financial losses, and curb the capacity growth, the government, as owner of ESI decided to effect a total reversal of its pricing policies for the sector – pricing on the basis of marginal principles were introduced. Henceforth domestic consumers would pay the steepest prices shifting the burden of paying up the losses incurred by the CEGB.

- Successive governments in the UK led by their Treasury department began to apply varying degrees of financial controls over CEGB. Governments introduced electricity pricing policies based on LRMC. Innovative concepts were introduced by the conservative governments in the 1980s to extract higher revenues from the sale of electricity to accelerate the repayment of debt. They also introduced stricter administrative controls by conducting frequent technical audits to pressure ESI management to reduce generation costs.
- Australia followed the UK model. States controlled electricity supply in Australia. ESIs belonging to Victoria and New South Wales faced problems like those of UK. Accelerated electricity capacity enhancement was resorted to anticipating mineral boom. Multiple electricity generating plant failures led to serious increases in electricity prices in these states. Australia followed the footsteps of the UK in handling the cost overruns and financial losses. The governments of Victoria and New South Wales introduced stringent financial controls and conducted frequent management audits to mount pressure on the management teams to bring in reduction in operating costs.

This high-cost and high-return model was difficult to replicate in developing countries. Even today 1.4 billion people world-over have been kept out of access to electricity by virtue of this factor.

3.6 Conclusions

The diligent work of brilliance by the scientists led to harnessing this primal force of nature and ushering in of a much-improved life style and economic benefits to the human society. Notwithstanding this nobility, was the strikingly commercial nature of the US investor-owned ESIs to latch on to growing profits, by adopting strategic pricing system exploiting the vulnerabilities of electricity to price manoeuvrings.

However, overtime several factors conspired to taper off the profitability potential of ESIs. Efforts to resurrect the profitability of ESIs resulted in an ever-increasing cost and price trajectories.

Pricing based on marginal principles was a valuable accessory in the process. Equity and fairness were no longer a concern for the industry. Pricing systems assumed were predicated upon continued growth of the industry. Sporadic attempts at course correction met with limited success putting the industry firmly on a steep upward cost-curve. Electricity as a vehicle for enhancing social welfare no longer guided policies.

In this context, this thesis is an inquiry to find out if social welfare principles can once again be incorporated into the pricing schemes for the sector within an economic framework. In order to pursue this objective, this study proposes to utilise the insights gained from this chapter to examine the appropriateness of the deregulated pricing system.

4 COMPREHENSIVE REVIEW OF DEREGULATED ELECTRICITY PRICING SYSTEM

4.1 Introduction

The previous chapter demonstrated how electricity pricing strategies were vulnerable to manipulation and distortion, which would enable high profit margins for the industry. It also showed how all the pricing philosophies that have emerged underpin a sustained growth momentum for this industry. Further, it underscored the importance of continually evolving technology to bolster the profitability of ESIs, disruption of which provoked a paradigm shift in pricing approaches. It was also discussed how this disruption provoked government interventions, such as PURPA and the introduction of marginal principles in pricing, shifting the burden of higher prices to those segments of society with the least capacity to bear it. How increasing prices failed to rein in consumption was yet another aspect discussed in the previous chapter.

This chapter will describe how the strong acceptance of market-based economy, inspired by *neoliberal* philosophy, led to a movement of divestiture and deregulation of large utilities worldwide, beginning around the 1970s. It will also discuss how the success of PURPA prompted a paradigm transformation in the structure of ESIs.

Several studies have reviewed the efficacy and impact of the introduction of neoliberal market based electricity reforms. Key studies include:

Period 1994-1999:
Galal, Jones et al. (1994), Surrey (1996), Pollitt (1997), Borenstein (1999), Borenstein and Bushnell (1999).

Period 2000-2003:
Steiner (2000), Watts (2001),Borenstein (2002), Dubash and Bouille (2002), Sharma (2002), Sharma (2002rs), Beder (2003), Sharma (2003), Sharma (2003a).

Period 2004-2007:
Hattori and Tsutsui (2004), Thomas (2004),Sharma (2004), Sharma (2005), Haselip and Hilson (2005), Thomas (2006), Beder (2007).

Period 2008-2013:
Zhang, Parker et al. (2008), Pollitt (2009), Pollitt (2009a), Belyaev (2011), Plaza (2013).

This chapter departs from the existing analyses listed above, in as much as it seeks to question the appropriateness of the new pricing paradigm for an industry like electricity, which has become so fundamental to modern human society, especially because it can be co-opted by vested businesses for their own benefit.

Chapter 4 is organized in the following manner. Section 4.2 provides an outline of the context that led to the adoption of market-based reforms for the ESIs. Section 4.3 provides a review of selected works and the formulation of hypotheses to be tested to assess the impact of reforms. Section 4.4 provides the details of the econometric model, the regressand variables, the regressor variables, and includes a graphical trend check on the regressand variables. Section 4.5 discusses the results of the econometric modelling, focussing on assessing the impacts of reforms. Section 4.6 provides a summary of the chapter.

4.2 Market-based reforms – context

Monopoly structure of ESIs questioned

As discussed in chapter 1, Neoliberalism emerged as the reigning ideology in the Western World during the 1970s and 1980s. Divestiture and deregulation of utilities therefore assumed importance. The governments of the US and the UK took the lead in implementing neoliberalism-inspired market reforms. In the developing world, this movement was heralded by Augusto Pinochet of Chile.

Divestiture and deregulation of ESIs was initially not considered as a possibility, because of the strong belief that this industry was a natural monopoly, too technically complex and posed a big risk considering its vital nature for society as well as the economy (Hunt and Shuttleworth 1996, Surrey 1996, Thomas 1996, Dubash and Bouille 2002, Victor and Heller 2007). Additionally, the monopoly structure of the ESIs and the scalable efficiency features offered cost advantages which supported the continuance of the monopoly structure (Hirsh 2002).

The myth of ever-continuing scalable efficiency improvements came under question when the collaborative efforts of manufacturers and ESIs to revive the plateauing trend of this feature ended in futility (as was also discussed in chapter 1). The cost of providing electricity reversed, from decreasing to increasing, during this period. Economists Alfred Kahn, Paul Joskow, as well as Think Tanks of the likes of Heritage Foundations (US based), the Centre for Policy Studies and Adam Smith Institute (UK based), took this as an opportunity to question the applicability of natural monopoly status accorded to the ESIs by the *progressive reformers* who had upheld the public utility concept during the early twentieth century (Hirsh 1999, Beder 2003).

The successful deployment of PURPA-sponsored IPPs, utilizing low-cost combined-cycle technology that did not have the scalable efficiency feature, and using natural gas as fuel (which was cheap in the late 1980s), meant that electricity could be generated at much lower costs without the help of large-scale ESIs. The successful functioning of IPPs with access to the grid dispelled the stability concerns, and the availability of alternative low-cost technology raised the confidence among neoliberal proponents to press for the deregulation of ESIs. The rationale that generating companies could be made to compete to deliver electricity became increasingly plausible. The notion that competition would promote a spirit of innovation, with generating companies attempting to reduce cost of generation through ingenious ways and market environment enabling reduced costs to be reflected in corresponding price, gained acceptance (Joskow 1998, IEA 1999, Bacon and Besant-Jones 2001).

Though Chile was the first country to introduce electricity reform, its reform program was relatively minor compared to that of Britain where a full-fledged market-based electricity reform was introduced (Surrey 1996). The electricity reform model of Britain gained worldwide recognition and was regarded as a standard to be emulated (Surrey 1996, Thomas 1996). The proponents of this model sought for unbundling of the industry into competitive and monopoly segments. They premised that ESIs could be unbundled into four privatised businesses: generation, transmission, distribution and retail. Generation and retail segments which represent between 55 to 60 per cent of the total electricity costs were considered as suitable for subjection to competition. It was envisaged that market-based electricity pricing will emerge in the wholesale markets through competition between unbundled electricity generating companies. In the retail segment, a gradual introduction of choice in obtaining electricity from competing retailers vying to supply was proposed. The monopoly segments, transmission and distribution, were to be priced based on economic principles favoured by the economists belonging to the Austrian school, e.g., Michael Becsley and Stephen Littlechild (Thomas 1996a). A system of incentive regulation which allowed the monopoly companies to raise electricity prices at the general rate of inflation adjusted for an efficiency factor was thus considered (Surrey 1996).

This neoliberalism-inspired reform then spread to other nations. While the spread of market-based reforms in the developed countries was significantly assisted by the efforts of neoliberalism-leaning think tanks (as noted above), in the case of developing countries, which needed large funds for infrastructure development, multilateral institutions (especially the World Bank) were the major proponents of neoliberal market-based ideologies.

Electricity reforms in the United Kingdom

Business interests, jointly with leading think tanks of the time, e.g., Confederation of Business Industry (CBI), Institute of Economic Affairs (IEA), The CPS and ASI aggressively promoted the neoliberalism ideology among the important politicians, intellectuals and journalists from the 1970s. Margaret Thatcher allowed these neoliberal think tanks to significantly influence the policy agenda of the government.

The think tanks assisted the British government to make a case for privatizing the ESI. The high prospects of significant revenue from the sale of the ESI were rather attractive for the Treasury. Moreover, the government saw privatisation as a means to reduce the influence of the British coal over its electricity supply (British coal was providing nearly 80 percent of the total fuel for producing electricity). Another alluring aspect, for the grout, from selling the ESI assets, was that it will be populistic (as many shares of the privileged ESIs were to be owned by the public at large). Somewhat false impressions of the high costs and prices of electricity for the industry users were created by the think tanks to mobilise opinion in favour of privatisation. To assist this task, questions were raised about the effectiveness of the governance and operation practices. The Electricity Act of 1983, much like PURPA, was enacted to encourage private generation companies; this however did not meet with success. CEGB's lukewarm response was blamed for this debacle. Despite CEGB's reputation as an efficient entity, able to produce low-cost electricity, the think tanks blamed the CEGB for the high electricity prices, which were actually set by the government, to get better returns as well as to secure a better sale price in the event of privatisation.

To mobilise opinion against the publicly-owned CEGB, and to strengthen the case for its privatisation, the CPS published a book "Privatise Power" in which a strong case was made to privatise and deregulate the CEGB (Beder 2003).

Think tanks also argued that private ownership will help in eliminating the costs arising from the need to meet social and environmental objectives of the government, which otherwise were being passed on to the industrial and other large electricity users.

In summary, the Thatcher government introduced Electricity reforms to curb union power, gain substantial revenue for the Treasury, and to maintain a continuance of political power by adopting populistic measures (Beder 2003). The passage of the "Electricity Act, 1989" led to the privatization and deregulation of the largest ESI of the time. This was considered historic and involved a major unbundling and restructuring of the industry.

Clearly, the electricity reforms in the UK were primarily driven by political considerations. The price of electricity was strategically increased by the Thatcher government, years in advance to make the sale of the assets attractive (Surrey 1996, Beder 2003).

Electricity Reforms in the United States

Electricity Reform in the United States was not led by the government (unlike in the UK), but by the initiatives of the businesses that were affected by the high electricity prices; the case for deregulation was further strengthened by the think tanks and their ideology-motivated preference for market-based reforms. As was discussed in chapter 1, Heritage Foundations (HF), the acclaimed US neoliberal think tank, came into being in the 1970s. It played a key role, by lobbying with the federal government in promoting a neoliberal ideology, and to contribute to the development of policies that favoured business interests. These think tanks became rather active during the Reagan years; they exerted considerable influence for the deregulation of the major electricity utilities.

HF argued that deregulation will provide benefit to two business groups in particular: (1) large industry electricity users (represented by ELCON) by enabling them to broker deals with low cost electricity suppliers; and (2) IPPs, by providing them with opportunities to make even greater profits by competing with traditional ESIs (Beder 2003). HF opposed energy conservation initiatives, and the activist regulators who tried to promote these initiatives, on the grounds that they will result in increased electricity prices to the industry users.

HF continued to build these arguments in the 1980s and 1990s, until they were finally able to influence the Bush administration to enact the Energy Policy Act of 1992 (EPA 1992) - which emphasised free-market principles (Hirsh 1999, Beder 2003). The EPA 1992 also provided a reprieve from PUHCA provisions even to those IPPs which were not qualified under PURPA. This essentially meant the dilution of fiscal and thermal efficiency norms. EPA 1992 was a federal provision; its actual implementation was however the responsibility of the states.

Think tanks followed up their electricity reform efforts till a state level implementation of EPA 1992 was achieved. California, Illinois, Massachusetts, New York, Ohio, Pennsylvania, and Texas are some of the states that took the lead. California was the first state to adopt electricity reform, with the passage of the deregulation bill AB 1890, in 1996, and it adopted the UK electricity reform model.

In the United States, electricity reforms were undertaken primarily to reduce electricity prices to industry users by discouraging conservation initiatives and also for providing increased profit opportunities to the IPPs (Hirsh 1999, Dubash and Bouille 2002).

Electricity Reforms in Australia

Neoliberal ideas in Australia, like in the US, were promoted by business interests. The BCA, with membership from leading Australian business groups, played an important role in advocating for, and influencing, the Federal government to adopt privatisation and deregulation policies.

Market-based reforms in Australia began in Victoria where the government adopted similar arguments as was done in the UK. The high state debt was a major issue during the election campaign in the early 1990s. The International Credit Agencies had downgraded the Credit rating of the state. Business leaders saw this as an opportunity to seek a change of government that would uphold their business interests.

Think tanks, for example, Tasman Institute (TI) and Institute of Public Affairs (IPA) – known for their strong support for neoliberalism ideology – were engaged to formulate an initiative (*Project Victoria)* to generate strategies for winning the election (Cahill and Beder 2005, Beder 2007). The strategies involved converting business interests into government policies. Following the installation of the Kennett government, the state of Victoria went into rapid privatisation initiatives and in time became one among the most privatised regions of the world (Beder 2003, Beder 2007). A prominent such initiative was the privatisation and deregulation of the Victorian ESI – based on the argument that Victorian ESI was debt-laden to an extent of AUD 8 billion.

Like in the UK, electricity prices had been strategically increased significantly, well before the sale, to augment the commercial attractiveness of the electricity assets. The success of the UK privatisation and the ensuing profits that accrued to the private electricity businesses also had a large influence on the Victorian ESI privatization. The Victorian electricity assets fetched much higher value than estimated (Beder 2003, Beder 2007). The proceeds of the sale were many times higher than the projected debt value.

The deregulation of ESIs became a national feature in the 1990s, while South Australia also privatised its electricity assets, New South Wales and Queensland did not do so.

World Bank Neoliberal Covenants for the developing countries

By virtue of being the largest shareholder of the World Bank, the US administration was well poised to influence its policies. Debt-burdened less developed countries were forced to open their electricity sectors to foreign investments during the Reagan years (Beder 2003). The World Bank, OECD, International Monetary Fund and other multilateral funding agencies regarded the tenets of *Washington Consensus* as their important articles of faith (Beder 2003).

In the early 1990s, the World Bank made electricity reform an explicit pre-condition for continuing lending to developing countries, and sought commercialization of the electricity sector through deregulation and privatisation (Hirsh 1999, Dubash and Bouille 2002). From 2002, privatisation, capital market liberalisation, market based pricing and free trade were added to the list of pre-conditions to be met, by the World Bank and International Monetary Fund (Beder 2003).

Beder (2003) and Beder (2007) throw light on how governments in the Western World had fully supported the establishment of ESIs based on non-commercial considerations (in view of the importance of electricity); these very governments however argued for commercial considerations (profit, cost recovery for foreign private investors) while dealing with developing countries.

Beder (2003) also explains how the extreme pro-business views even drew dissenting views within IMF; many insiders began to openly express displeasure about policies that showed clear tilt in favour of enabling economic and social needs of the capitalist economies, rather than meeting the needs of the less developed borrowing countries.

From the arguments presented above, it appears that the lending covenants of the World Bank had largely reflected the business interests of its major shareholders (such as the US). The market-based reforms necessitated the developing countries to sell electricity at much higher prices to recover costs and meet the profitability requirements of foreign private investors. In the process, the social obligations of the governments in developing countries, to providing energy services to lower income citizens, were clearly undermined.

4.3 Impacts of market-based pricing of electricity

Electricity price trends of the US, the UK, New South Wales, Queensland, Victoria, and South Australia (Figures 1-6 to 1-11 chapter) reveal that average real electricity prices have continually increased at higher and higher rates over the period. These increases were accompanied by a growing divergence between domestic and industry prices, especially after deregulation. Also Figure 1-13 (chapter 1) shows how electricity equipment prices have sharply increased over the period from 2007 to 2014. Chapter 1 also argued that the chequered post-reform performance of ESIs raises concerns about their long-term viability. Some studies also have argued that post-reform electricity prices are on the rise (Beder 2003, Nagayama 2009, Pollitt 2012). Others have raised concerns on arising energy poverty due to increasing unaffordability of electricity (Beder 2003, Platchkov and Pollitt 2011). Dubash and Bouille (2002) argues that market-based reforms have affected access and affordability of electricity to the poor in the developing world. Economist (2011), Economist (2015), Economist (2017) project a gloomy outlook for the deregulated electricity sector in the UK; concerns have been expressed about the continuously increasing electricity prices, lack of investment in the electricity sector, the risk of blackouts and the need for special market bypassing arrangements for facilitating new investments. Beder (2003) suggests that private companies purchasing public electricity assets at exorbitant prices allude to the premise that these companies were confident that they would be able to charge high electricity prices in deregulated markets, given the essential public service characteristic of electricity.

Despite concerns about the suitability of market-based reforms for ESIs, there are others who subscribe to reforms and emphasise that reforms are based on well-founded theories of competition, property rights, agency and public choice, bureaucracy and regulation; they strongly believe that deregulation and privatisation lead to more efficient firms that are likely to minimise costs, operate commercially and help maximise allocative efficiency in the economy. Some also hold the view that electricity price increases are attributable to rising commodity prices, relaxation of cross-subsidisation initiatives, and increasing environmental concerns (Platchkov and Pollitt 2011, Pollitt 2012). Thus, there exists opposing views on the appropriateness of market-based reforms of the ESIs.

4.3.1 Review of Selected studies

As noted above, and earlier in (Section 4.1), there exist differing economic beliefs and social outlooks on electricity market reform. This section presents a review on these opposing viewpoints, to understand how such review could assist one to develop a perspective on the appropriateness of electricity pricing in deregulated markets (the main focus of this research).

This review is organised as follows. Section 4.3.2 provides a summarised review of studies that have been generally supportive of market based reforms. Section 4.3.3 provides a summarised review of studies that dissent market based reforms and question the very basis of its suitability for electricity. The review (in Sections 4.3.2 and 4.3.3) is presented in a tabular format, focusing particularly on objectives of the reforms, findings and insights. The 'findings' list the main achievements as well as the discordant issues of the reforms. Insights reflect how the authors interpreted the integrity of the outcomes and the appropriateness of reforms. The details for both the reviews are provided in Appendix B.

Contradictions observed between the insights of the two opposing viewpoints are then used (in Section 4.3.4) to develop specific hypotheses, which are then subject to econometric assessment – to establish the veracity of arguments presented in the review.

4.3.2 Review of Studies supportive of reforms

Table 4-1 provides a summarised review of the selected studies that are broadly supporting the principles of market-based electricity reforms broadly (details in Appendix B).

Table 4-1 **Reviews of Studies Generally Supportive of reforms**			
Study	**Objectives/Methodology**	**Findings**	**Insights**
Galal, Jones et al. (1994)	Objectives: • Assess impact of ESI reforms on CHILGENER (Chilean ESI) Methodology: • Compare actual post reform performance with what would have been if the enterprise had not been reformed (utilising counterfactual methods)	• Electricity prices increased significantly • Reduction in workforce and commercialised operation reduced factor costs • Net gain: private shareholders Ch$ 5.6 billion; foreign investors Ch$ 2.7billion • Net loss: Chilean Government Ch$ 2.7 billion • Fiscal Impact on ESI (-) 22 per cent of sale price	• Regardless of increased electricity prices and job loss, authors opine that divestiture has eased debt crises and provided impetus for economic growth • Pricing based on marginal principles, competition, commercialised operation (regardless of ownership- type) will produce benefits
Pollitt (1997)	Objectives: • Impact of liberalization on the performance of ESIs Methodology: • International Survey	• Productivity gains (UK and Chile) • Factor cost reductions • Higher price compensation to transmission and distribution segments (UK and US) • Relatively lower passing on of benefits to consumers • Significant economic gains (UK, Chile and Argentina) • Shift away from large-scale capital investments • Increase in unemployment • Increased GHG emissions because of deployment of inefficient coal fired power plants to reduce costs	Author acknowledges: • Shareholders and private companies have profiteered at the cost of consumers by exercising market power • Significant re-distributional effects in the economy In-spite of above Author holds: • Publicly-owned firms caused inefficiency; managers maximized their own importance and interests rather than corporation or society • Publicly-owned ESIs were inflexible, secretive and engineering dominant rather than focused on finance • Decision to deregulate was appropriate • Effective competition by way of further disaggregation will help realise objectives of reform

Table 4-1 **Reviews of Studies Generally Supportive of reforms**			
Study	**Objectives/Methodology**	**Findings**	**Insights**
Newbery and Pollitt (1997)	Objectives: • Whether restructuring and privatisation was socially beneficial Methodology • Similar to what was adopted by Galal, Jones et al. (1994) • Created a counterfactual model by assuming CEGB continued under public ownership	• Rich cost benefits form reduced fuel prices and moving away from nuclear power investments • Profits to electricity businesses and shareholders in the range of UKP 4-9 billion • Share prices rose by over 250% • Restructuring expenses offset the gains obtained from labour productivity improvements *Dash for Gas* left 24000 coal miners jobless • Fall in costs did not translate to corresponding fall in electricity prices to consumers • Unfettered competition among electricity generating companies not realised even after passage of six years	• Authors optimistic that potential benefits accrue from competition: ○ Cite revival of nuclear plants based on AGR technology (a technology that was declared a failure before reforms) as evidence to benefits from competition • Benefits to consumers will flow when *effective competition* is achieved

Table 4-1 **Reviews of Studies Generally Supportive of reforms**

Study	Objectives/Methodology	Findings	Insights
Steiner (2000)	Objectives: • Assess impact of liberalisation on performance of generation segment of the ESIs Methodology: Econometric Assessment; Panel Data Techniques; *Random Effect* Model Scope: 19 OECD Countries Period 1987-1996 Regressand • *Capacity Utilization and Departure from optimal reserve capacity norms* to represent *performance* • *Industry electricity price and Industry/Domestic price* ratio to represent *consumer welfare* Regressors • *Dummy variables* derived by *multilevel score technique* to represent extent of *reform element implementation*	• Reform elements *presence of wholesale market and third-party access* lower *industry prices and ratio of industry/domestic price ratio* (increase in consumer welfare) • Reform elements *unbundling and private ownership* improve *utilization factor and* reduce *departure from optimal reserve capacity norms* but result in disproportionate fall in *industry/domestic price ratio* • Reform element *private ownership* increases both *industry as well as domestic electricity prices* Author concedes that introduction of *wholesale market and privatisation* of electricity generating companies has lowered *industrial electricity prices* but disproportionately increased *domestic electricity prices*.	• Author highlights the danger of market power and its intensification causing increased discrimination of prices against domestic consumers of electricity • Author recommends greater regulation to control market power and recommends effective disaggregation of generation segment to enable to generate competition

Table 4-1 **Reviews of Studies Generally Supportive of reforms**			
Study	**Objectives/Methodology**	**Findings**	**Insights**

Hattori and Tsutsui (2004)	Objectives:
	
	• Differ from the findings of the study of Steiner (2000)
	• Re-examines Steiner (2000) with changed criteria for defining elements of reform
	
	Methodology
	
	Econometric Assessment; Panel Data Techniques; utilized both *random* and *fixed effect* model
	
	Scope: 19 OECD Countries
	Period 1987-1999
	
	Regressand:
	
	• *Industrial electricity price* and ratio of *Industrial/Residential electricity price* as *consumer welfare*
	
	Regressors:
	
	• Modifies definitions of the different *Regulatory indicators,* more specifically for *unbundling of generation from transmission* and the *extent of retail access* from that of Steiner (2000)
		• Findings differ dramatically from that of Steiner (2000)
		
		• Establishing of wholesale market led to:
		  ○ increasing of electricity prices for both industry as well as residential consumers
		  ○ increase in industry/residential electricity price ratio
		
		• Expanding retail access led to:
		  ○ reduction in industrial electricity price
		  ○ reduction in industrial/residential electricity price ratio
			• Introduction of Wholesale Market leads to increasing of electricity prices for both industrial as well as residential consumers
			
			• Authors recommend:
			  ○ further assessment of impacts of reforms as the industries are in a transitional state
			  ○ estimation of long-run effects and more realistic assessment of reforms – based on a longer time series

Table 4-1 **Reviews of Studies Generally Supportive of reforms**

Study	Objectives/Methodology	Findings	Insights
Zhang, Parker et al. (2008)	Objectives: • Impact of reforms on performance of ESIs of developing countries Methodology: Econometric Assessment utilizing panel data; Scope 36 developing countries; Period: 1985-2003 Regressand: • *Utilisation factor;* • *Electricity generation per capita;* • *Installed generation capacity per capita;* • *Electricity generation per employee* Regressors: • *Privatisation* • *Competition* • *Regulation*	• Combination of competition and regulation shows significant potential for improving capacity utilisation • Performance improvements in electricity generation per employee are assured when competition is promoted • Improvements improve in the presence of independent regulation	• The results of the study show a significant emphasis on the importance of achieving effective competition for achieving better performance results (*utilisation factor and electricity generation per capita*) • Further fortification in performance is seen to take place with the presence of independent regulation Authors caution developing countries provide guidelines while considering introduction of IPPs; they are concerned about the luring tactics of lending institutions

4.3.3 Review of dissenting view points

Table 4-2 provides in the review of the selected works of authors who dissent on the appropriateness of electricity reforms based on a detailed review which has been included in Appendix B.

Table 4-2 **Review of studies with dissenting viewpoint**

Study	Objectives	Findings	Insights

Beder (2003) and Beder (2007)	• Assess veracity of claims of electricity reforms from an international perspective	• Electricity generating exploit the inelastic demand nature of electricity to set high prices by introducing high variable cost plants to generate electricity.
		• Cost reductions have been only through indiscriminate job-cuts and discontinuance of important asset maintenance practices.
		• Goals of innovation to improve allocative efficiency, to reduce costs and prices turned out to be rhetoric and irrelevant as profits were easily obtained by resorting to price setting.
		• Transmission and Distribution networks allowed higher profits at rates higher than by most listed companies. The share values of private companies rose by over 200 percent in the UK.
		• Overtime market power has become institutionalised.
		    o Governments and IEA authorities justified market power, citing, need for financial optimisation of the privatised electricity generating companies and electricity sector's stability (Stridbaek 2006)
		• Post reforms, 61 privatised electricity generating companies have shown profit averaging at 45 per cent – artificial high price-setting and non-sharing of cost reductions with consumers have contributed to this.
		• Social welfare has been compromised.
		    o 150,000 ESI workers in the US and 83,000 in Australia lost jobs
		    o lower prices to industry/commercial and large users were provided by shifting the burden of the differential on to the poorer segment of the society
		    o lack of attention to power generating assets led to blackouts and damages to power plants during the 1990s
		• Vertical and horizontal re-integration belies the professed basis of enabling competitiveness to achieve allocative efficiency – this change has furthered the ability of generating companies to consolidate market power with greater ease
		• Investments on base-load efficient power plants have virtually ceased, instead, low-fixed-/high-variable-cost plants have been rampantly deployed to set higher prices.
			• Electricity reforms have failed to deliver on their promises.
			• Market power that has enabled price setting to bolster profits has been institutionalised. Allocative efficiency has lost relevance.
			• Work and social ethos have been replaced by profit (by any means) ethos.
			• Disregard to environmental norms has gained acceptance.
			• Over-time the rationale of disaggregation to generate competition is losing relevance and the process of reintegration into large monopolies for gaining scale economies is reviving.
			• Investments towards setting up efficient environment compliant electricity generating plants have ceased.
			• Low cost, inefficient and non-environment compliant electricity generating plants are being set up to support setting of high electricity prices and market power manoeuvrings.

Table 4-2 **Review of studies with dissenting viewpoint**			
Study	**Objectives**	**Findings**	**Insights**
Surrey (1996) Thomas (1996) MacKerron and Watson (1996) Chick (2011)	Analyse impact of UK electricity reform from an economic and distributional effects perspective	• Governments had pre-emptively increased price of electricity by 15 percent before reforms to make the assets attractive for sale • ESI reforms and coal mine privatisation made around 40,247 members of ESI workforce (31 percent) and 250,000 coal mine workers redundant • 22 million captive domestic electricity consumers bore the burden of the differential arising between the price of British coal and International coal prices during the initial three years post reforms • Reserve margins were reduced from 27 percent to 18 percent by closing down power generating stations for the sake of profit generation to the electricity generating businesses at the time of introduction of reforms • Precipitous cost reductions of coal did not reflect as a reduction in the market-based electricity prices. Profits went to the electricity businesses and the shareholders. • Market power enabled market prices to be set at 10 to 20 percent above the costs of newly introduced Combined Cycle Gas Turbine (CCGT) plants. • Windfall profits accrued to privatised electricity generating companies • Fixed charges for domestic consumers of electricity rose by 47 percent during the period 1985-1995 • Income inequality in the UK increased significantly post introduction of electricity reform	• Reforms pre-emptively ensured profit environment • Reforms affected coal mine and ESI workers and socially depressed segment of the population • Undue profits were enabled by market power and generous transmission and distribution prices • Reforms aggravated social inequity and energy poverty problems

Beder (2003), Haselip and Hilson (2005), Beder (2007)	• Impacts of reforms from social and environmentally sustainable future perspectives	• Less developed countries that raised revenues from International Financial Institutions under the auspices of *Washington Consensus* suffered from serious socio-economic inequalities, and the fate of over 1.5 billion poor people of the world without access to electricity is at stake. o Multinational corporations benefitted o AES (USA) through its energy operations in South America, Africa and Asia generated revenues more than US$8 billion in 2003 o EDF of France similarly achieved a revenue of Euro 48 billion and a profit of Euro 5.2 billion in the year 2002 • Government guaranteed Power Purchase Agreements (PPA) organized between developing countries and IPPs forced governments of those countries to bear most of the burden of risk associated with projects. • Environmentally non-compliant generation technologies are favoured by electricity generating companies as they provide the advantage of low-fixed but high variable costs and deployed them for setting high prices while exercising market power • A survey of fuel technology adopted by upcoming IPPs show that they are outdated and more polluting: PPAs of IPPs as they are not subjected to environmental scrutiny. • The EPA 1992 Act of USA repealed the requirement of efficiency norms laid out by PURPA to qualify for benefits under PUHCA • Discontinuation of successful energy efficiency programs in the mid-1990s was one of the contributing factor for the California electricity market crash • Environmental norms have been disregarded post deregulation o Californian power generating companies were encouraged to set up power plants in Mexico to avoid Californian environmental regulations(Dubash and Bouille 2002) o Post-deregulation environmental norms were relaxed	• Reforms have encouraged narrow economic considerations and amplified social inequity issues among the less developed countries • The responses to environment under reforms have largely been incidental; choice of fuel technology has been largely led by price-cost differentials and not by environmental concerns • Some of the richest countries like Australia have become icons as the worst polluting countries

Table 4-2 **Review of studies with dissenting viewpoint**			
Study	**Objectives**	**Findings**	**Insights**
		• Electricity generated by brown coal in Australia increased from about 23 percent to 31 percent of sources between 1992 and 2001. Australia, post reform, went on to become the second highest polluter among the OECD countries (43 percent above the IEA average). Australia also has been bracketed among the least energy efficient countries of the world	

4.3.4 Insights and Hypotheses

The insights gained from Sections 4.3.2 and 4.3.3 provide useful bases for developing hypotheses for this thesis.

Discussion on the insights:

The pro-reform views, while upholding the soundness of the core principles of reform, blame adverse post-reform outcomes on the lack of depth of reform, i.e., they argue that the industry has not been disaggregated to levels required for fostering effective competition. They also emphasise the importance of independent regulation as a precondition for the realisation of gains of reform. The undesirable outcomes of reform, such as exercise of market power, increasing electricity prices are outcomes of fallible implementation method as discussed above, they contend. Such arguments were commonplace until the early 2000s.

With unrelenting increasing electricity price trends in the late 2000s, new views began to emerge. Stridbaek (2006) argues that increasing prices are necessary to stabilise the deregulated electricity generating companies, and even justifies the exercise of market power as a means to achieve financial optimisation. Pollitt (2012) attributes electricity price increases to increasing commodity prices, unwinding of subsidies, reducing rates of technological progress and rising environmental concerns. Platchkov and Pollitt (2011) hold the view that higher prices have helped to moderate demand and reduce GHG emissions. Such diverse views appear to suggest that increasing electricity prices, bolstered by market-based pricing system, are advantageous and necessary.

The reform-sceptics have however continuously maintained that market-based pricing has promoted economic interests and contributed to amplifying the distributional distortions in society. Short-sighted profit-driven initiatives have led to inappropriate investments that encourage inefficient energy use. The promotion of business interests, they argue, legitimise abuse of market-power, encourage generous pricing for the monopoly networks, and reduce attention for environmental concerns and the need for establishing efficient base-load power plants. They point to the post-reform electricity business – supported by market-based pricing regimes – as having become sub-servient to profit motives, resulting in increased social inequity and energy poverty. The sceptics view the current paradigm as unsustainable.

Based on the above discussions this research proposes the following hypotheses.

Hypothesis 1

Deregulated electricity pricing system leads to a disjuncture between electricity prices and costs.

Hypothesis 2

Deregulated electricity pricing system encourages and sustains increasing electricity price trends.

Hypothesis 3

Deregulated electricity pricing system contributes to increasing social inequity.

Hypothesis 4

Deregulated electricity pricing system leads to increasing departures from stipulated environmental norms.

4.4 Scope, Data and Econometric Models

This section provides details of the econometric models employed in this research to test the above noted hypotheses.

Data utilized for econometric analysis covers historic data of electricity prices and costs of electricity for the period 1960-2014. The countries (regions) include the United States, the United Kingdom, and Australia (more specifically, New South Wales, Victoria, Queensland and South Australia); this selection of countries, it is argued, is appropriate, in view of the fact that they have been at the forefront of reform and hence their experience over extended period provides a useful basis to test the hypotheses.

The required data has been obtained from various sources, specifically from IEA, EIA, DECC, Energy Supply Association of Australia (ESAA), Australian Government Sources, World Bank, Federal Power Commission (FPC (1964), DOEUK (2016), Electricity-Council (1990), Beder (2003), Hirsh (2002), and Surrey (1996). Plant cost data have been derived from EIA (2010), EIA (2013m), and Frontier-Economics (2013a) and utilised for the estimation of cost of generation data wherever this was not directly available.

This research has chosen the ANOVA type of model provided by Gujarati and Porter (2003). The generic form of this model is given below.

$$Y_t = \beta_1 D_{1t} + \beta_2 D_{2t} + \beta_3 D_{3t} + \ldots \beta_n D_{nt} + u_t \quad \text{Equation 4-1}$$

where

D_{nt} are dummy regressor variables taking the value of 1 or 0 to characterise presence or absence of politico-economic circumstances that have affected ESIs and caused significant changes to electricity price trends. t represents the various periods chosen for the study.

Y_t is the dependent variable – it represents the performance variable selected for each of the four hypotheses described above, e.g., in the case of Hypothesis 1, for the US, the performance variable is *profit* (expressed in USC/kWh), obtained by taking the difference between nominal price and the nominal cost per kWh. The results of regression provide the mean values of the performance variable for the various time-periods of study, enabling a comparison among the periods; it also serves to establish the veracity of the respective hypotheses.

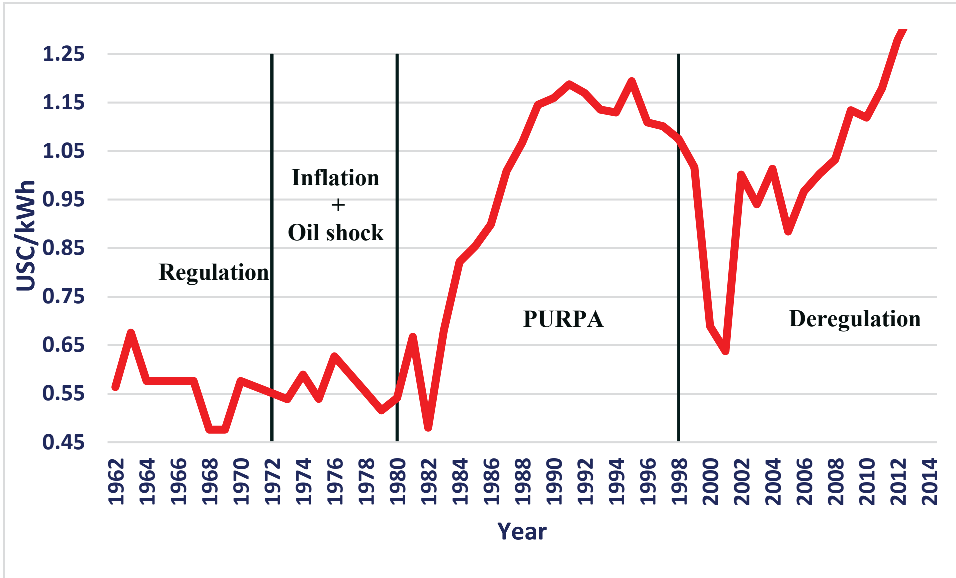
In addition to econometric testing of hypotheses, trend charts of selected performance (dependent) variables are also provided, for visual review covering all the countries/regions under study, hypothesis-wise, to serve as pre-checks. Tables provide the details of dependent as well as the dummy regressor variables hypothesis-wise.

Hypothesis1

Deregulated electricity pricing system leads to a disjuncture between electricity prices and costs.

Figure 4-1 provides per unit profit trends for the United States. Per unit profit represents the difference between per unit price and per unit cost, expressed in nominal terms.

Figure 4-1: Profit Trends (US)



Sources: Data developed from DOE (1994), DOE (2002), DOE (2008), (DOE 2012), DOE (2014), DOE (2015), DOE (2016) (The data for the figure have been furnished in Appendix B.)

Annual (per-unit) profits for the US were estimated as follows. For the period 1990-2014, they were estimated directly from available price and cost data. For the period 1962-1989, as the cost data was not available, it was estimated as follows: A reference value was developed utilising the available cost and industry price data for the year 1990. This value was used as the multiplier for developing the cost data series from the available industry price data series for the period 1962-1989.

Further, econometric analyses for the US were carried out for the following time periods:

Regulation (till 1972) – during this period the industry was under regulatory price system and performed as a declining cost industry.

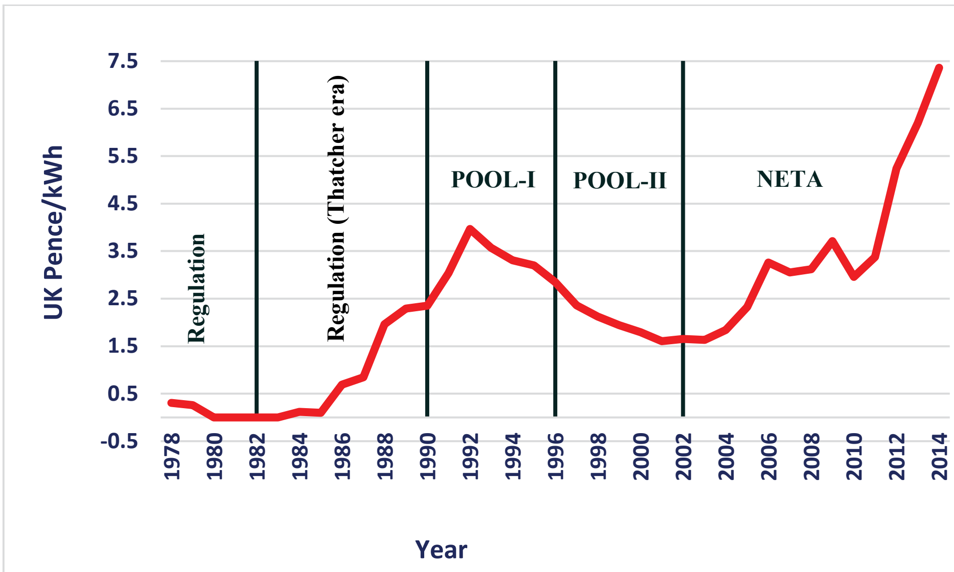
Inflation + oil shock (1972-1980) – the regulated industry during this period, under the influence of inflation, oil-shock and plateauing of technology, changed from decreasing cost to increasing cost industry.

PURPA (1980-1998) – the regulated industry was subject to PURPA reforms – PURPA sponsored IPPs and QFs were provided with assured markets and generous pricing.

Deregulation (from1998 onwards) – following the passage of Energy Policy of 1992, the deregulation of ESIs began from 1998.

Figure 4-2 provides per unit profit trends for the United Kingdom. Per unit profit represents the difference between per unit price and per unit cost, expressed in nominal terms.

Figure 4-2 Profit Trends (UK)



Sources: Data developed from Electricity-Council (1990), DOEUK (2016), IEA (2017(1d)), IEA (2017(1e)), IEA (2017(1f)), IEA (2017(1g)), IEA (2017(1h)), IEA (2017(1i)), IEA (2017(1j)), IEA (2017(1k)), IEA (2017g), IEA (2017h), IEA (2017i), IEA (2017j), IEA (2017k), IEA (2017l) (The data for the figure have been furnished in Appendix B.)

As brought out earlier, the annual (per-unit) profits for the UK were estimated as follows. For the period 1978-1984, they were estimated directly from available price and cost data. For the period 1985-2014, as the cost data was not available, it was estimated as follows:

Cost data was computed by generating fixed cost and variable cost data streams (O&M cost and fuel cost).

Fixed cost stream was generated by assuming remaining life period for the existing assets and interest rates based on market information from the year 1985 onwards. For new assets, added after 1985, separate fixed cost streams were generated as explained above. Capital costs of new assets were estimated based on government information. Associated transmission and distribution costs were estimated on normative basis. The sum of all the streams provided the total fixed cost data series for the period 1985-2014.

Operation, maintenance and fuel costs were available for the period 1978-1990. For the remaining period, 1991-2014 these were estimated as follows:

The O&M cost of 1990 was taken as reference and the data stream was generated for the period 1991-2014 by indexing it with CPI. Fuel costs for this period were estimated based on fuel price information, fuel consumption and generation values that were obtained from the above noted sources.

The cost data per unit of electricity was generated by dividing the sum of fixed cost, O&M cost and fuel cost data by the total units of electricity sold.

Further, econometric analyses for the UK were carried out for the following time periods:

Regulation till 1982 – this period represents nationalised ESI with minimal financial oversight by the government – pricing system was gradually transitioning from average-cost basis to marginal-cost basis.

Regulation pre-reform period (1982-1990) – this period witnessed nationalised ESI being subject to more stringent financial controls – industry went through inflection phase – government imposed higher financial targets on the industry.

POOL-I (1990-1996) – this early reform period provided ESIs with liberal price and assured markets.

POOL-II (1996-2002) – during this period the industry went into a new phase which marked the waning of the early government concessions and the beginning of stricter control by the Independent Regulator.

NETA (2002 onwards) – during this period the industry came under New Electricity Trading Arrangements (NETA).

Figures 4-3 to 4-6 provide per unit profit trends for the Australian states NSW, Victoria, Queensland and South Australia. Per unit profit represents the difference between per unit price and per unit cost, expressed in nominal terms.

Figure 4-3 Profit Trends (NSW)

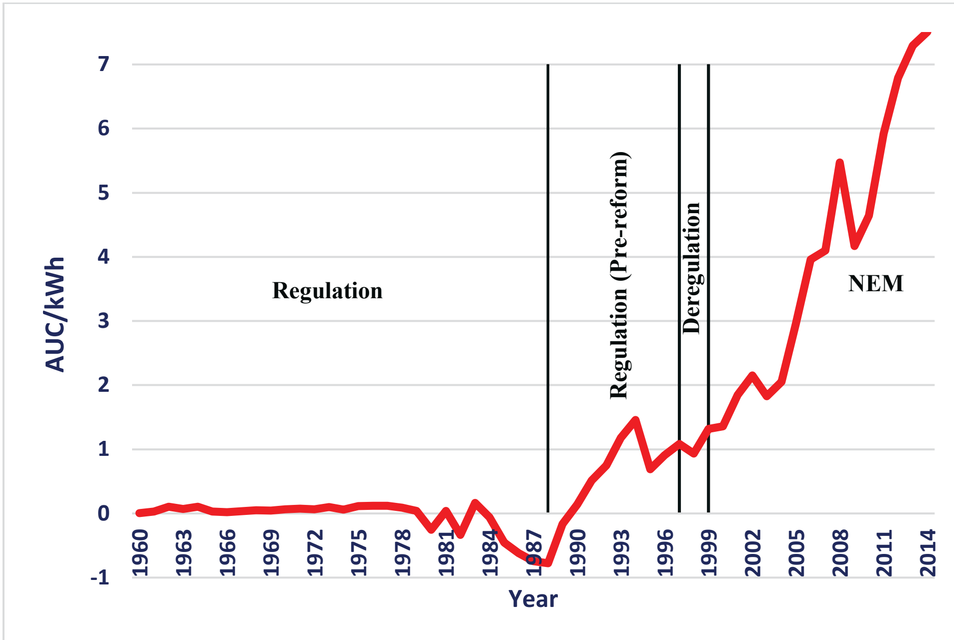


Figure 4-4 Profit Trends (Victoria)

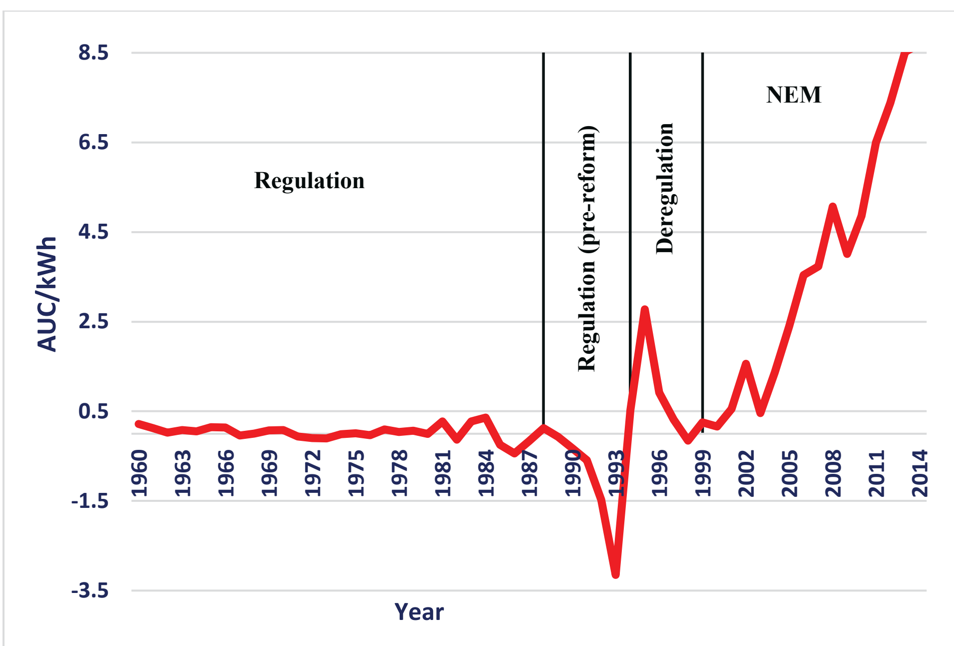


Figure 4-5 Profit Trends (Queensland)

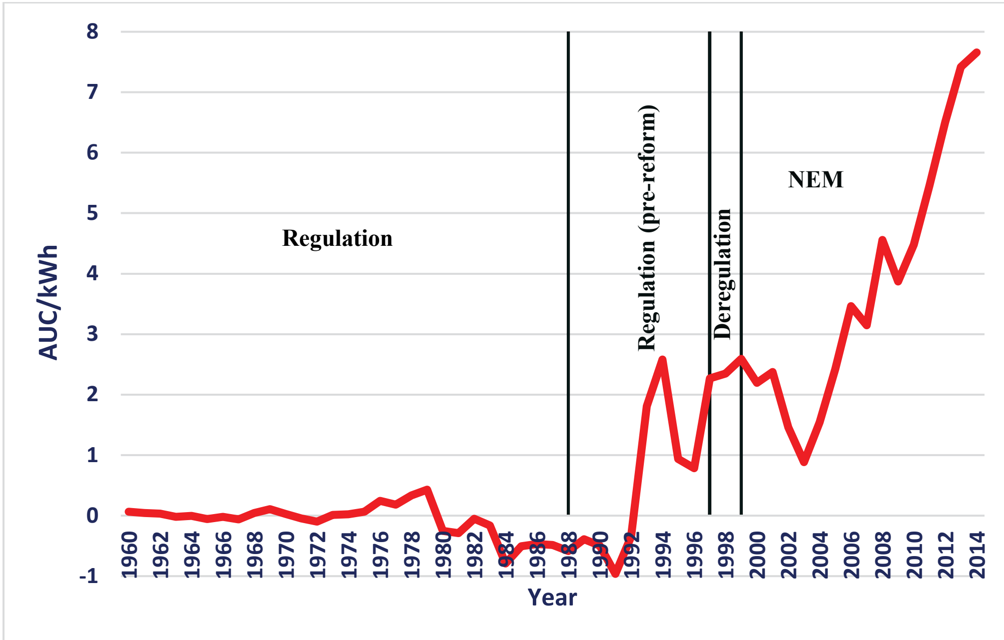
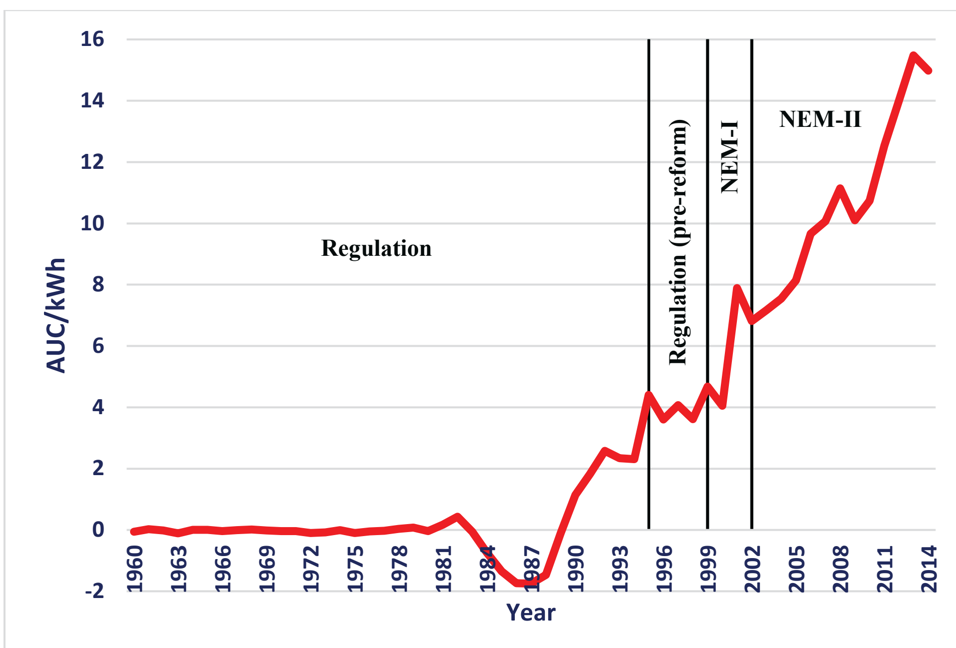


Figure 4-6 Profit Trends (South Australia)



Sources: Data for the Australian States (figures 4-3 to 4-6) developed from ESAA (2005), ESAA (2006), ESAA (2007), ESAA (2008), ESAA (2009), ESAA (2010), ESAA (2011), ESAA (2012), ESAA (2013), Frontier-Economics (2013b), ESAA (2014), ESAA (2015), ESAA (2016), IEA (2017e), IEA (2017f), IEA

(2017g), IEA (2017h), IEA (2017i), IEA (2017j), IEA (2017k), IEA (2017l), IHSCERA (2018). (The data for the figures 4-3 to 4-6 have been furnished in Appendix B.)

Annual (per-unit) profits for the above Australian states (also, as brought out earlier) were estimated as follows. For the period 1960-1998, for the states NSW, Queensland and South Australia and for the period 1960-1995for Victoria, they were estimated directly from available price and cost data. For the period 1999-2014 in the case of NSW, Queensland and South Australia and for the period 1997-2014 in the case of Victoria, as the cost data was not available, it was estimated as follows:

Cost data was computed by generating fixed cost and variable cost data streams (O&M cost and fuel cost).

Fixed cost stream was generated by assuming remaining life period for the existing assets and the interest rates based on market information from 1999 onwards for the states NSW, Queensland and South Australia and in the case of Victoria from 1997 onwards. For new assets, added separate fixed cost streams were generated as explained above. Capital costs of new assets were estimated based on government information. Associated transmission and distribution costs were estimated on normative basis. The sum of all the streams provided the total fixed cost data series for the concerned periods.

Operation, maintenance and fuel costs were available for the period 1960-1998 (for the states NSW, Queensland, and South Australia) and 1960-1996 (for Victoria). For the remaining period, these were estimated. The O&M cost of year 1999 in the case states NSW, Queensland and South Australia and year 1997 in the case of Victoria were taken as reference and the data series for the missing period was generated by indexing the obtained reference data with CPI. Fuel costs were estimated based on fuel price information, fuel consumption and generation values that were obtained from the above noted sources. The cost data per unit of electricity was generated by dividing the sum of fixed cost, O&M cost and fuel cost data by the total units of electricity sold.

Further, econometric analyses for the Australian states are carried out for the following time periods:

NSW:

Regulation (1960-1989): during this period the industry was under state regulated pricing system – the industry till 1970s was on declining cost phase – inflection period began from early 1980s.

Regulation Pre-reform (1990-1995): during this period the industry came under stringent financial controls and increasing financial targets under the influence of neoliberalism ideology in Australia.

Deregulation (1996-1999): the industry was deregulated and began to operate on market principles within the state jurisdiction.

NEM1 (2000 onwards): the industry came under the purview of National Electricity Market.

Victoria:

Regulation (1960-1988): during this period the industry was under state regulated pricing system – the industry till 1970s was on declining cost phase – inflection period began from early 1980s.

Regulation Pre-reform (1989-1993): during this period the industry came under stringent financial controls and increasing financial targets under the influence of neoliberalism ideology in Australia.

Deregulation (1994-1999): the industry was deregulated and began to operate on market principles within the state jurisdiction.

NEM1 (2000 onwards): the industry came under the purview of National Electricity Market.

Queensland:

Regulation (1960-1990): during this period the industry was under state regulated pricing system – the industry till 1970s was on declining cost phase – inflection period began from early 1980s.

Regulation Pre-reform (1991-1996): during this period the industry came under stringent financial controls and increasing financial targets under the influence of neoliberalism ideology in Australia.

Deregulation (1997-2001): the industry was deregulated and began to operate on market principles within the state jurisdiction.

NEM1 (2002 onwards): the industry came under the purview of National Electricity Market.

South Australia:

Regulation (1960-1994): during this period the industry was under state regulated pricing system – the industry till 1970s was on declining cost phase – inflection period began from early 1980s.

Regulation Pre-reform (1995-1995): during this period the industry came under stringent financial controls and increasing financial targets under the influence of neoliberalism ideology in Australia.

NEM1 (2000-2003): the industry was deregulated and came under the purview of National Electricity Market.

NEM2 (2004 onwards): implementation of deregulation in the retail sectors in South Australia

Visual examination of the figures 4-1 to 4-6 suggest that profit trends were generally stable during the regulated pricing regimes; increasing profit trends can be seen from the time of the emergence of neoliberalism – it can be also seen from the trends that deregulation, over time, has fortified profits.

The generic model described in Equation 4-1 has been adopted for econometric estimation. Profit per kWh has been chosen as the performance variable for hypothesis 1. Table 4-3 provides a description of major phases in the evolution of the electricity industry and other details of the econometric model.

Table 4-3: Details of econometric model – Hypothesis 1

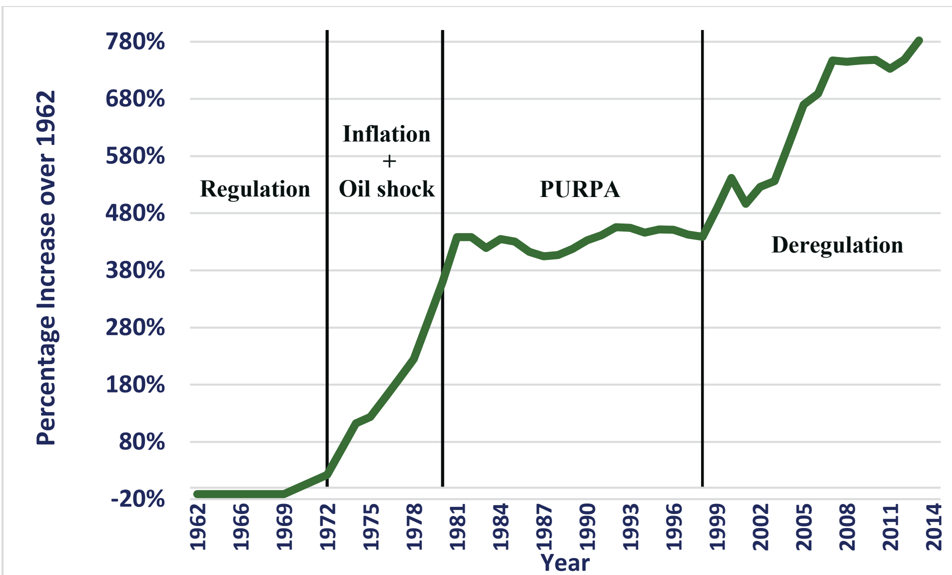
Country/State	Dependent Variable	Major phases in the evolution of the industry considered for regression	Regressor symbol
US	Profit (in national currency)/kWh – difference between nominal price and nominal cost per unit electricity	Regulated Pricing period (1962-1971) Adverse Macroeconomic and Oil shock period (1972-1980) PURPA Period (1981-1998) Deregulation from March 1998 onwards	*REG* *INFLOILSH* *PURPA* *DEREG*
UK		Regulated Pricing Period (1978-1981) Regulatory Period influenced by emerging neoliberalism (Thatcher Period) (1982-1989) Deregulation Phase I (1990-1995) Deregulation Phase II (1996-2000) Deregulation (New Electricity Trading Agreements Phase—from 2001)	*REG* *REG1* *PL1* *PL2* *NETA*
New South Wales		Normal Regulatory Period (1960-1989) Regulatory Period influenced by emerging neoliberalism (1990-1995) Deregulation Phase I (1996-1999) Deregulation with the advent of National Electricity Market (from2000onwards)	*REG* *REG1* *DEREG* *NEM*
Victoria		Normal Regulatory Period (1960-1988) Regulatory Period influenced by emerging neoliberalism (1989-1993) Deregulation Phase I (1994-1999) Deregulation with the advent of National Electricity Market (from2000onwards)	*REG* *REG1* *DEREG* *NEM*
Queensland		Normal Regulatory Period (1960-1990) Regulatory Period influenced by emerging neoliberalism (1991-1996) Deregulation Phase I (1997-2001) Deregulation with the advent of National Electricity Market (from2002onwards)	*REG* *REG1* *DEREG* *NEM*
South Australia		Normal Regulatory Period (1960-1994) Regulatory Period influenced by emerging neoliberalism (1995-1999) NEM Phase I (2000-2003) NEM Phase II (from2004 onwards)	*REG* *REG1* *NEM1* *NEM2*

Hypothesis 2

Deregulated electricity pricing system encourages and sustains increasing electricity price trend.

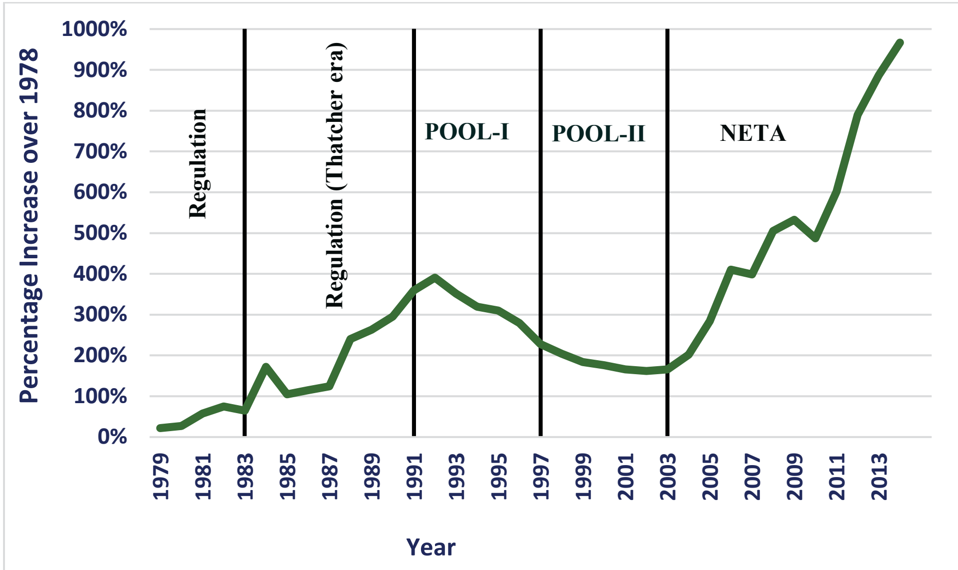
Figures 4-7 to 4-12 provide price trends for the United States, the United Kingdom, and the Australian states of New South Wales, Victoria, Queensland and South Australia respectively. (The data for these are provided in Appendix B.)

Figure 4-7 Price Trends (US)



Sources: Data obtained from EIA (2016), EIA (2017)

Figure 4-8 Price Trends (UK)



Source: Data obtained from DOEUK (2016)

Figure 4-9 Price Trends (NSW)

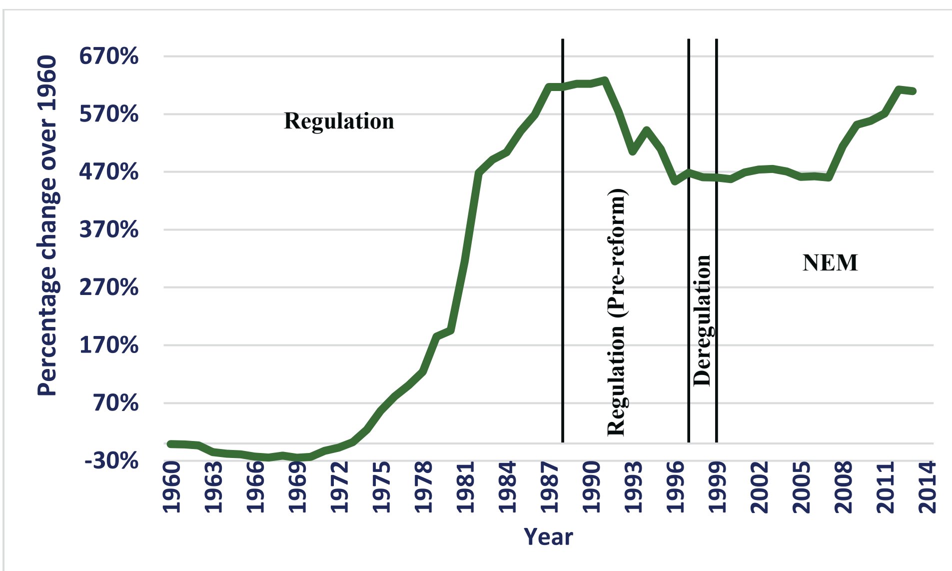


Figure 4-10 Price Trends (Victoria)

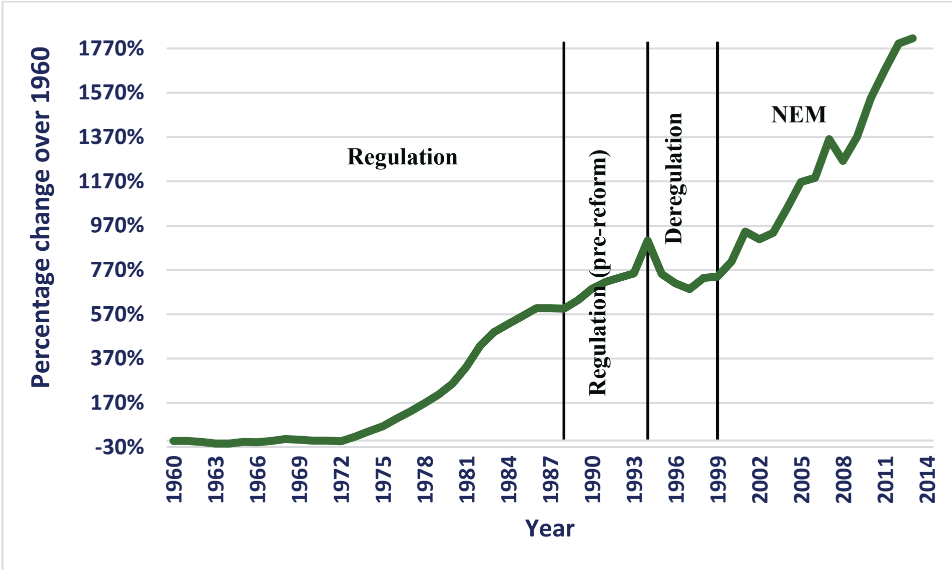


Figure 4-11 Price Trends (Queensland)

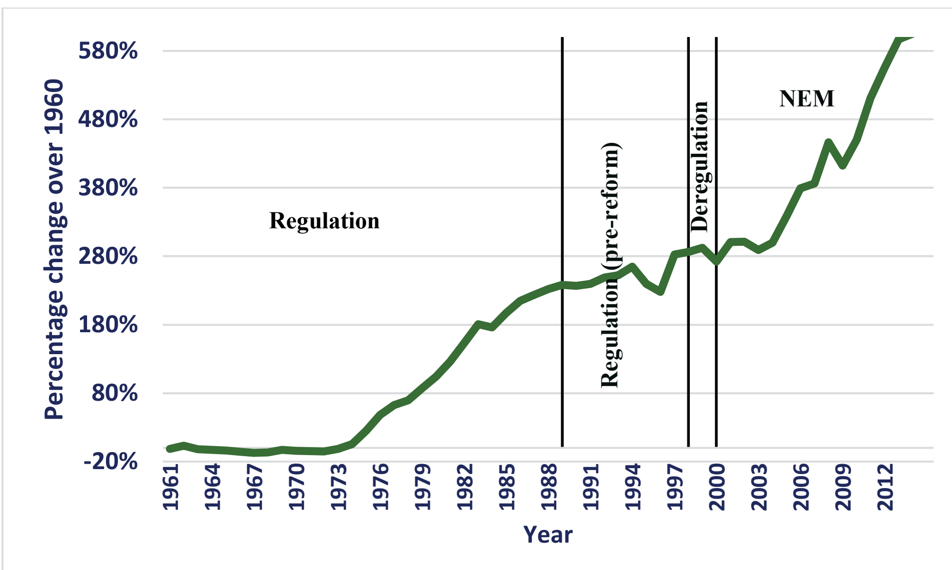
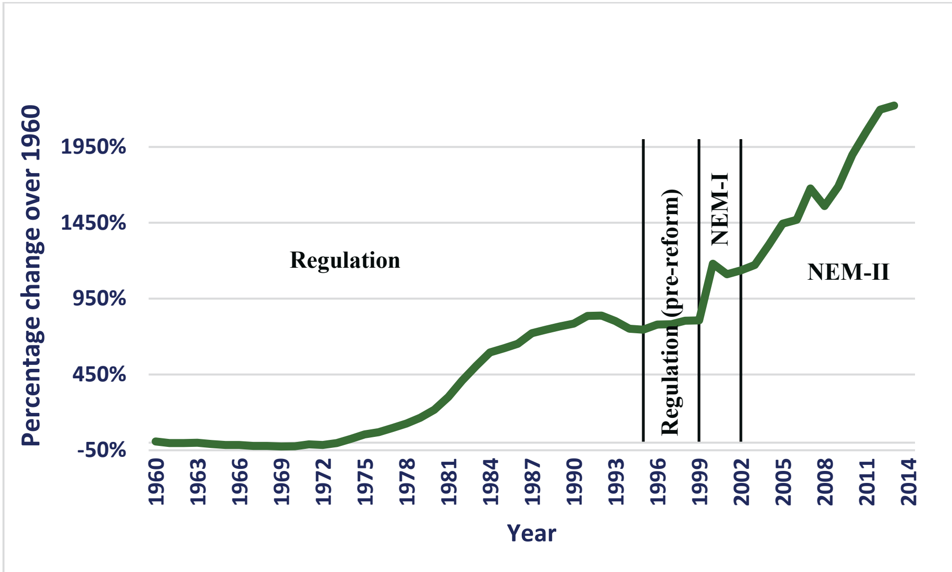


Figure 4-12 Price Trends (South Australia)



Sources: Data for the Australian States (figures 4-9 to 4-12) developed from ESAA (2005), ESAA (2006), ESAA (2007), ESAA (2008), ESAA (2009), ESAA (2010), ESAA (2011), ESAA (2012), ESAA (2013), ESAA (2014), ESAA (2015), ESAA (2016), IEA (2017d), IEA (2017e), IEA (2017f)

Visual examination of the figures suggests that electricity prices had been steady till the mid-1970s; increasing price trends commenced with the emergence of neoliberalism and technology plateauing. Deregulation has generally heightened this price trend; in Australia, this trend pattern can be seen more prominently in Victoria and South Australia where electricity assets had been privatised along with deregulation.

The generic model described in Equation 4-1 has been adopted for estimation. Change in price from the base year expressed in percentage has been chosen as the performance variable for *hypothesis 2*. Table 4-4 provides description of major phases in the evolution of the electricity industry and other details of the econometric model.

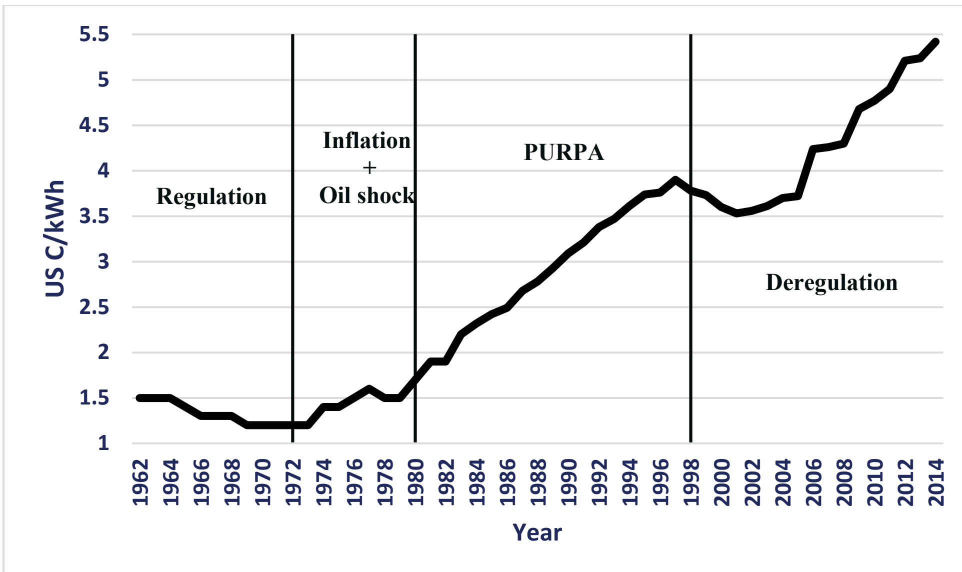
Table 4-4: Details of econometric model - Hypothesis 2

Country	Dependent Variable	Major phases in the evolution of the industry considered for regression	Regressor symbol
US	Price change from base year expressed in percentage	Regulated Pricing period (1962-1971) Adverse Macroeconomic and Oil shock period (1972-1980) PURPA Period (1981-1998) Deregulation from March 1998 onwards	*REG* *INFLOILSH* *PURPA* *DEREG*
UK		Regulated Pricing Period (1978-1981) Regulatory Period influenced by emerging neoliberalism (Thatcher Period) (1982-1989) Deregulation Phase I (1990-1995) Deregulation Phase II (1996-2000) Deregulation (New Electricity Trading Agreements Phase—from 2001)	*REG* *REG1* *PL1* *PL2* *NETA*
NSW		Normal Regulatory Period (1960-1989) Regulatory Period influenced by emerging neoliberalism (1990-1995) Deregulation Phase I (1996-1999) Deregulation with the advent of National Electricity Market (from2000onwards)	*REG* *REG1* *DEREG* *NEM*
Victoria		Normal Regulatory Period (1960-1988) Regulatory Period influenced by emerging neoliberalism (1989-1993) Deregulation Phase I (1994-1999) Deregulation with the advent of National Electricity Market (from2000onwards)	*REG* *REG1* *DEREG* *NEM*
Queensland		Normal Regulatory Period (1960-1990) Regulatory Period influenced by emerging neoliberalism (1991-1996) Deregulation Phase I (1997-2001) Deregulation with the advent of National Electricity Market (from2002onwards)	*REG* *REG1* *DEREG* *NEM*
South Australia		Normal Regulatory Period (1960-1994) Regulatory Period influenced by emerging neoliberalism (1995-1999) NEM Phase I (2000-2003) NEM Phase II (from2004 onwards)	*REG* *REG1* *NEM1* *NEM2*

Hypothesis 3: *Deregulated electricity pricing system contributes to increasing social inequity*.

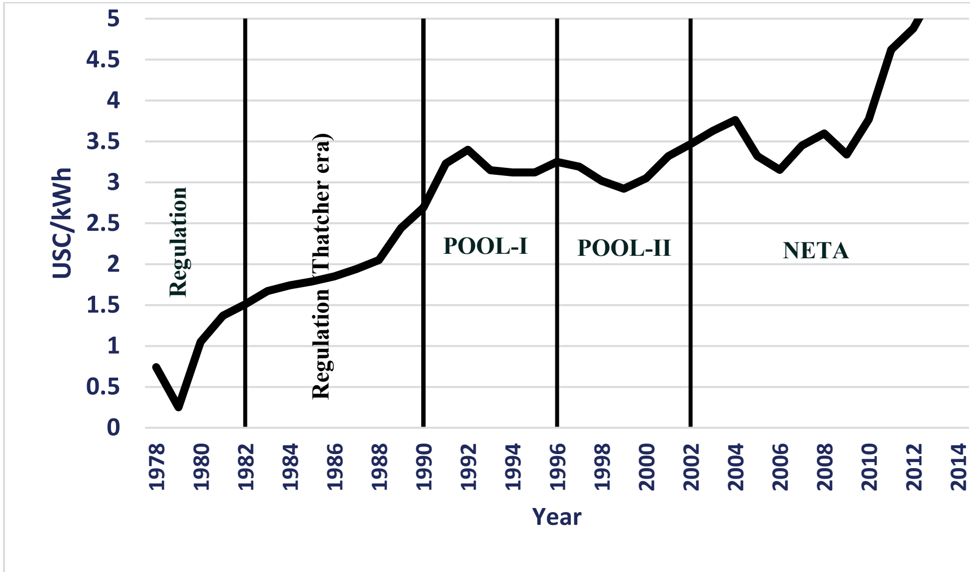
Figures 4-13 to 4-18 provide inequity trends (*difference between household and industrial electricity price per kWh*) for the United States, the United Kingdom, and the states of New South Wales, Victoria, Queensland and South Australia. (The data for these figures are provided in Appendix B.)

Figure 4-13 Inequity Trend (US)



Source: Data has been developed from EIA (2017)

Figure 4-14 Inequity Trend (UK)



Source: Data has been developed from DOEUK (2016), IEA (2017a1)

Figure 4-15 Inequity Trend (NSW)

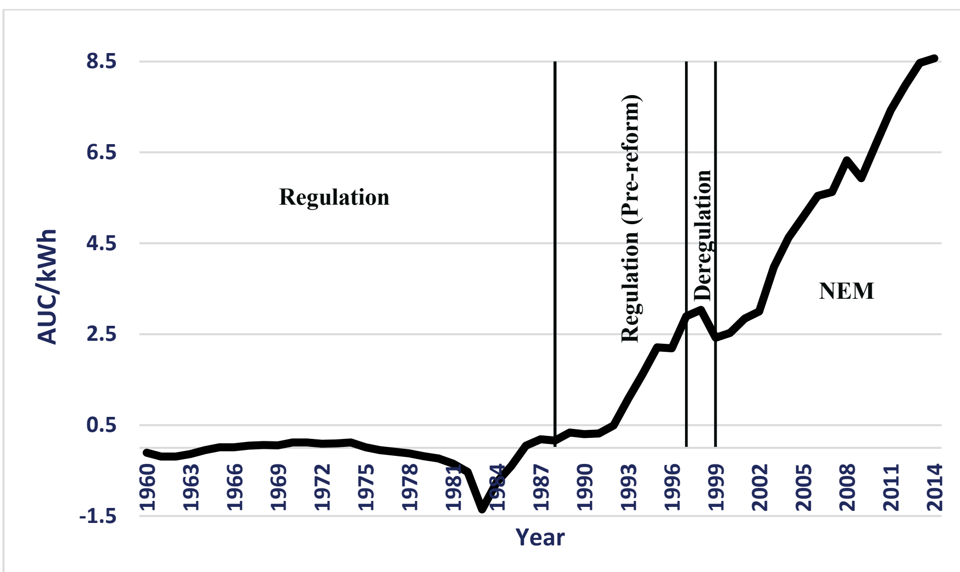


Figure 4-16 Inequity Trend (Victoria)

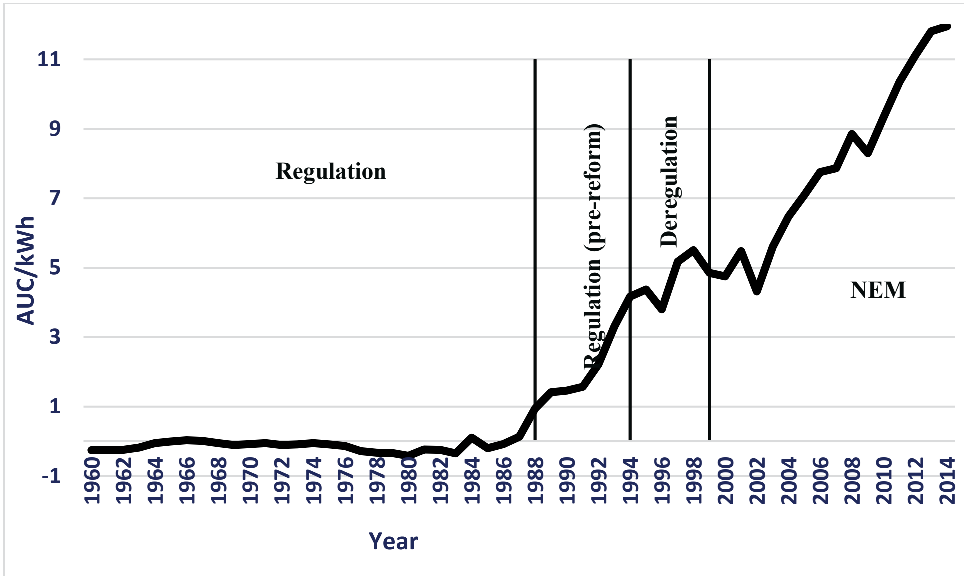


Figure 4-17 Inequity Trend (Queensland)

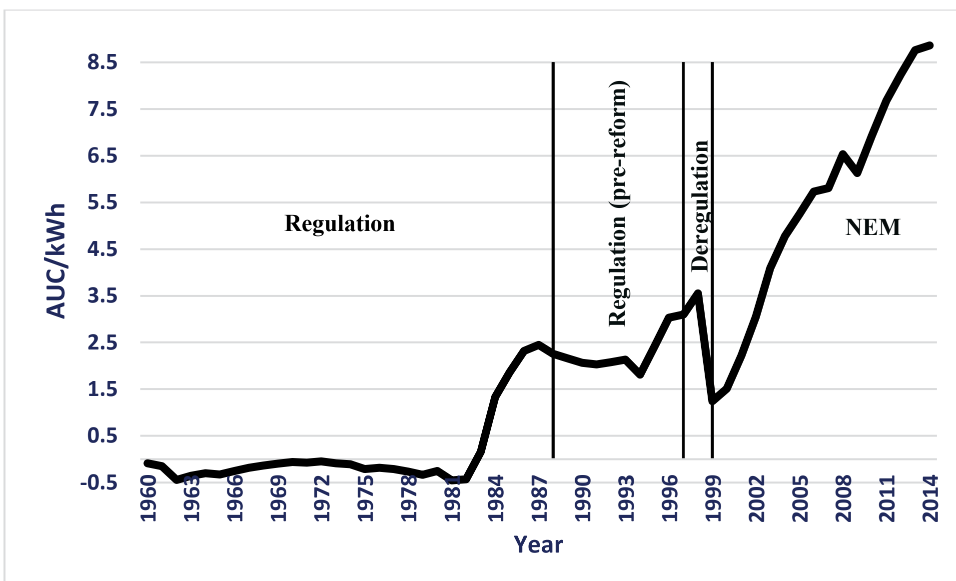
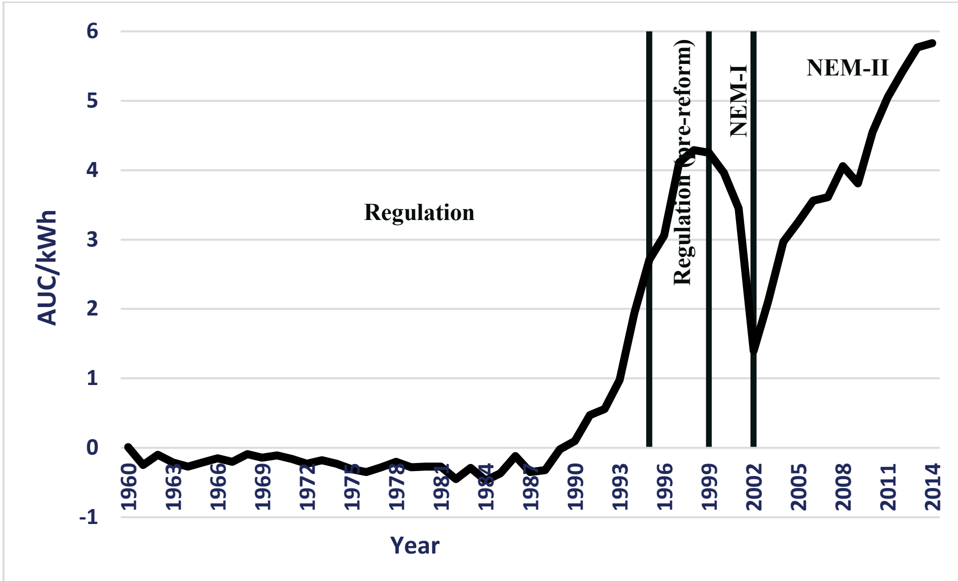


Figure 4-18 Inequity Trend (South Australia)



Source: Data for the Australian States (figures 4-15 to 4-18) have been developed from ESAA (2005), ESAA (2006), ESAA (2007), ESAA (2008), ESAA (2009), ESAA (2010), ESAA (2011), ESAA (2012), ESAA (2013), ESAA (2014), ESAA (2015), ESAA (2016), IEA (2017d), IEA (2017e), IEA (2017f)

Visual examination of the figures suggests that inequity trends have remained steady until around the mid-1980s. Increasing inequity trends have commenced from the time of inflection of electricity prices, and introduction of electricity pricing based on marginal principles. Introduction of market derived marginal-cost based pricing following deregulation has over time heightened the increasing trends of inequity. Victoria and South Australia, where privatisation had also taken place, show these trends in a more profound manner.

The generic model described in Equation 4-1 has been adopted for estimation. Inequity, expressed as the difference between household and industry electricity price has been chosen as the performance variable for *Hypothesis 3*. Table 4-5 provides description of major phases in the evolution of electricity industry and other details of the econometric model.

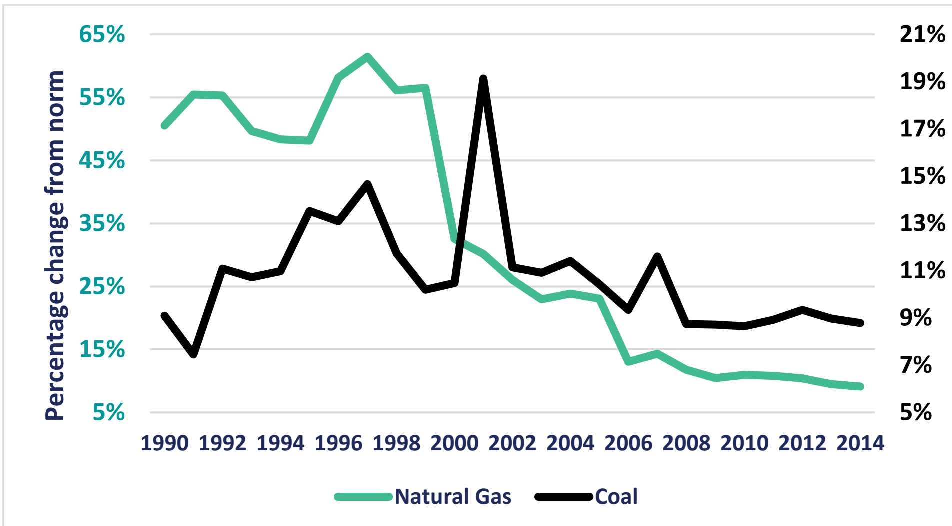
Table 4-5: Details of econometric model - Hypothesis 3

Country	**Dependent Variable**	**Major phases in the evolution of the industry considered for regression**	**Regressor symbol**
US	Difference between the household and industry nominal electricity price per kWh	Regulated Pricing period (1962-1971) Adverse Macroeconomic and Oil shock period (1972-1980) PURPA Period (1981-1998) Deregulation from March 1998 onwards	*REG* *INFLOILSH* *PURPA* *DEREG*
UK		Regulated Pricing Period (1978-1981) Regulatory Period influenced by emerging neoliberalism (Thatcher Period) (1982-1989) Deregulation Phase I (1990-1995) Deregulation Phase II (1996-2000) Deregulation (New Electricity Trading Agreements Phase—from 2001)	*REG* *REG1* *PL1* *PL2* *NETA*
NSW		Normal Regulatory Period (1960-1989) Regulatory Period influenced by emerging neoliberalism (1990-1995) Deregulation Phase I (1996-1999) Deregulation with the advent of National Electricity Market (from2000onwards)	*REG* *REG1* *DEREG* *NEM*
Victoria		Normal Regulatory Period (1960-1988) Regulatory Period influenced by emerging neoliberalism (1989-1993) Deregulation Phase I (1994-1999) Deregulation with the advent of National Electricity Market (from2000onwards)	*REG* *REG1* *DEREG* *NEM*
Queensland		Normal Regulatory Period (1960-1990) Regulatory Period influenced by emerging neoliberalism (1991-1996) Deregulation Phase I (1997-2001) Deregulation with the advent of National Electricity Market (from2002onwards)	*REG* *REG1* *DEREG* *NEM*
South Australia		Normal Regulatory Period (1960-1994) Regulatory Period influenced by emerging neoliberalism (1995-1999) NEM Phase I (2000-2003) NEM Phase II (from2004 onwards)	*REG* *REG1* *NEM1* *NEM2*

Hypothesis 4: *Deregulated electricity pricing system leads to increasing departures from stipulated environmental norms*.

Figures 4-19 to 4-21 provide trends of departure of CO_2 emissions from standard emission norms.[4] (The data for these figures are provided in Appendix B.)

Figure 4-19: CO2 Emission Trends (US)



[4] Standard emission norms have been identified by Frontier-Economics (2013a). "Input assumptions prepared for IPART." Frontier Economics Publication, Australia, electronic copy available at: www. frontier-economics. com.

The suggested norm for coal and natural gas fired electricity generation according to this report are 852 and 367 gm CO2/kWh respectively.

Figure 4-20: CO2 Emission Trends (UK)

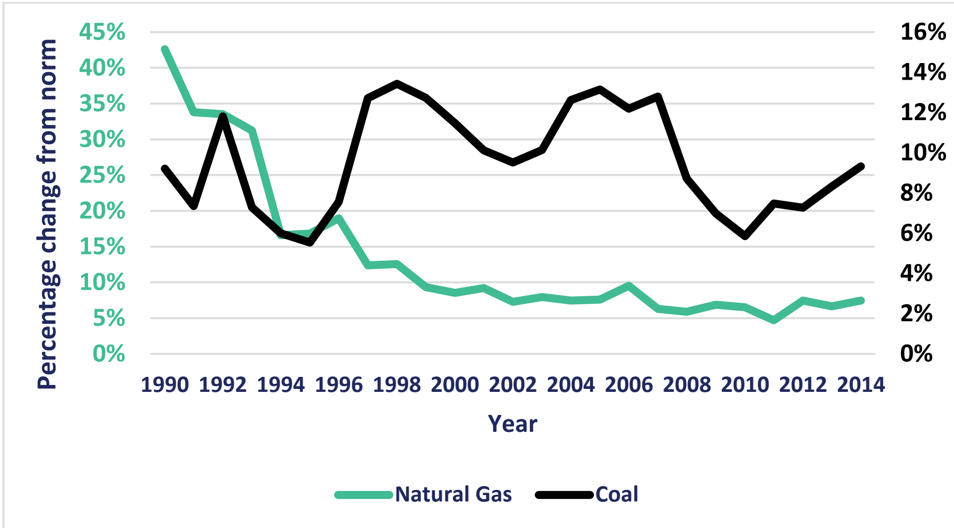
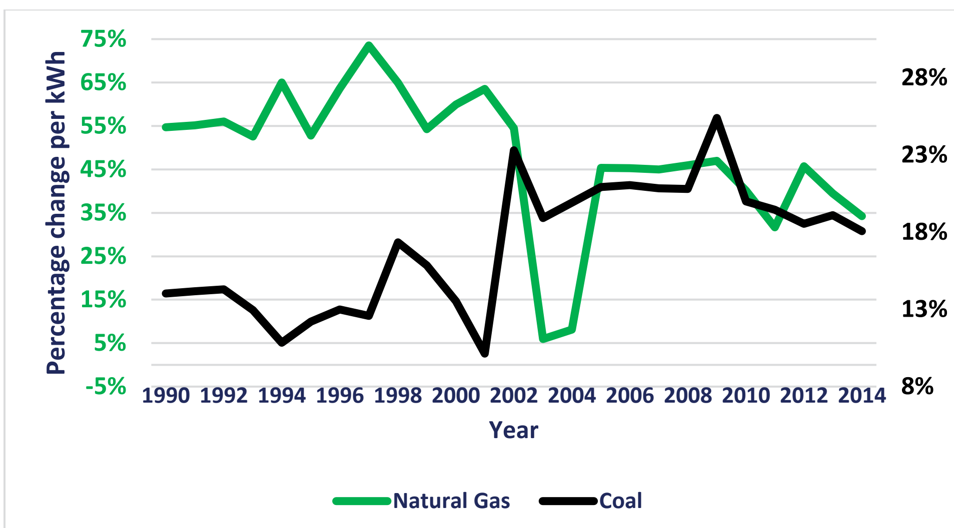


Figure 4-21: CO2 Emission Trends (Australia)



Visual examination of the figures during the period (1990-2014), suggests, that there exists significant scope for reducing emissions in both coal and natural gas fired electricity generation plants in all the three countries. Emissions have tended to increase significantly in the case of Australia following deregulation and introduction of market-based electricity pricing system.

The generic model described in Equation 4-1 has been adopted for estimation. Change in *CO2* emissions per kWh from norm (expressed in percentage) has been chosen as the performance variable for *Hypothesis 4*. Table 4-6 provides description of major phases in the evolution of electricity industry and other details of the econometric model.

Table 4-6: Hypothesis 4

Country	Dependent Variable	Major phases in the evolution of the industry considered for regression	Regressor symbol
US	Departure of CO_2 emissions from identified norm.	PURPA Period (1981-1998) Deregulation from March 1998 onwards	*PURPA* *DEREG*
UK		Deregulation Phase I (1990-1995) Deregulation Phase II (1996-2000) Deregulation (New Electricity Trading Agreements Phase—from 2001)	*PL1* *PL2* *NETA*
Australia		Regulatory Period influenced by emerging neoliberalism (1990-1995) Deregulation Phase I (1996-1999) Deregulation with the advent of National Electricity Market (from2000onwards)	*REG1* *DEREG* *NEM*

4.5 Econometric Regression Results and Discussion

Regressions were conducted on the models for all the hypotheses. The econometric regression results of *hypotheses 1, 2,* and *3* are presented in in Table 4-7.

Table 4-7 ***Results of Hypotheses (1,2 & 3)***

US		REG	INFLOILSH	PURPA	DEREG		ADJRSQ	Du-Wat
	Hyp.1 (*Profit*)	0.562006	0.560748	0.993487	1.038718		0.4400656	0.656109
		(7.719885)	(8.169851)	(20.47027)	(20.17821)			
	Hyp.2 (*Price Trends*)	-0.112395	1.336246	4.299062	6.399943		0.907821	0.543077
		(-0.383819)	(5.174168)	(23.54198)	(33.04220)			
	Hyp.3 (*Inequity*)	1.375000	1.444444	2.975556	4.279375		0.788108	0.4918490
		(6.486970)	(7.227969)	(21.05710)	(28.55187)			
UK		REG	REG1	PL1	PL2	NETA	ADJ RSQ	Du-Wat
	Hyp.1 (*Profit*)	0.142328	0.752008	3.239634	2.215171	3.380280	0.494778	0.419598
		(0.231307)	(1.728374)	(6.448250)	(4.024969)	(10.27749)		
	Hyp.2 (*Price Trends*)	0.355566	1.448963	3.376599	2.142002	4.684121	0.390069	0.259941
		(0.344282)	(2.291057)	(4.623691)	(2.677556)	(9.797737)		
	Hyp.3 (*Inequity*)	0.852500	1.873750	3.118333	3.086000	3.955662	0.770678	0.527881
		(2.968017)	(9.225685)	(13.29659)	(12.01221)	(25.76471)		
NSW		REG	REG1	DEREG	NEM		ADJ RSQ	Du-Wat
	Hyp.1 (*Profit*)	-0.062101	0.788380	1.061286	4.136521		0.717399	0.321443
		(-0.301705)	(1.712915)	(1.882726)	(14.21037)			
	Hyp.2 (*Price Trends*)	1.654191	5.857796	4.765193	5.105419		0.493590	0.154989
		(4.974464)	(8.012566)	(5.321968)	(11.04177)			
	Hyp.3 (*Inequity*)	-0.109298	1.003765	2.634995	5.641594		0.835592	0.324521
		(-0.542946)	(2.229936)	(4.779632)	(19.81673)			
Victoria	Hyp.1 (*Profit*)	0.029800	-1.122589	0.773177	3.921340		0.554484	0.330023
		(0.100815)	(-1.576941)	(1.189773)	(9.540911)			
	Hyp.2 (*Price Trends*)	1.614895	6.751481	7.576373	12.39513		0.779771	0.244133
		(3.455185)	(6.104246)	(7.503865)	(19.41086)			
	Hyp.3 (*Inequity*)	-0.105537	1.989750	4.642945	8.069749		0.872672	0.357145
		(-0.419447)	(3.283663)	(8.393521)	(23.06645)			
Queensland	Hyp.1 (*Profit*)	-0.102308	0.801347	2.355684	4.067539		0.685107	0.382871
		(-0.483694)	(1.666766)	(4.472812)	(12.45323)			
	Hyp.2 (*Price Trends*)	0.723067	2.347387	2.747150	4.121812		0.729877	0.177542
		(4.555284)	(6.613578)	(7.065509)	(17.09369)			
	Hyp.3 (*Inequity*)	0.308349	2.249753	2.325251	6.293673		0.809113	0.384134
		(1.442415)	(4.629964)	(4.368396)	(19.06527)			
South Australia		REG	REG1	NEM1	NEM2		ADJ RSQ	Du-Wat
	Hyp.1 (*Profit*)	0.084857	4.072000	6.480000	11.30545		0.902883	0.626984
		(0.338769)	(6.144315)	(8.745521)	(25.30259)			
	Hyp.2 (*Price Trends*)	1.339757	3.814778	5.221675	8.377519		0.767359	0.231637
		(5.021727)	(5.483300)	(6.713168)	(17.86074)			
	Hyp.3 (*Inequity*)	-0.080571	3.684000	2.732500	4.352727		0.889741	0.814506
		(-0.696174)	(12.03115)	(7.981651)	(21.08436)			

Note: t-statistics given in the parenthesis

Discussions: Hypothesis 1 *(Deregulated electricity pricing system leads to disjuncture between electricity costs and prices.)*

Statistically-significant coefficients, representing mean-value of profits show that profit became fortified post deregulation in all the countries and regions. For instance:

- In the US, the mean value of profits has been the highest during the period of deregulation; profits rose from 0.56 USC/kWh (under regulatory pricing regime pre-1970s), to 1.04 USC/kWh during deregulation, and 1.0 USC/kWh during PURPA (which is also significant)
- In the UK, the mean value of profit was highest during the period of NETA; mean profit rose from 0.14 UKP/kWh (during regulated pricing regime that existed pre-1980s), to 3.2 UKP/kWh (during deregulation phase 1(1990-1995)), to 3.4 UKP/kWh (during NETA).
- Profits were highest during period of NEM in all the four states of Australia. In New South Wales, the mean profit rose from 0.06 AUC/kWh (during regulated pricing pre-1970s), to 1.06 AUC (during pre-reform period pre-1990s), and from there on to 4.1 AUC/kWh (during NEM). In Victoria, the mean profit rose from 0.03 AUC/kWh (during regulated pricing pre-1970s), to 0.8 AUC/kWh (during initial pre-reform phase pre-1990s), and from there on to 4.0 AUC/kWh (during NEM). In Queensland, the mean profit rose from (-) 0.1 AUC/kWh (during regulated pricing pre-1970s), to 2.35 AUC/kWh (during pre-reform phase pre-1990s), and from thereon to 4.06 AUC/kWh (during NEM).
- Profits of South Australia are distinctly higher. The mean profit rose from zero (during regulating pricing pre-1970s), to 4.07 AUC/kWh (during pre-reform phase pre-1990s), to 11.3 AUC/kWh (during NEM 2).

The above analysis clearly suggests that deregulation did indeed promote a disjuncture between cost and prices, thus establishing ***Hypothesis 1***.

Discussions: Hypothesis 2 *(Deregulated electricity pricing system encourages and sustains increasing electricity price trends)*

Steepening electricity price trends have followed deregulation – the statistically significant coefficients representing mean changes in price trends establish this fact – they also show that there exists a proclivity for even higher price increases when divestiture of assets occur at elevated price levels. The results of tests of Hypothesis 2 show:

- In the US, the mean price change over base year of 6.4 was the highest (during deregulation) followed by 4.3 (during PURPA); in the UK, the highest was 4.7 (during NETA) followed by 3.4 (during pre-reform (pre-1990s).
- In NSW, the highest was 5.8 (during pre-reform) followed by 5.1 (during NEM); in Victoria where the assets got sold at record high prices the highest mean change was 12.4 (during NEM) followed by 6.7 (during pre-reform); the results of South Australia follow Victoria closely – the highest was 8.4 (during NEM).
- The price changes in Queensland were relatively lower – the highest mean change was 4.12 (during NEM) followed by 2.3 during pre-reform period.

The above analysis clearly suggests that deregulation has resulted in increasing price trends, thus establishing ***Hypothesis 2***. Further it is seen that government induced price changes during pre-reform period may also have contributed to the increasing price trends.

Discussions: Hypothesis 3 (*Deregulated electricity pricing system contributes to increasing social inequity*.)

Shift of pricing system towards marginal principles initiated divergence in electricity prices between domestic and industry consumers – deregulation and introduction of market-based pricing has propelled this divergence – statistically-significant coefficients representing mean inequity point to this. For instance:

- In the US, the mean inequity was highest at 4.3 USC/kWh (during deregulation), as compared with 3 USC/kWh (during PURPA); in the UK the highest was 3.95 UKP/kWh (during NETA) followed by 3.11 UKP/kWh (during pre-reform period)
- In Australia, Victoria registered the highest mean inequity at 8.06 AUC/kWh. Queensland also showed proclivity toward high inequity at 6.29 AUC/kWh (during NEM). NSW at 5.64 AUC/kWh and South Australia at 4.35 AUC/kWh (during NEM) are also significant.
- Inequity during pre-reform period in the Australian states was in the range of 2 to 3.68 AUC/kWh.

The above analysis confirms that mean inequity that began to grow with the introduction of pricing based on marginal principles was accelerated to much higher rates following introduction of deregulation and market-based pricing.

Table 4-8: ***Results of Hypothesis 4***

US		PURPA	DEREG		ADJ RSQ	Du-Wat
	Hyp.4a (*Coal emission*)	0.113721	0.104200			1.381438
		(13.97467)	(17.07278)			
	Hyp.4b (*NG emission*)	0.536725	0.197172		0.709087	0.816932
		(15.24080)	(7.465161)			
UK		PL1	PL2	NETA	ADJ RSQ	Du-Wat
	Hyp.4a (*Coal emission*)	0.078623	0.115815	0.096053	0.167466	0.923823
		(8.191257)	(11.01475)	(15.28625)		
	Hyp.4b (*NG emission*)	0.290993	0.123611	0.072090	0.743012	1.243372
		(13.39788)	(5.195389)	(5.070080)		
Australia		REG1	DEREG	NEM	ADJ RSQ	Du-Wat
	Hyp.4a (*Coal emission*)	0.560472	0.641152	0.407939	0.301678	1.447693
		(10.28106)	(9.602836)	(11.83176)		
	Hyp.4b (*NG emission*)	0.125823	0.141897	0.188330	0.435388	1.633791

Note: t-statistics given in the parenthesis

Discussions: Hypothesis 4 (*Deregulated electricity pricing system leads to increasing departures from stipulated environmental norms*)

The regression results show that mean departure of emissions from norms has been significant in Australia, post deregulation, with respect to both coal and natural gas – above norms by 41 to 64 % for coal and 14 to 19% for natural gas. Coal emissions have increased post deregulation in the UK above norms from 8 to 12 %. In the US post-deregulation, the mean departure from stipulated norms for natural gas has been19.71 %; this is higher than that of the UK as well as that of Australia. The emission departures from norms clearly bring out the fact there is significant scope for improvement in all the countries.

Econometric assessment conclusions

Regression results have conclusively proven ***Hypotheses 1, 2 and 3*** for all the countries/regions considered in this research. The results also suggest that the effects of reforms were more profound when deregulation was accompanied by privatisation of assets. It is also significant to note that profits during the deregulation period are largely due to price increases. The results also show that South Australia, Victoria and the UK have experienced relatively higher increases in electricity prices and inequity levels. The results of ***Hypothesis 4*** point to Australia more specifically, as moving away from environmental norms, followed by the US. A greater reliance on profit by increasing prices is evidenced by the results.

4.6 Summary

The objective of this chapter was to provide a comprehensive review of deregulated electricity pricing system with a view to assess its appropriateness. The following are the major findings of this review.

- A confluence of many factors and developments led to the deregulation of ESIs worldwide. ESIs of the developed world faced a major turning point in the 1980s when they were faced by technology plateauing – which meant ceasing of scale economies and the prowess of ESIs to earn profit. The capital intensiveness of the ESIs that had hitherto provided the capital base for earning returns began to be viewed as burdensome as the decreasing cost industry began to take the trajectory of increasing costs. The industry in the US began to be viewed with circumspection, the monopoly status awarded was questioned and the regulatory system blamed for its lenience to the industry.
- Following the success of PURPA in introducing low-capital electricity generating companies, economists saw the opportunity for fragmenting the industry into competitive and monopoly segments and subject the competitive segments to market-based competition.
- Accelerated capacity growth and technology glitches that followed technology plateauing made electricity prices to increase significantly worldwide. Fuel price increases following Middle-East oil shocks exacerbated the situation.
- Neoliberal think tanks (the advocates of privatisation and deregulation) seized this opportunity to push for deregulation of ESIs – they portrayed how competing generating companies vying to supply electricity in a free-market environment will succeed in generating electricity price that would approximate marginal energy costs when supply was in excess of demand, and during periods of relative supply shortages they could rise to higher levels to reflect marginal capacity costs. This process they argued provided the right price signals to maximise allocative efficiency. For network service, the neoliberal think tanks

suggested an incentivised regulatory pricing system, and at the retail level they envisaged deregulation by providing consumers the choice to select their electricity supplier.

- Neoliberal think tanks were able to influence governments owning the industry to deregulate by citing the advantages of revenue to Treasury following sale, an improved vote bank by offering public shares of the industry and elimination of worker-led unions. CEGB was the first major ESI to be deregulated and this paved way for introducing deregulation of ESIs worldwide. Governments owning the industry were attracted by the sale revenue following the privatisation of assets. This new practice eventually set off a new paradigm of recapitalising electricity assets for the sake of gaining capital. Deregulation and privatisation of CEGB was portrayed as a success by neoliberal proponents. The profits that accrued to the private companies in its initial spell after deregulation in the UK were astounding. This business became lucrative – the Victorian ESI privatisation that followed fetched the government sale revenues that were far higher than their estimated values, which were already high (as they were based on inflated electricity prices set up by the government prior to sale).
- Neoliberalism was embraced by the World Bank, IMF and other multilateral funding institutions. Pursued by the US and other developed economies, these institutions stipulated neoliberal covenants for the loan-seeking developing countries such as privatisation, deregulation, tax reductions and repatriation of profits. The developing countries that were in dire need of funds for improving their electricity infrastructure were thus drawn into the fold of market-based electricity reforms.

Over time anomalies of electricity reforms began to surface – paradigm changes in the functioning of electricity businesses appeared to emerge. Actual outcomes of reforms began to diverge from the expectations and claimed benefits, leading to controversies about their true objectives.

Reform skeptics voiced their disagreement with market-based pricing for an essential commodity like electricity. They maintained that exclusive emphasis on profit will lead to deterioration of social and environmental values. They brought to the fore several fallibilities of the reforms. They argued for example, that:

- Technical constraints make electricity demand response highly inelastic to price changes. Subjecting such a commodity to market-based pricing would inevitably lead to price volatilities. The binding technical requirement of simultaneity between generation and consumption makes electricity demand highly inelastic and in a market environment this provides an opportunity for the generating businesses to strategically generate shortages for the sake of setting higher prices.
- The introduction of market-based pricing made it easier for the electricity generating businesses to realise high profits – it was no longer necessary to engage in innovative efforts to reduce costs to obtain profits. Electricity generating businesses are being overtaken by a new culture – companies resorting to deliberate withdrawal of efficient generation capacity to set higher prices and earn high profits. High marginal-cost plants such as simple-cycle gas turbines and old polluting coal-fired power plants are substituted to set higher market prices. A culture of resorting to the abuse of market power for earning profits has emerged.
- The higher electricity prices affect the households and socially depressed segment of society. Larger consumers and industries are able to obtain electricity at lower prices through negotiations with electricity supply companies. Social inequity has become increasingly institutionalised.
- Investments in energy efficient generating power plants are avoided by companies in order to bring reserve margins to such levels so that perpetually increasing electricity price trends can be maintained. The regulated pricing of the monopoly segments is also on very generous terms.
- With passage of time, the electricity companies have embarked on increasing their market power and scale economies – through a process of reintegration both horizontally and vertically. Large monopoly companies are re-emerging – a *volte face* to the monopoly structure of the industry but without a regulatory pricing system.
- The developing countries which adopted electricity reforms to receive loans also face serious problems – electricity prices have risen significantly – and job-losses in the electricity sectors are rampant. The only beneficiaries are large multinational ESI companies.

Proponents of neoliberalism defend the virtues of electricity reforms. They maintain that reforms are based on well thought out competitive market principles. The poor outcomes, they argue, are due to the inadequacies in implementation of reforms and increasing factor costs that are exogenous to reforms. Many pro-reform studies using statistical/mathematical models have been carried out to support the view that how *capacity-utilisation factor*s (a key to portray success of reforms) are due to the lack of vertical and horizontal disaggregation and ineffective independent regulation.

However, as electricity prices have continued to increase unrelentingly, supporters of reform have shifted their stance. They now argue that such increases in electricity prices and exercise of market power are essential for the stability of the sector and for encouraging timely investment in the industry. They even argue that increasing electricity price are necessary for curtailing profligate consumption. The anticipated price reductions that spurred the reforms were no longer in the radar of the reformists.

Based on the understandings derived from the above reviews, this research has formulated specific hypotheses and econometrically tested them for their veracity, for the United States, the United Kingdom, and the Australian states of New South Wales, Victoria, Queensland and South Australia extending over several decades.

The econometric analysis suggests that following deregulation, there has been an accentuating disjuncture between price of electricity and cost of producing electricity; electricity price increases have accelerated post deregulation; the deregulated pricing of electricity, based on marginal principles, has shifted a disproportionate percentage of price burden on the economically weaker segments of the society; and deregulation has generally produced adverse environmental outcomes as measured in terms of CO2 emission.

The wave of neoliberalism has overwhelmed the electricity sector. The electricity pricing system is exclusively driven by considerations to maximise profits. The proclivity to keeping low reserve margins, by shunning investments in efficient base-load electricity generating plants and resorting to investments in low-capacity high-variable cost plants, has assumed alarming proportions.

The entire deregulation exercise appears to have only accomplished the task of cherry picking profits from the assets that were already established by nationalized electricity utilities. The market-based pricing system appears to have only succeeded:

- in generating a trend of increasing prices even though fixed costs are either low or even non-existent (as the new investments are fewer and the older assets have already been paid-off; the new capital is only a non-existent financially conceived speculatively created capital)
- in sustaining price increases despite declining demand growth; and
- in avoiding investments in efficient base-load generating plants.

This chapter also brings to the fore another important question – whether indiscriminate introduction of generation from high variable cost (inefficient) plants to substitute generation from efficient base-load plants for the sake of profit, has led to in lowering of capacity utilisation – contrasting the claimed virtues of improving allocative efficiency by reform.

The above aspect would need further investigation to get a broader outlook on the motives of market-based pricing. Accordingly, in the following chapter, this thesis analyses the impact of introduction of high-variable, low-fixed cost plants on the capacity utilisation of base-load plants. This analysis will include, as before, the United States, the United Kingdom and Australia.

5 ALTERNATIVE TO MARKET-BASED ELECTRICITY PRICING SYSTEM

5.1 Introduction

Chapter 4 revealed how electricity deregulation, supported by market based pricing system for generation and incentive-based regulated pricing system for transmission and distribution, shifted the ethos of this industry by singularly emphasising profits. High electricity prices, assisted by the exercise of market power, are even regarded as inevitable for ensuring financial stability and future investments. *Volte face* reversals through horizontal and vertical reintegration of the industry belie the principles of competition; rolling back to achieving scale economies with substantial market power has become a new reality. Efficiency and lower consumer prices have become a far cry.

Chapter 4 has also highlighted the need for investigating the impact of rapid introduction of simple cycle gas turbines and other similar high variable-cost plants (to buttress the exercise of market power) and its implications on capacity utilisation of base-load plants. Such an investigation should establish whether deregulation actually improved allocative efficiency.

This chapter, based on the insights gained from the analyses in the previous chapters, suggests an alternative pricing paradigm that can provide impetus to allocative efficiency without compromising social, environmental and economic considerations.

Section 5.2 reviews capacity utilisation in the generation segment, post deregulation. Section 5.3 examines the challenges posed by deregulated pricing system. Section 5.4 provides an alternative approach for pricing. Section 5.5 provides a summary of the findings of this chapter.

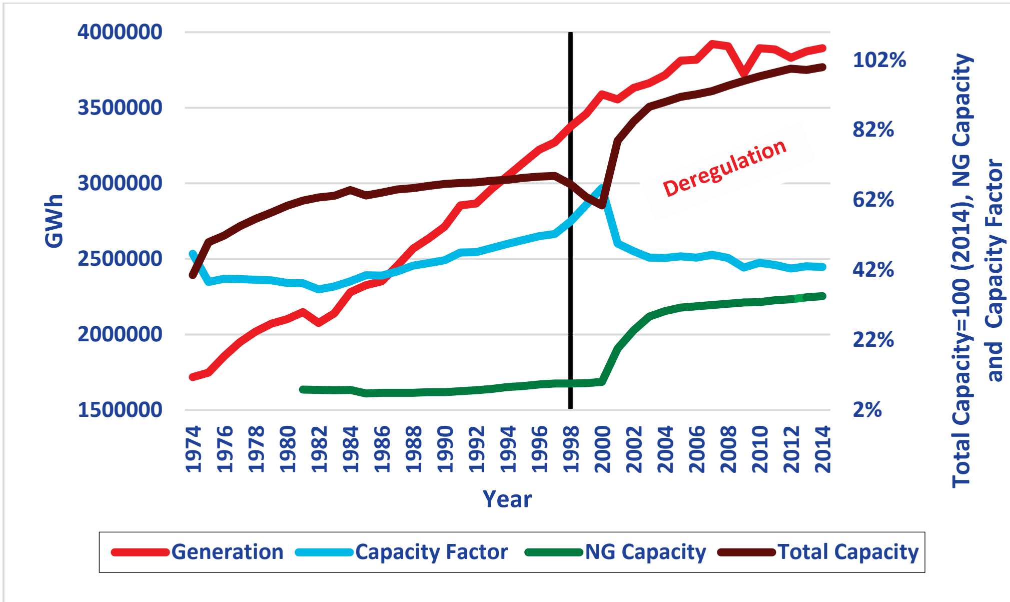
5.2 Capacity Utilisation post deregulation

This section presents the following trends to demonstrate the implications of de-regulation on capacity utilisation. Also presented are the analyses of these trends.

Overall Capacity Utilisation

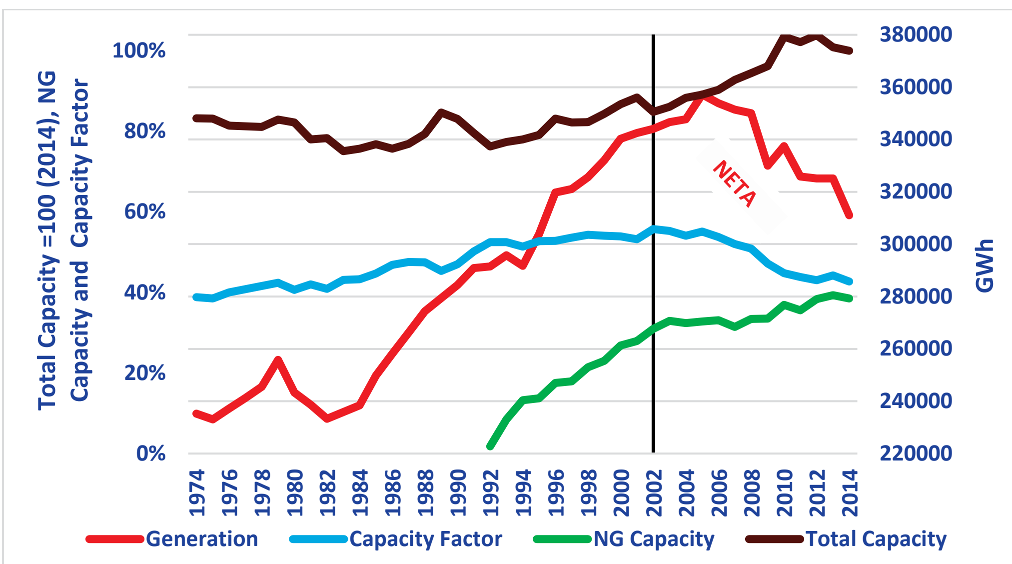
Figures 5-1 to 5-3 present trends for the period 1974-2014; for total capacity (expressed as percentage capacity of the year 2014), capacity utilisation factor, natural gas capacity (expressed as percentage of total capacity), and total generation.

Figure 5-1 Total Generation, Total Capacity, Capacity Utilisation, Percentage NG capacity (US)



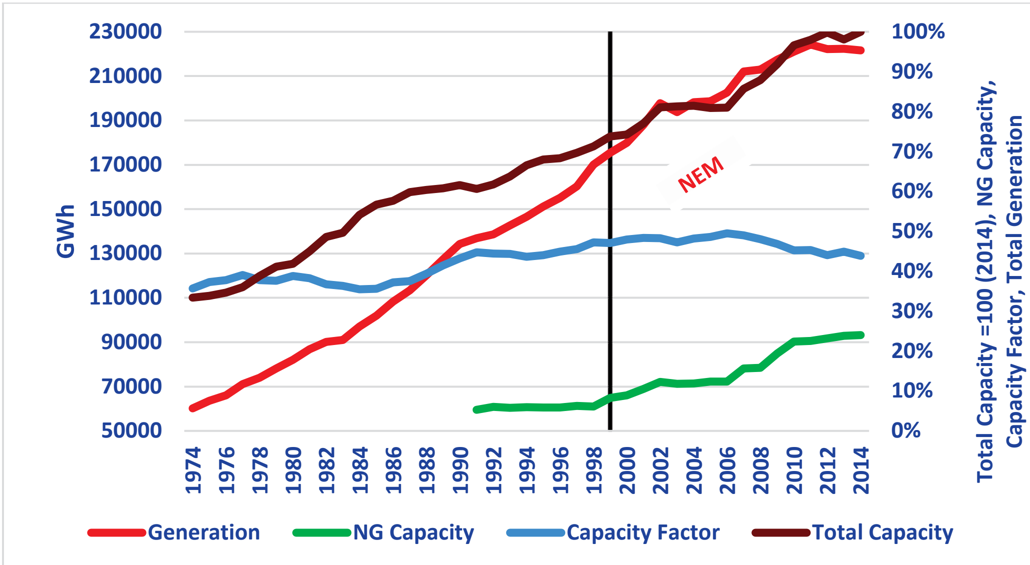
Sources: Data developed from EIA (2016), IEA (2017a2), IEA (2017o), IEA (2017t)

Figure 5-2 Total Generation, Total Capacity, Capacity Utilization, Percentage NG capacity (UK)



Sources: Data developed from IEA (2017a2), IEA (2017o), IEA (2017t)

Figure 5-3 Total Generation, Total Capacity, Capacity Utilization, Percentage NG capacity (Australia)



Sources: Data developed from IEA (2017a2), IEA (2017o), IEA (2017t)

These figures clearly show that capacity and capacity utilisation trends were improving during the pre-reform years, which could be attributed to assured prices and assured markets provided by the regulatory regimes which in turn incentivised better capacity utilisation resulting in cost reductions. The reversal of these trends started only after these enabling factors were withdrawn, with the introduction of market-based reform.

- Capacity utilisation factor in the United States improved considerably over the period 1974-1998. This period represented a period of generous prices and assured markets for the qualified IPPs under PURPA. Electricity reforms were initiated in 1998, and over the period 2000-2014, capacity utilisation factor experienced a steep decline. This can be explained by the fact that, following the onset of deregulation (in 1998), conservation efforts were discontinued. Additionally, capacity additions during these years were predominantly simple cycle gas turbines (low fixed cost/high variable cost) as they offered prospects of charging high market prices – to gain high profits. Emphasis on higher prices through exercise of market power rather than cost-reductions through improved capacity utilisation became the new trend for gaining profits.
- In the UK, the capacity utilization improvements over the period 1970-1990 could be attributed to the strict oversight by the government which ensured publicly-owned ESI

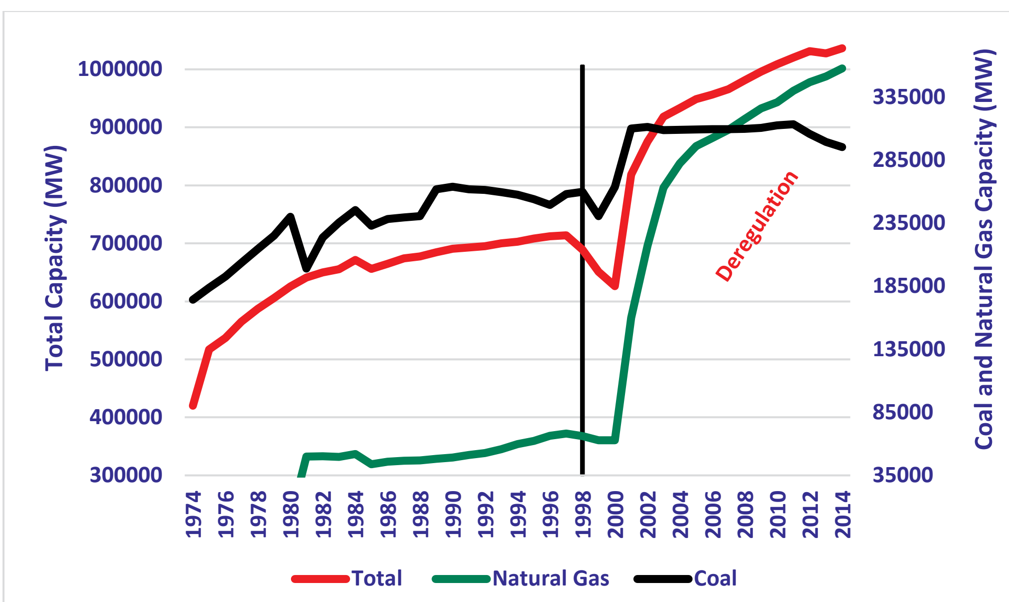
adhering to high performance standards. These trends continued till the year 2002. In these years the high costs of new IPPs were borne by captive consumers (MacKerron and Watson 1996, Thomas 1996). The introduction of NETA presented opportunities for the exercise of market power, and hence low-fixed-cost and high-operating-cost gas turbine plants were added rather than the more efficient base-load plants (Currie 2002, Beder 2003, Beder 2007).

- In Australia, such incentives were not available to the ESIs. Hence capacity utilisation factors began to decline right from the onset of deregulation. The improving trends, in the mid-1980s to the late 1990s, are however attributable to performance improvements resulting from 'internal reforms' of the ESIs. These reforms emphasised better management and control arrangement for the ESIs. Further, the continuation of improving trends beyond the late 1990s, till the year 2004, could be attributed to the growing demand for electricity averaging, approximately 3.8TWh per year, without any additions to generation capacity. After 2004, the capacity utilisation started to decline, following the introduction of simple-cycle gas turbine generating plants.

Capacity by fuel

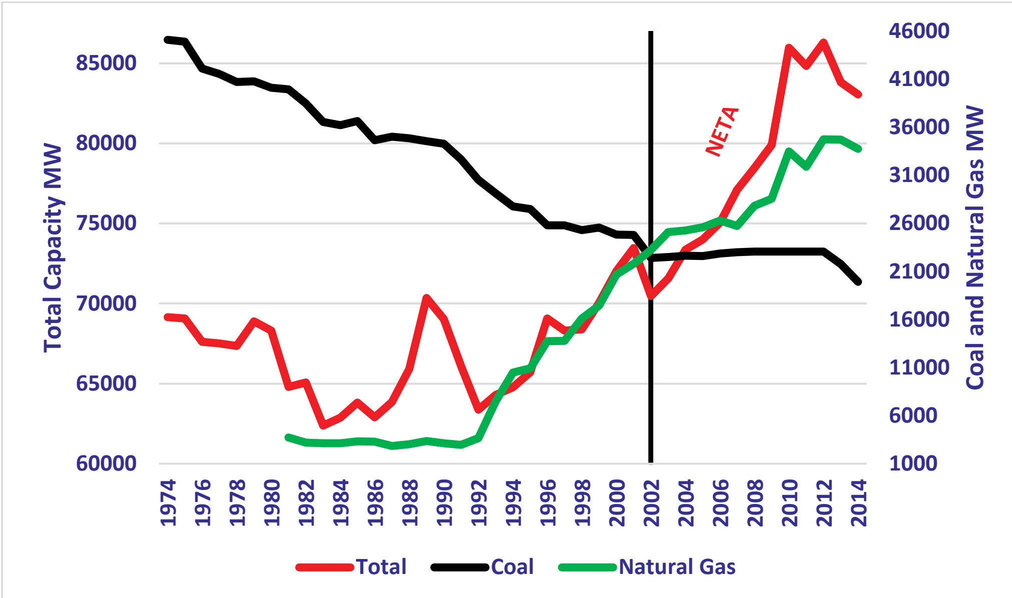
Figures 5-4 to 5-6 show trends in total capacity, coal capacity and natural gas capacity.

Figure 5-4: Generation capacity by fuel (USA)



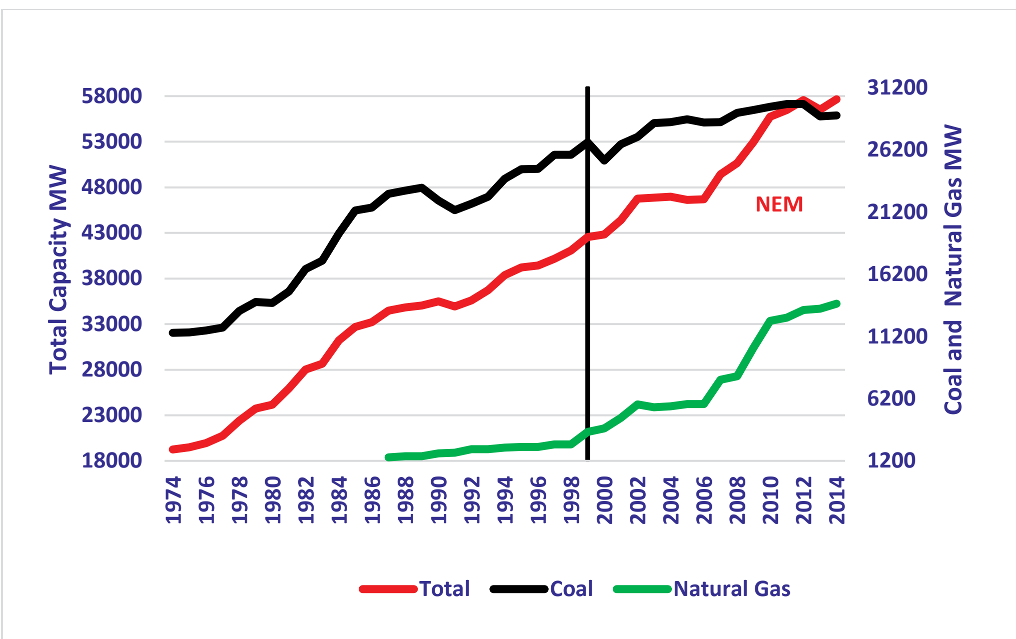
Sources: Data developed from IEA (2017o), IEA (2017s), IEA (2017t)

Figure 5-5: Generation capacity by fuel (UK)



Sources: Data developed from IEA (2017o), IEA (2017s), IEA (2017t)

Figure 5-6: Generation capacity by fuel (Australia)



Sources: Data developed from IEA (2017o), IEA (2017s), IEA (2017t)

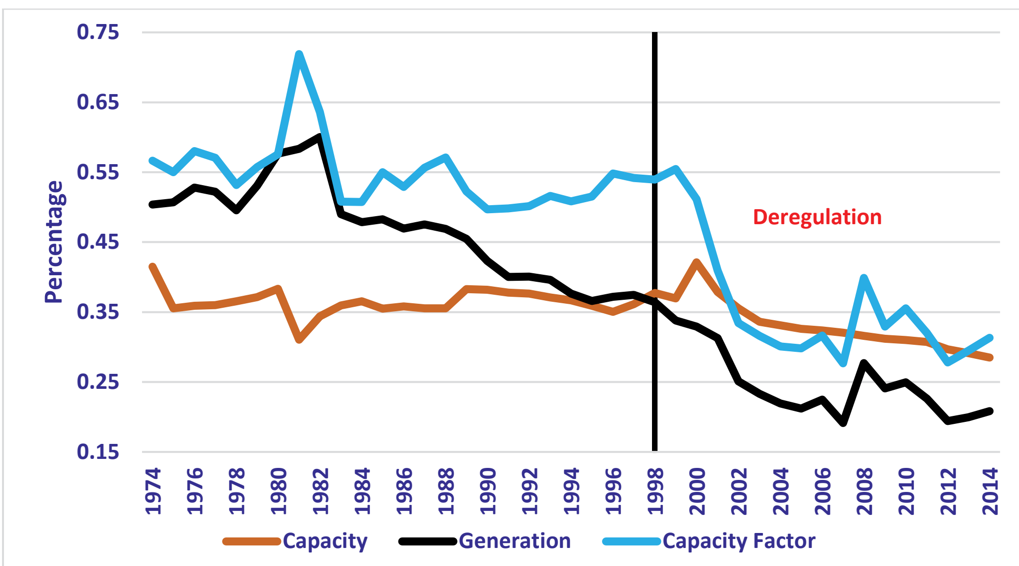
These figures clearly suggest that deregulation resulted in a shift in the fuel choice away from coal, towards natural gas in all countries under consideration.

- In the U.S, for example, gas capacity increased by nearly tenfold since the start of deregulation in 2000. Relatively marginal increases in coal capacity also took place over these years. Further, total capacity began to flatten from year 2002. The increases in gas capacity in the US predominantly falls in the class of simple cycle gas turbines post deregulation. The increases in CCGT plants have largely taken place during PURPA years.
- In the UK, while the natural gas capacity increased significantly post deregulation (1990s), coal based capacity began to decline. From 2009, the overall capacity also began to decline.
- In Australia, natural gas capacity rose significantly post deregulation (late-1990s). Coal capacity continued to increase initially, however, from around 2002, its growth has plateaued. The increase in gas capacity was predominantly in the form of simple-cycle gas turbines.

Capacity utilisation of coal plants

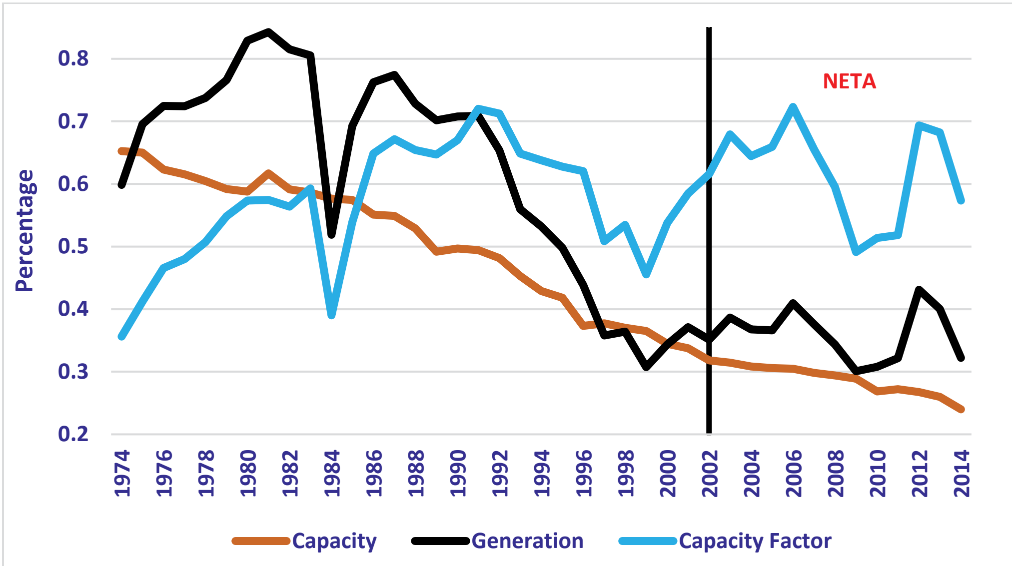
Figures 5-7 to 5-9 present trends in coal capacity, coal generation, and coal capacity factor.

Figure 5-7: Capacity Utilization Coal-based Power Plants (US)



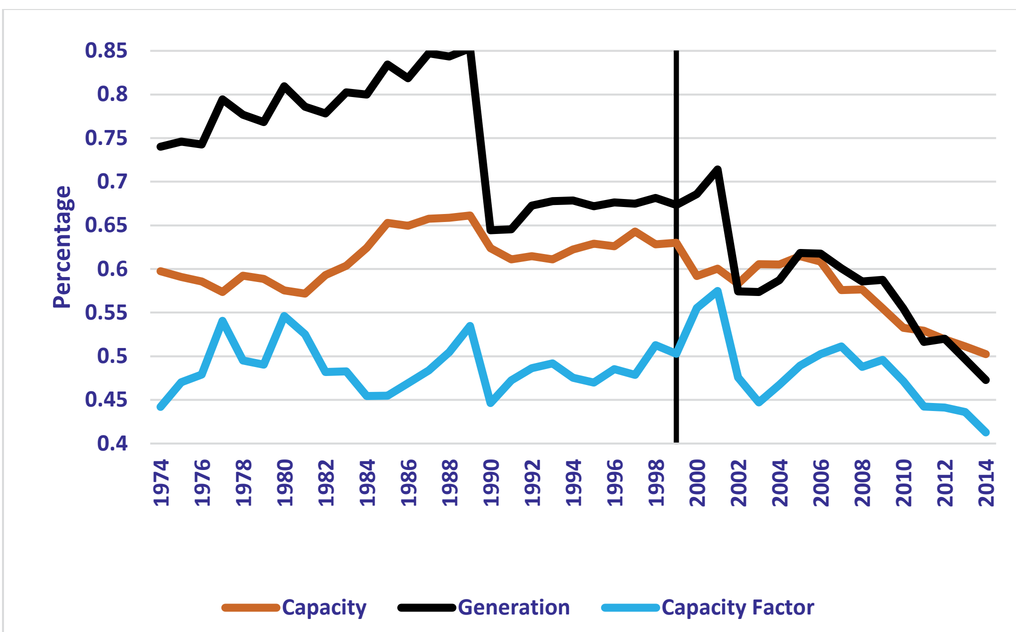
Sources: Data developed from IEA (2017(1b)), IEA (2017(1d)), IEA (2017(1j))

Figure 5-8 Cap. Utilization Coal-based Power Plants (UK)



Sources: Data developed from IEA (2017(1b)), IEA (2017(1d)), IEA (2017(1j))

Figure 5-9 Cap. Utilization Coal-based Power Plants (Australia)



Sources: Data developed from IEA (2017(1b)), IEA (2017(1d)), IEA (2017(1j))

These figures clearly show that the utilisation factors of coal fired power plants have declined since the introduction of deregulation.

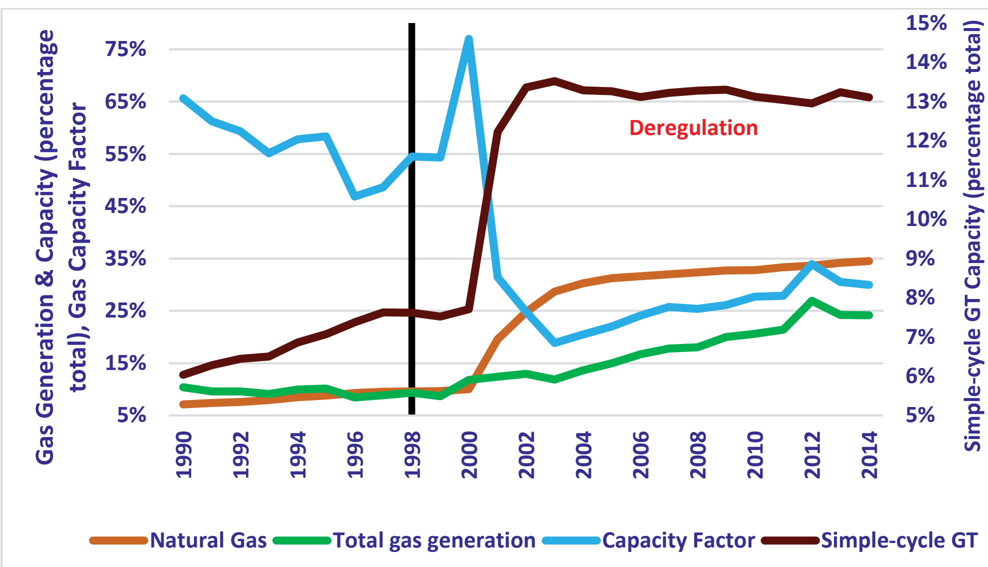
In the U.S, there was a steep fall in utilisation of coal plants post deregulation even though coal based capacity remained relatively constant. In the UK, the utilisation of coal plants improved significantly in the decade preceding deregulation when the management was under pressure to reduce costs. However, post-deregulation there was a noticeable fall in the utilisation of coal plants as the government promoted CCGT plants. There was also a continuous reduction in coal based capacity.

In Australia, utilisation of coal plants improved significantly in the decade prior to deregulation, however, the utilisation of these plants had a steep fall beginning 2000. Capacity of coal plants also began to decline from 2005.

Capacity utilisation of gas based power plants

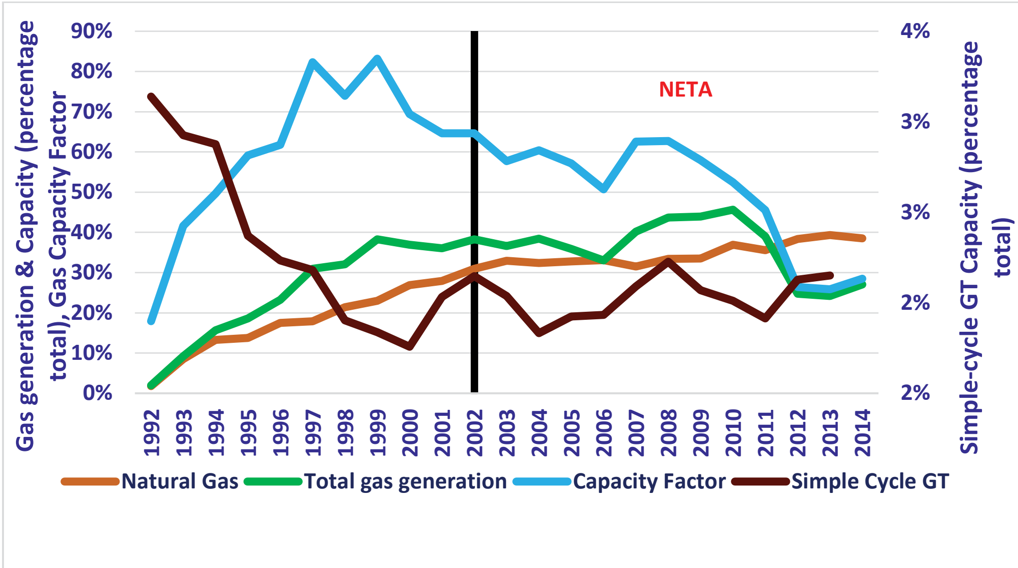
Figures 5-10 to 5-12 present the trends in natural gas capacity, natural gas generation, capacity factor and capacity of simple-cycle gas turbine plants.

Figure 5-10 Cap. Utilization NG based Power Plants (US)



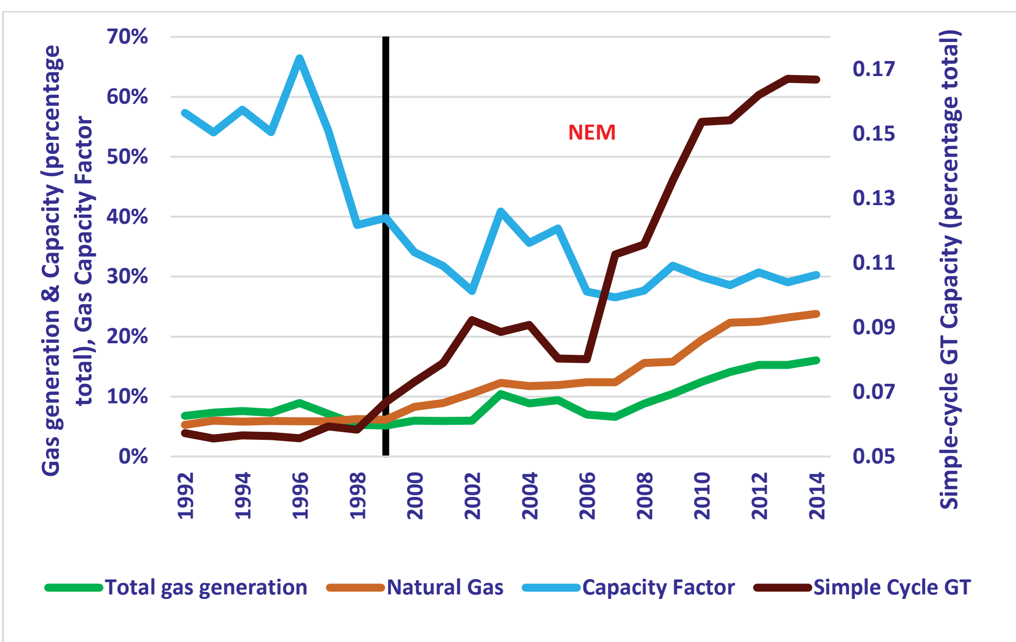
Sources: Data developed from IEA (2017(1h)), IEA (2017t)

Figure 5-11 Cap. Utilization NG based Power Plants (UK)



Sources: Data developed from IEA (2017(1h)), IEA (2017t)

Figure 5-12 Cap. Utilization NG based Power Plants (Australia)



Sources: Data developed from IEA (2017(1h)), IEA (2017t)

These figures depict trends in the utilisation of natural gas based plants that occurred during the period 1990-2014. These trends show a distinct decline in capacity utilisation following deregulation. The curves also provide evidence of the relationship between declining utilisation of natural gas based capacity and increasing trends of simple-cycle GT capacity.

1. In the U.S, natural gas based plants witnessed rapid increase in utilisation during PURPA period (to a level of 75%). In an equally striking manner, the utilisation took a steep reduction (to a level of 25%) post deregulation; interestingly, an almost contemporaneous steep increase in simple-cycle GT capacity is also seen. This clearly shows that there was no drop in demand to justify the under-utilisation of most efficient plants, but a conscious and deliberate move to substitute less efficient plants for strategic reasons.
2. In the UK, utilisation of natural gas based plants increased significantly (to a level of over 80%) during the period 1992-2002 when the government had provided an assured price and assured market. Post-withdrawal of the enabling conditions described previously and introduction of new market system (NETA), the utilisation of natural gas based plants fell significantly. Generation by natural gas fell significantly from 2010.
3. In Australia, the period 1992-1995 witnessed significant improvement in utilisation of natural gas based plants. Post deregulation utilisation of natural gas based plants fell significantly (by 30 percent). From 1999 there has been significant increase in simple-cycle gas turbine capacity for strategic reasons.

In summary: The above discussion suggests that post deregulation, the overall capacity utilisation factors in the US, the UK and Australia have assumed declining trajectories, falling at average annual rates of 1.6, 1.44 and 1.2 per cent respectively. Capacity utilization factors for natural gas fired electricity generating plants declined more significantly, by 3.7, 4.5, 1.9 per cent per annum respectively. In contrast, capacity utilization factors for coal fired electricity generating plants declined by 1.3, 3.1, and 1.23 per cent per annum respectively.

In the US, simple cycle gas turbine constituted nearly 10% of total capacity additions over the period 2001-2014. Similarly, in Australia, simple cycle gas turbines accounted for nearly 10% of total capacity addition during the period 2005 to 2014.

The analyses also reveal that the capacity utilisation rates were higher, on average by at least 2 per cent, in the pre-deregulation years – when the industry was still under the old arrangements.

5.3 Insights, challenges and thoughts for alternative approach

Chapter 2 provided a reflection on the current pricing paradigms that lay singular emphasis on profits, and economic thinking in the ancient times that emphasised fairness of *exchange value* to ensure social equity and communal harmony.

Chapter 3 described how electricity paradigms that evolved over the next hundred or so years (1880-1980) essentially aimed to sustain the profitability potential of the ESIs, regardless of their ownership.

Chapter 4 analysed the impact of deregulation on electricity prices and described how deregulation contributed to the divergence between electricity costs and prices in general and divergence in prices of various consumer categories in particular. The previous section in this chapter unambiguously established that deregulation failed to produce the anticipated outcome, i.e., to improve capacity utilisation factor of base-load power plants.

In chapter 2, review of pricing philosophies showed that human society for over 2000 years held dear the virtues of fairness, social equity and community welfare. Profiteering was looked down upon, as it could erode social values and community welfare. Aristotle even foresaw how *exchange-value* can enter thought, culture and morals, and how it could become an end product for all human endeavours rather than means. Aristotle also viewed that the introduction of money as a means of exchange led to easy substitution of the goals of exchange from natural ends to money – money can be easily multiplied through the process of exchange without limits, which he contended was unacceptable. Guan Zhong (725-645 BC), in his book *Guan Zi*, provided ideas on how prices of commodities could be reined in; he characterised profit as a covetous attraction for which people undertake inordinate struggles to possess and enrich themselves (Landreth and Colander 1976).

Agrarian advancements in the medieval periods produced significant changes in the character of human society. Substitution of human labour by capital improved productivity and profits which led to growing exchanges and monetary activities. Growing economic activity brought to the fore concerns about fairness in exchange and justness of price.

Scholastics imposed religious standards to regulate economic conduct. Prices of commodities in the marketplace began to be determined by the forces of supply and demand as well as by labour and cost. Despite these developments, profiting from scarcity, deliberate impeding of the flow of market and manoeuvring to induce scarcity were considered unacceptable. Scholastics tended to accept *exchange value* that remained within the confines of *need*. Margins in the process of exchange were viewed tolerantly if they met the criteria of virtuousness and were used for either self-support, or charity, or contributed to the public wellbeing (Wood 2002).

Scientific inventions that followed between 15th and 17th centuries led to the age of exploration; this expanded avenue for international trade. Scholastic economic thinking gave way to mercantilism that promoted nationalism, profits and accumulation of monetary wealth. Mercantilism justified profit and government-enabled economic privileges for the merchant traders. Merchants in turn, favoured governments that granted monopolies for them. The view that profit stimulated economic activity began to gain credibility (Hunt 2002).

Mid-18th century saw the emergence of entrepreneurial young independent thinkers seeking to accelerate productivity improvements – they introduced mechanisations and new techniques of labour deployment through specialisation and division of labour techniques to improve productivities. The invention of steam turbine fuelled by coal heralded a hitherto unseen magnification of industrial productivity during this period. Cantillon (in the pre-classical period) conceived a market system wherein 'profit' coordinated activities between producers and consumers better than what mercantilism ever could, marking the beginning of *laissez faire* (Landreth and Colander 1994).

Seeking to encourage these industrial capitalists, classical economic thinking emerged which was a combination of Scholasticism, Mercantilism and *laissez faire* of Cantillon and Physiocracy. This thinking reinforced *laissez faire*, introduced capitalistic ideologies and encouraged a pricing system that would promote economic growth wherein competition was considered key to enable allocative efficiency. *Capital accumulation* and continuously improving *productivities* became imperatives for economic growth. Pricing systems justified profit for the capitalist far in excess of the compensation provided to labour. Labour which was one of the factors of production was held at subsistence level. Malthus population theory that portrayed labour's high rate of fertility as unacceptable was considered veritable and classical economists produced a wages-fund doctrine that prescribed labour wage at a level of subsistence to rein in their fertility rate.

Legitimacy of profit as well as social inequality began to be accepted (Landreth and Colander 1976, Hunt 2002).

The advocacy of *laissez faire* by classical economists of the likes of Smith to achieve allocative efficiency was based on the presupposition of the existence of unrestrained competition. Smith accepted this presupposition as he was overwhelmed by the failings of the governments of his time to do any social good as the governments had actually helped the merchants to enrich themselves. Smith's advocacy of *laissez faire* was also qualified – he exempted goods and services that were essential for the society – as they were considered not profitable enough (Landreth and Colander 1994).

While classical economists argued that profits lead to efficient allocation of capital, Karl Marx considered profit as a source of exploitation of labour and harmful to the human society. Marx regarded that importance given to capital meant shifting of the orientation of economic activities from *use-values* to *exchange values*. Marx also maintained that it is labour that created *surplus-value* and not *capital* (Hunt 2002). According to Marx, stepping up rates of profit hinged on stepping up of rates of productivity which in turn depended on the choice and rate of change of technology (Landreth and Colander 1994).

Neo-classical economic theories emphasised on maximising utility and profits. John Bates Clark (1847-1938) developed a marginal productivity theory that justified return to capital and considered capital as productive to counter Marx's *theory of exploitation* – he tried to show that these returns are fair, and that equity was not compromised. Alfred Marshall (1842-1924) provided a quasi-rent theory in which he showed that during market and short-run periods factor payments become price-determined as the supply curves become inelastic and argued that during such periods profits accrue to the capital (Landreth and Colander 1994). Augustin Cournot (1801-1877) showed that profits are maximised when *marginal-cost* equals *marginal-revenue* (Landreth and Colander 1976).

Oskar Lange (1904-1965) showed that factor prices can be determined without the paraphernalia of institutions of competitive markets; he pointed to socialist economies being able to identify factor prices through a process of planning and achieving allocative efficiencies. State-firms are able to operate on long-run average costs and achieve equalisation between price and cost (Lerner 1946).

Modern economic theories have adopted the maxim '*maximise profit and minimise cost*'. Neoliberal proponents sought deregulation of businesses and advocated *free-market principles* by arguing that competing businesses, in pursuit of profit, will minimise costs and prices (Thomas 1996, Beder 2003).

Piketty (2014) has tracked the evolution of inequality since the beginning of the industrial revolution and challenges the justifiability of the traditional marginal productivity theory – by placing before the world, data on the growing inequality in the capitalist economies (Foster and Yates 2014). Piketty (2014) also points to the absence of natural forces to contain the growing inequality and contends that only options such as rapid technological progress, rising population or government intervention can be counted upon. These views of Piketty are being acknowledged by some distinguished economists like Paul Krugman, Robert Solow and others (Economist 2014, Boushey, DeLong et al. 2017).

Though innovations and breakthrough technologies produced galloping improvements in productivity during industrial revolution they were accompanied by displacement of labour, human suffering and permanent changes in the social order. On the contrary, the discovery of electricity provided a salutary experience, one that benefited humanity immensely. In fact, electricity has earned itself a place alongside water, air and sewage services indispensable to modern society.

Chapter 3 provided insights into how differing pricing strategies influenced the ESIs. ESIs that took birth in the US evolved uniquely – their evolution was bold, creative and steady. The business acumen of the founding fathers provided the industry with growth and continuously improving technology that fostered it on a declining-cost mode perennially. State provided the industry with a natural monopoly status, an assured market and a generous pricing system with regulatory oversight, which kept the initial formative phase steady. The highly industrially oriented economy and a political landscape that was influenced by the *progressive movement* provided the right environment for this industry's growth in the US (Mikis 2016).

Electric power attained superiority by providing comfortable life styles to people, increasing productivities to the factories and a whole lot of potential opportunities to the scientists for further innovations and technological breakthroughs. High fixed costs, cyclical demand, demand inflexibility, and non-storability attributes that would have otherwise dragged down other businesses were turned into opportunities for profit by the pioneers of ESIs who evolved new economic concepts. Utilizing innovative price discrimination techniques, they improved load diversity thus lowering generating costs, adopted pricing techniques based on 'value-of-service' and succeeded in generating growing profits. They also strategized pricing by partially sharing profit with consumers achieving a declining price trend to consumers. This together with regulatory oversight, projected the industry as benevolent to the society – the growing profits therefore did not raise any alarm. The potential for ever improving technical excellence and its consequent productivity increases bolstered the profits. The reimbursement of expenses under the cost-plus regulatory pricing formula translated into generous prices for the equipment manufacturers also. Incidentally this also meant beneficial remuneration for the employees.

With the above pricing strategies, ESIs continually earned revenues in excess of what was allowed by the regulatory pricing formula. ESIs resorted to ingenious fiscal practices to mask the supernormal profits; they introduced the concept of holding companies to conceal higher than allowed earnings which were now shown as legitimate company expenses. For example, a federal commission inquiry report in the US in the late 1920s revealed that such excess earnings which should have been shared rightfully with the consumers totalled a staggering US$ 1 billion. PUHCA was introduced by the government to rein the ESIs in the year 1935.

Plateauing of technology, accelerated demand growth, and exogenous increases in factor costs occurring simultaneously in the 1970s ended the golden period for the electricity industry worldwide. Technical glitches and forced outages exacerbated the problems – electricity prices soared like never before – the industry was transformed from declining-cost to a rapidly increasing-cost type. Economists, environmental activists and consumer advocates became adversaries of the traditional ESIs in the US. Regulatory pricing system came under criticism for its inefficiencies; promotional pricing techniques for the sake of ramping up business growth and increasing capital-intensiveness of the industry was strongly criticised for not contributing to economic efficiency.

The US government enacted PURPA reforms to promote energy efficient technologies and energy conservation initiatives in the electricity sector. PURPA introduced marginal avoided cost based pricing system to encourage high-efficiency low-cost technologies along with assured market. This was supplemented by innovative project financing schemes. PURPA-sponsored electricity generating companies earned super normal profits.

In the UK and other Western countries where industries were under the State-ownership, pricing based on marginal principles was deployed to ensure economic efficiency. Pricing based on marginal principles helped the State-owned ESIs to earn increasingly higher revenue streams; pricing based on marginal principles also meant that the burden of the fixed costs of the electricity industry was shifted on to the domestic consumers who were the main peak consumers.

France introduced *Tarif Vert*, an electricity pricing system based on marginal principles, right from the time of nationalisation of its ESI. *Tarif Vert* was intended to bring about rapid industrialisation and economic progress, and this also meant shifting the burden of fixed costs of the ESIs to be shared by the less privileged segment of the society.

The above discussion (as detailed in chapters 2 and 3) shows that while electricity has transformed human society by providing a lot of benefits unseen before, it has also opened avenue for growing profits and concentration of capital in the hands of industry utilising price discrimination and value-of-service based pricing techniques.

Chapter 4 discussed how, prompted by neoliberal thinking, the electricity industry was subjected to a pricing system based on market-based reforms, which were expected to bring down the prices through cost-reduction achieved by competition between electricity generating companies.

However, post-reforms electricity prices have only increased, and the increases are unrelenting. The divergence between household and industry prices is increasing like never before. Cost reductions that have taken place have only been due to indiscriminate job-reductions. Such measures have only resulted in damages to electricity generating equipment and consequent forced outages. Electricity generating companies, taking advantage of the inelasticity of electricity demand, have resorted to set high prices by engineering supply shortages. This artificial construct of price has prevented any initiative to innovatively reduce costs by improving efficiency in operation and maintenance of electricity generating assets. The companies, in order to set high prices, have also resorted to introducing inefficient generating plants (low-fixed cost/high-variable cost technologies) to substitute efficient base-load generation. Post-deregulation, the pricing of transmission and distribution based on as incentivised regulatory system has also been extremely generous and the returns of these companies have been found to be lucrative.

Chapter 4, on the basis of econometric analysis, has proved that deregulated pricing system has not succeeded in bringing down prices. Exercise of market power has vitiated the governance of the industry and enabled a culture of profiteering. Electricity prices are continuously on the rise – the spread between domestic and industry prices is widening. Electricity generation efficiencies have dropped post deregulation leading to increasing emissions.

Section 5.2 has shown how capacity utilisation of base-load electricity generating plants have experienced declining trends post deregulation – inefficient low-fixed/high-variable cost technologies have been encouraged by electricity generating companies to enable their price-setting strategies.

McNerney, Farmer et al. (2011) have shown that fuel and operation & maintenance cost of coal fired electricity generating plants have been very steady (i.e., they have not increased) since early 1990s. This supports the argument in this thesis that electricity generation costs are not responsible for increasing electricity prices post deregulation. Sharma (2004pd) explains, in the context of Australian electricity sector, how persuasive claims of the potential of market reforms to produce a pricing system that is cost reflective and non-discriminatory ended up only to satisfy narrow economic interests. Sharma (2003) points to indiscriminate job-cuts in the electricity sector post-reform in the Australian context that took place even though substantial staff-reductions through administrative steps had taken place prior to reforms – these steps seriously affected the quality of electricity services. Richardson (2017) notes that while general prices between 1996 and 2016 have risen by 64 per cent, electricity prices have risen by 183 per cent – profits in 2014, according to him was 35 % of the value of electricity supply.

Other authors have also commented on the tough commercial approaches of deregulated ESIs. For instance, in the summer of 2000, when SA was reeling under the sweltering heat, power companies sold power to Victoria and made huge profits while leaving 35000 households in SA without power. A single day revenue for one of the power companies of SA jumped from AUD 75000 on the previous day, to AUD 8.4 million on the following day (Beder 2003).

Electricity generating companies, resorting to indiscriminate market power, have even come to the notice of industry watchers – glaring instances of engineering artificial shortages during off-peak hours (affecting large number of agricultural consumers) were among them (Booth and Booth 2003). This contrasts the very low prices being offered through bilateral negotiations to big industrial users (like aluminium and glass). Beder (2003) points to such actions as unjustified as they shifted the burden of higher electricity prices on to the depressed segments of the society.

The Australian Conservative Foundation has noted that Australia's environmental performance in respect of energy usage has significantly fallen post-deregulation – in fact Australia is being equalled among the most polluting countries of the world. Beder (2007) ascribes this to the excessive deployment of old low-cost polluting power plants for the sake of earning high profits. International reviews have estimated that GHG emissions have increased by more than thirty percent since the industry was deregulated (Beder 2007). Beder (2003) also points to how research priorities changed following deregulation – for instance, she points to the discontinuance of AUD 10 million originally allocated for research in renewable energy and instead the sanction of AUD 70 million for research in brown-coal electricity generation.

Increasing horizontal and vertical integration has led to the possibility of emergence of powerful energy conglomerates. Beder (2007) considers that such energy conglomerates will be able to wield market power with greater ease and push electricity prices even further.

Even as early as 2011, a quarter of generating capacity in the UK was due for retirement (Economist 2011). In 2017, the government is saddled with the need to find UKP 110 billion to augment capacity in the next three years. As this investment will not be easily forthcoming from the market players, the government intends to guarantee higher rates above the market to attract investments.

In summary, it is amply evident that ESIs, right from their inception, have demonstrated susceptibilities to price manoeuvrings for achieving high profits. Market-based electricity reforms, that were introduced in the late 1980s to rein in increasing electricity price trends that commenced from mid-1970s, have not succeeded. It has only served to increase the susceptibilities by opening new avenues for the abuse of 'market power' which has helped artificially manipulate prices for the sake of earning high profits. This pricing system has contributed to lowering of plant efficiencies, deterioration of environmental performance, and placed a high emphasis on commercial considerations – serving only to draw all possible benefits from assets that have been set up through State/State policies using tax payers' money. Such a pricing system, this thesis argues, is unsuitable and unsustainable from a long-term point of view. With the assets of the industry reaching the stage of retirement in most of the developed world, it is argued that this pricing system could result in serious repercussions in terms of providing electricity services in a secure manner. The increasing prices of electricity and electricity equipment also pose a challenge to extend electricity access to the unconnected population in the world, particularly the developing world. Electricity being a derived form of energy, conversion efficiencies should be integral to any new pricing paradigm. This is even more salient in the context of compelling climate change threats. A rethink of alternative pricing paradigm is clearly warranted.

5.3.1 Reimagining Electricity Supply

Historically, the ascendency of ESI worldwide coincided with the periods of technological, productive and cultural excellence. The contexts and circumstances that provoked such transformations provide useful insights. Two phases of such transformations are distinct in the history of ESI's evolution.

Phase I: Substantial development of ESIs took place in the US when regulatory framework grandfathered the ESIs, resulted in a pricing system that had a sound economic base. Technological edge and a sense of pride associated with technological accomplishments nurtured the ESIs and led to their successful evolution. These factors invigorated the industry right from its infancy and helped to instil a culture of innovation and achievement.

Samuel Insull, the founding father of this industry, was an early example – he urged the manufacturers to build 5MW generating units based on steam turbine technology in the year 1903 when he realized that the surviving reciprocating steam engines had reached the limits of their capacity. Steam Turbine technology was just evolving during that period and only 1MW units were in vogue but Insull preferred larger units as this would provide better thermal efficiency and an edge over his competitors. Insull also added two more such units within a span of 2 years (1905). By 1911, he had replaced the 5MW by 12 MW units. He clearly believed that big was beautiful (Hughes 1993).

While Insull encouraged the emergence of new technologies he also demonstrated how new generating units could be combined with existing older technology systems to avail maximum advantages. He combined the AC and Direct Current (DC) technology to get the best benefits. Insull's ESI *Commonwealth Edison* achieved recognition for its best efficiency. This ESI could produce electricity at the lowest cost and hence came to be regarded as most progressive in the world.

The success of *Commonwealth Edison* served as an example for others to emulate. Insull inculcated a culture of learning. Technological innovations, engineering design and managerial techniques and economic principles received great importance. Insull was also conscious of the need to provide affordable electricity which endeared him to consumers as well and this eventually resulted in the phenomenal growth of this industry (Hughes 1993).

By 1923, Insull was able to provide electricity to a territory covering 6,000 square miles and 195 communities (Hughes 1993). The efforts of Insull and the likes of him led to significant increase in electricity generation from 5.9 GWh in 1907, to 75.4 GWh in 1927. During this period the electricity prices also declined by 55% (NMAH 2014).

Insull was also keen that ESIs were staffed by learned engineers – this led him to include technical institutions of repute to join in his endeavour of providing electricity services. Leading universities and technical institutions such as American Institute of Electrical Engineers came to the forefront to train engineers for managing technology-based industries. The trainings not only helped the students to learn better industry management skills but also inculcated in them a sense of community values, adherence to good engineering practices and a greater commitment to the goals of engineering profession. National level meetings and international conferences to showcase and share technological prowess became a periodical feature. A culture of learning and furthering frontiers of technological excellence emerged (Hirsh 2002).

With the passage of time this culture was emulated by others. For instance, Detroit Edison Company went in for steam turbines that could operate at 1000-degree Fahrenheit in the 1920s when the industry norm for temperature was 750-degree Fahrenheit. This, while providing significant improvement in efficiency, invited accolades from the international institutions. Edison Electric Illuminating Company of Boston set up a 25.1% thermal efficiency central power station when the norm was only 15.5%.

During the formative period of ESIs, it was largely the initiative taken by the ESIs that prompted the manufacturers to build more advanced units. Trade journals and technical institutions recognized such advancements and promoted a culture of excellence. This kind of approach also motivated manufacturers to wholeheartedly cooperate in these efforts and in turn they also gained expertise and experience. Some notable collaborations of this kind were between manufacturing company General Electric and the ESI, American Electric Power Company; and General Electric and the ESI, Duke Power Company. American Electric Power Company under the presidency of Philip Sporn achieved notable technical excellence. Duke Power Company developed highly capable power engineers who could achieve path breaking power plant performance (Hirsh 2002).

During the successful phases in the evolution of ESIs, engineering values took precedence over commercial behaviour. Regulatory framework which had been institutionalized right from the infancy of ESIs, provided a sound economic base; this allowed engineers of the industry to pursue goals of technical excellence and a culture of offering improving electricity services to the society (Hirsh 2002). Introduction of PUHCA also helped ESIs to refrain from placing too much emphasis on profit maximization.

Phase II (1978-1998): PURPA reforms introduced in 1978 provided a framework that encouraged efficient generation, conservation of natural resources, and deployment of renewable resources. PURPA provided generous support for such alternative generating companies that met the standards of efficiency and resource conservation and fuel diversity norms (Hirsh 1999). PURPA grandfathered such qualifying facilities/IPPs by providing these non-ESI power generating companies with generous electricity sale price, assured electricity market, exemption from PUHCA, and access to special low-cost project financing arrangements. Research efforts in enhancing gas turbine efficiency in aircraft came in handy for ESIs as well.

These efforts culminated in many manufacturing companies agreeing to undertake to manufacture Gas Turbines for generating electricity; these companies included General Electric (USA), ASEA Brown Boveri (Sweden), Siemens-KWU (Germany), and Mitsubishi (Japan). By the mid-1980s, combined cycle gas turbine technology had reached efficiency levels of 52 to 53% (Hirsh 1999). By 1990, the price of natural gas also dipped, favouring its use for power generation. Beginning late 1980s, IPPs began to adopt this technology aggressively, and by 1992 this technology almost reached 50 per cent of the total IPPs (Hirsh 1999). Wind turbine was another technology that had evolved rapidly under PURPA.

In summary, it is evident from the foregoing discussion that ESIs evolved rapidly and became well established under a pricing system that provided an assured financial base and contributed to laying the foundations of modern industrial society. Productivity improvements realised through technological advancements fostered a culture of excellence. Focus on improving conversion efficiency was instrumental in achieving allocative efficiency. Resorting to commercial approach post-reforms disrupted this trend. Therefore, it is reasonable to surmise that allocative efficiency is best served by improving conversion efficiency. If we are to draw the right lessons from history, we cannot but hark back to the imperative of continuous technological innovations to improve efficiency.

However, improving efficiency is a necessary but not sufficient condition for economy wide benefit. It needs to be supplemented with policies that benchmark improvements continually and mandate them for the industry. Markets have failed to achieve this objective and hence regulatory intervention is indicated.

5.4 Recommendations for Alternative Pricing System

Now that it is apparent that deregulation has failed it is time to reinstate regulation of a different kind. A new regulatory pricing paradigm that incorporates the following features might be a useful tool to turn the industry around:

- A policy to monitor and implement continual efficiency improvements in generation (and transmission) technologies needs to be put in place.
- Simultaneously, generating companies should be incentivised for innovations in efficiency improvements. *Pari passu*, costs should be benchmarked to continually improving efficiencies.
- Even as prices emerge on sound economic basis they should be periodically adjusted to incorporate gains from efficiency improvements.
- Statutory compliance of environmental norms should be enforced.

- Governments need to provide policy guidelines on apportioning tariff between various consumer categories. Due consideration will have to be given to ensure meeting basic minimum needs of all citizens.
- New investments may be regulated based on stipulated norms to meet the policy goals of the electricity sector.

5.5 Summary

This chapter has provided a review on the capacity utilization of ESIs post deregulation and deliberated on the challenges invoked by deregulated pricing system and utilizing insights gained from previous chapters has provided suggestions for redressal. Main points include:

- Capacity utilisation of ESIs have significantly deteriorated post deregulation.
- ESIs have been overshadowed by a commercial culture which has led to erosion of 'values'.
- Simple-cycle gas turbine plants and old inefficient plants with high variable costs have become the instruments for setting prices.
- Pricing systems that consider electricity as an economic commodity become susceptible to profit motives.
- Recommendations for alternative pricing system emphasise adherence to technical, cultural, environmental and social values.

6 CONCLUSIONS AND RECOMMENDATIONS

In the backdrop of electricity's vulnerability to price manoeuvrings for the sake of profit, and given its essentiality to human society and economy, this research examined the appropriateness of pricing paradigm that followed deregulation of the electricity industry.

The main findings of this thesis are provided below.

6.1 Main Findings

Productivities and technological breakthroughs shaped modern day economic thinking

A review of pricing philosophies from the origin suggests that transformational changes to economic thinking have taken place since the medieval times, when inspired thinkers with their ideas and understanding contributed to improving agrarian productivities, through scientific and technological inventions. Such changes transformed the pricing paradigm of the pre-medieval times that strived to achieve *exchange-value* that bespoke fairness and equity in exchange, into a pricing paradigm that emphasised profit for capital and legitimised social inequality.

- In the history of humanity, a period of around 2000 years beginning from the Aristotelian times stands distinct. This was the period when fairness and social equity was held paramount and profiteering was looked down upon. Fairness in *exchange* was accorded utmost importance and was considered as the binding element in the society. Even during early periods, a concern existed that unreined *exchange value* can unleash a culture of pursuit for unlimited gains – if *exchange value* is let to latch on with activities that relate money as the end objective, real things of value can get compromised. A just *exchange* warrants achieving an uncontestably genuine *need* between the *exchangers* and the *need* thus achieved should merit justifiable *commensurability*. As achieving such equivalence is difficult, fairness in *exchange value* was considered a conundrum.

- Inspired people of early medieval times of the Western world, with ideas and quest for knowledge, improved agricultural productivity and specialised skills which resulted in surpluses and attractive products for sale. This led to increased trade and commercial activities – the merchant traders stood to gain and became powerful in the society. Scholastics who held a superior position in the society and preached Christian thought and teachings that forbade any form of trade or any activity that purported economic gains, came under pressure – powerful merchant traders and business men questioned the virtuousness of religious teachings. Eventually this led to a tempering of the strict religious traditions by infusing Aristotelian economic thinking. Scholastics allowed gradual transitioning towards economic ideals. Though they were not successful in developing a pricing philosophy, and tended to accept differing notions about pricing, they were concerned about fairness in exchange – they provided strict guiding tenets to ensure that all exchanges conformed to the confines of *need*, and remained within the aegis of ethics, fairness and justice.

- Scientific inventions and innovations that followed led to a period of *explorations* – advent of international trading increased the dimensions of economic activities. Mercantilism that followed, generated a nationalistic fervour leading to powerful nations led by monarchs. These changes sanctified wealth and profit in the form of money. Powerful monarchies provided protection and support to the trader-capitalists enabling them to become unassailable monopolies earning supernormal profits by pricing commodities according to their utility while keeping the costs low by curtailing wages to labour. Emphasis on monetary wealth gained importance. This period marked a significant shift away from ethical values. The widespread adoption of Putting-out system during this period led to craftsmen losing the ownership of their tools and becoming a part of the labour group. Tools became the capital of the merchant traders.

- Over time declining profits waned the influence of merchant traders and saw the resurgence of the guild in the form of a new creed of industrious capitalists. They challenged the state-supported trader-capitalist monopolies and fanned an activist movement of *individualism* that sought for *an environment of free market where men motivated by self-interest could be allowed to compete and produce maximum welfare to the society*. Protestant theology provided a moral standing to this movement. Introduction of specialisation, division of labour and arrival of steam engines made productivities of factories to leapfrog in the UK and other European countries. This period witnessed increased rates of agrarian productivity; increased mechanisation of the economy, and improved transportation systems. These changes represented a major turning point in the history of human society. Classical economic theory that emerged avowed the benefits of these changes – it upheld Laissez Faire, and recommended a *cost of production theory* and *income distribution theory* that justified *profit* for the capital and *wages at subsistence level* for the labour. Capital accumulation, labour productivity and largeness of market were regarded as the primary factors that will contribute to the good of a nation.

- With economic progress on the ascent, the method of pricing of goods came under focus and debates that ensued raised questions on the appropriateness of pricing goods according to the cost of factors of production. Neoclassical economic thinking that emerged during the late nineteenth century provided theories to reinforce profit for capital and introduced demand perspectives in estimating the value of a commodity. Marginalist economists provided greater importance to *scarcity* and introduced a pricing system in which *market price* would correspond to the highest *marginal cost*. *Marginal productivity theory of distribution of income* reinforced the legitimacy of profit for *capital*; *land rent* was also merged into capital and together they represented earnings that characterised their *productivit*y. Their relatively higher earnings were justified based on their *marginal product*. Commodity prices based on *value-of-service* and monopoly pricing strategies increased *profits* and this practice became increasingly prevalent unleashing a culture of *profit*.

- Neoliberalism that emerged during the 1970s extolled the advantages of free market principles and advocated against any kind of State involvement in the economy; it also supported policies favouring business interests. Neoliberalism has encouraged increasing profits to capital, and has contributed to a widening of inequality.

ESIs: essential to society – lucrative to investors – revenue source to Treasury

Review of electricity pricing paradigms that existed during the period 1880-1980s suggests that electricity pricing has always shown vulnerability to price manoeuvrings regardless of the type of ownership. State support and business leaders with strong business acumen succeeded in making this industry evolve rapidly. Continuously improving scalable and fuel efficiencies and relatively stable macroeconomic conditions kept the cost of producing electricity on a continuously declining trajectory up until mid-1960s. The plateauing of scalable and fuel economies from the 1960s and deteriorating macroeconomic conditions was a turning point for the ESIs worldwide – the ESIs entered a phase of increasing costs – and pricing paradigms shifted to improve the economic fundamentals of the industry.

- The period between late nineteenth and early twentieth century witnessed a wave of industrialisation in the United States and Germany stimulated by the advent of electric power. The United States largely pioneered the successful establishment of ESIs. The advent of versatile electric power that could enhance productivities of factories and the life styles of households significantly transformed human society, thus establishing the essentiality of electricity to human society.

- The end of Civil War in the United States was followed by economic and political tensions. While the economic upheavals included a welcoming race for technological innovations, the growing pace of consolidation and monopolisations caused concern. The ideology of *Progressivism* which favoured regulatory oversight evolved as a response, to effect harnessing of these changing economic forces for the good of the society.

- The evolutionary phase of ESIs was saved from the throes of the free market in the US – the ESIs were provided natural monopoly status, and a regulatory framework with a pricing formula that provided the industry with generous returns after reimbursing all the costs incurred. Technology-led continuously-improving scalable economies and fuel efficiencies contributed to the profit potential of ESIs and was responsible for sustaining the industry as a declining-cost type for over a hundred years. High fixed costs and cyclic demand-led low-utilisation and highly inelastic short-term demand response characterised ESIs. ESIs converted these weaknesses into opportunities by pricing electricity differentially between consumers on the basis of value-of-service (to reduce costs), thus obtaining increasing rates of profits as well as sustaining the industry on a phenomenal growth trajectory. The evolution of ESIs was dominated both by technology and capitalistic ideologies that made the industry to develop a culture where profit determined the cost of goods and services.

- In the United States, the investor-owned ESIs aligned strongly with classical and neoclassical economic thinking in their pursuit of higher profits. Marginal principles provided strategies for price discrimination between consumers to gain monopoly profits. Value-of-service based pricing system helped ESIs to earn profits above allowable limits of regulatory pricing formula. Scalable economies significantly reduced costs and provided strategic opportunities to manage declining electricity prices to consumers, earning their goodwill as well as be in a position to mute the role of regulators. Profits of ESIs in the US were far in excess in comparison with other industries. ESI holding company abuses were noted for their significant role in the financial crash of 1930s. PUCHA (1935) was enacted to rein in the ESIs. Until the early 1950s, electricity prices were essentially based on average-cost principles.

Pricing based on marginal principles introduced in France to revitalize capital intensive ESIs

- Post Second World War, France, facing dire economic conditions, needing electricity industries to invigorate the failing economy, adopted electricity pricing system based on marginal principles so as to ensure that revenue stream matched up to the level of capital intensiveness of the industry. *Tarif Vert*, a tariff based on marginal principles, was developed by eminent French marginalist Marcel Boiteux. This pricing system modified the average-cost based pricing system by introducing marginal principles to reflect consumers' price of electricity according to the marginal estimated cost of producing that service.

ESIs' cost-trends suffers inflection – invokes shifts in pricing paradigms

- The productivity in the US through the period 1890s to late1950s had improved significantly, averaging 5.5% per year that approximately translated to a cost reduction of 40% for every MW of added capacity. This helped sustain the lucrativeness of the ESIs. The productivity improving trends however ended when technological efficiency of steam turbine technology plateaued from around early-1960s – this was not specific only to the US, it was a worldwide phenomenon. Contemporaneous occurrence of oil-shocks, environmental activism and a stubborn stagflation that defied solution generated unprecedented cost increases for the ESIs. Accelerated electricity demand increases during this period exacerbated the already difficult situation of ESIs. The ESIs and equipment generating companies resorted to untested ways of scaling up the new units (i.e., scaling up without proper design considerations) to meet the exigencies. This led to failures, protracted outages and huge financial losses. Electricity and electricity equipment prices increased in unprecedented ways. The already capital-intensive electricity assets became even more so. Economists held regulatory pricing system as responsible for encouraging inefficiencies and blamed investor-owned ESIs for having defied the basic notions of allocative efficiency for the sake of profit. Where ownership was with State, the governments blamed the ESIs for having been negligent and instituted stricter oversight over their functioning. The cost increases, above all, led economists worldwide to introduce electricity pricing along the lines followed by France – pricing based on marginal principles. It was argued that this would improve allocative efficiency and contribute to economic welfare.

- In the US, PURPA was enacted as a response to encourage: 1) low capital-intensive and more productive technologies for generating electricity by providing generous prices (based on marginal avoided cost of traditional ESI) and assured markets, and 2) conservation by encouraging more efficient use of energy and mandating regulatory commissions to bolster such initiatives. These moves increased profits for IPPs sponsored under PURPA and resulted in higher electricity prices.

- The governments of the State-owned ESIs belonging to the developed world introduced pricing based on marginal principles. They also introduced stricter financial targets for increasing revenue for their Treasuries. Pricing based on marginal principles increased the revenue stream for the governments – the differential pricing between consumers also led to increased suffering for the most depressed segment of the society (mainly, poor households with inelastic electricity demand).

- From around the late 1970s, as the ideology of neoliberalism began to overtake the Western world, a more radicalised form of marginal pricing of electricity began to emerge in the UK and Australia. Margaret Thatcher, a neoliberal proponent, went even further to set increasing returns as financial targets for the publicly owned ESI (CEGB).

- The inflection in costs for ESIs and consequential shifts in electricity pricing (based on average cost principles to marginal cost principles – as discussed above) resulted in increasing the divergence household and industrial prices mainly to the disadvantage of the households. State governments however benefited from such shifts as they provided higher revenue streams that also helped to liquidate ESI debts.

Success of IPPs and Plateauing of technology scalability undermine natural monopoly of ESIs

- Following unsuccessful attempts of resurrecting plateaued scalable technology, the disapproval for monopoly status for ESIs became more vocal. Low-capital intensive more efficient CCGT plants utilising natural gas whose prices were on the decline, were seen as alternative to traditional electricity generating technologies in the late 1980s – this strengthened the rationale of setting up competition between traditional ESIs and IPPs.

Neoliberalism and market-based reforms for ESIs

The wave of neoliberalism

- The exigencies of Korean and Vietnam Wars and the spending spree following the zeal of welfare-state policy approach for gaining political leeway by the US government led to inflationary trends in the US economy. Middle-East oil shocks worsened the economic outlook for the whole world and stubborn stagflation in the US challenged the economists of the time. Keynesian economic approach was blamed for being ineffective in reviving the macroeconomic conditions – neoliberalism emerged, espoused the benefits of free-market principles and sought an end to government regulation of businesses. Business interests funded the movement of neoliberalism and think tanks aided its propagation across the world. United States and the UK were strong proponents of neoliberalism and they influenced the World Bank and other multilateral global agencies to enshrine the principles of free-market, reduction of taxes and government debt in their lending practices. Developing countries were subjected to the covenants of neoliberal ideology as a prerequisite for receiving developmental assistance from the World Bank and other agencies.

Market-based reforms for ESIs

- Neoliberal economists and think-tanks in the US and the UK, encouraged by the outcome of the PURPA reforms, questioned the natural monopoly status for the ESIs and strongly argued for the introduction of free-market-principles-based reforms for the ESIs. The UK government was persuaded to adapting electricity reforms by neoliberal think tanks. They provided arguments claiming the superior advantages of competition in effecting efficiency improvements, thus raising the prospects of cost and price reductions for electricity. The government's attention was drawn to the potential benefits of reform (i.e., increased revenue for the Treasury; the opportunity the reform offered to break up the National Union of Mines; and the spectre of popular support for the government from the flotation of stock by privatising ESIs). Market-based reforms were consequently introduced in the UK in a rather speedy manner. The introduction of electricity reforms in the UK engendered similar reforms in other countries such as Norway, Sweden, Australia, New Zealand and the United States.

- These reforms resulted in the breaking up of ESIs into their competitive and monopoly segments. The new pricing system involved a market discovered marginal-cost based pricing for the generation segment and a performance-incentivizing regulatory pricing system for the monopoly segments (transmission and distribution). The deregulation of the retail segment that was to provide consumer with the choice of electricity supplier was introduced in a staggered manner and the price to consumer was to be determined by a competitive process. A major contention of this reform was that it will result in a non-discriminatory cost reflective pricing system that would enable innovative approaches to efficiency, which could bring about cost reductions as well as corresponding price reductions.

- The track record of ESIs following deregulation however did not measure up to its professed claims. Mixed views emerged about the benefits of reform – proponents blaming the shortcomings in the way the reform was implemented, and sceptics questioning the wisdom of subjecting an essential commodity like electricity that has already shown its susceptibility to price manoeuvrings for profit to a market-based pricing system. Overwhelming evidence of incessantly increasing price of electricity by exercise of market power without any correspondence to costs as well as increasingly divergence of prices between large/industrial consumers and households has emerged and the industry responsible for providing this fundamentally important service to society and economy appears to be on a discordant path.

- To further substantiate the above noted claims this thesis generated the following hypotheses:

  Hypothesis 1: *Deregulated electricity pricing system leads to a disjuncture between electricity prices and costs*.

  Hypothesis 2: *Deregulated electricity pricing system encourages and sustains increasing electricity price trends.*

  Hypothesis 3: *Deregulated electricity pricing system contributes to increasing social inequity*

  Hypothesis 4: *Deregulated electricity pricing system leads to increasing departure from environmental norms*.

  These hypotheses were econometrically tested for ESIs from the US, the UK, and Australia (including different States in Australia) for a time period in the range of four to five decades. Key results are discussed as follows.

- *Hypothesis 1*: Electricity deregulation has indeed lead to a disconnect between electricity prices and costs. For example, In the US, the mean profit – representing difference between costs and prices – has increased from 0.56 USC per kWh during the era of regulatory pricing (pre-1970s), to 1.0 USC per kWh, post deregulation. In the UK, the mean profit rose from 0.14 UKP per kWh during the State regulated pricing era (pre-1980s), to 3.4 UKP per kWh post NETA. The corresponding values for Australia are from close to zero under the state-regulated pricing era (pre-1980s), to between 4.0 and 11.3 AUC per kWh post NEM. Further, maximum divergence is observed for South Australia where mean profit increased from zero under the state-regulated pricing era, to 11.3 AUC per kWh post NEM. Particularly high levels of profit in the UK, Victoria and South Australia point to the additional influence of privatisation of assets suggesting proclivity to higher profit and a greater tendency to the abuse of market power.
- *Hypothesis 2*: Analysis suggests that continuously increasing price trends have become a permanent feature in the post-deregulation era in all countries considered in this research. For example, in the US, price trend, changed from a mean falling rate of -0.1 percent per annum during regulatory pricing era (pre-1970s), rose to a mean increasing rate of 6.4 percent per annum post deregulation. In the UK, the mean rose from 0.35 during the State regulated

pricing era (pre-1980s) to 4.7 post NETA. In the Australian states, the corresponding mean changed from nil, during State regulatory pricing era (pre-1980s), to between 4.12 and 12.4 percent per annum during NEM. The highest change of 12.4 percent per annum occurred in the state of Victoria. Particularly high levels of profit in the UK, Victoria and South Australia point to the additional influence of privatisation of assets suggesting proclivity to highly commercialised approach and a greater tendency to the abuse of market power.

- *Hypothesis 3*: Deregulation has increased the divergence of electricity prices between industry and household consumers – bulk of the revenue for the industry is realised from the household consumers. For instance: in the US, increased mean inequity – representing the difference between household and industry consumer electricity prices in USC/kWh – rose from 1.375 during the time of regulatory pricing era (pre-1970s), to 4.3 post deregulation. In the UK it rose from 0.35 UKP/kWh during state-controlled regulated pricing era (pre-1980s), to 4.7 UKP/kWh post NETA. In the Australian states, it rose from 0 AUC/kWh during state-controlled pricing era (pre-1980s), to a level ranging between 5.65 to 8.1 AUC/kWh post-NEM. The highest mean inequity, of 8.1 AUC/kWh, occurred in Victoria.

- *Hypothesis 4*: Analysis point to significant increases in emissions in Australia; analysis also shows that in all countries considered in this research there exists a scope for further reducing emissions in the range of 10 – 20 percent.

- This thesis has further analysed the historical trends of capacity utilisation in the US, the UK and Australia in order to examine deregulation from the perspective of its ability to improve allocative efficiency. The findings reveal that:

- The capacity utilisation factors improved when the industry was assured of economically sound electricity price and market for dispatch. For instance, in the US the overall capacity utilisation improved by around 15 percent during the PURPA period (1982 – 1997) which provided IPPs generous pricing and assured market. In the UK, capacity utilisation improved by around 15 percent during the period 1970-2002 when the industry had the State support for price as well as market. In Australia, strict government oversight improved the capacity utilisation by 10 percent during the period 1980-1996.

- Although there were some noticeable improvements in capacity utilisation in the initial stages of deregulation, the trend however did not sustain and continuous declines in capacity utilisation became the new order subsequently.
- In the United States, the overall capacity utilisation declined from 62% to 42% during the period 1999-2014; in the UK, from 56% to 43% during the period 2002-2014, and in Australia, from 48% to 44% during the period 1998-2014.
- Base-load coal plant capacity utilisation declined by 14 percent in the US during the period (2000 – 2014); in the UK by 10 percent during the period 2003 – 2014; in Australia by 17 percent during the period 2001-2014.
- Base-load gas plant capacity utilisation declined by 50% in the US during the period 2000-2014; in the UK by 40% during the period 2002-2014; in Australia by 10% during the period 1999-2014.
- Base load generation has been substituted by low-fixed-cost/high-variable simple cycle gas capacity. In the US, for instance, during the period 2000-2014 simple cycle gas plant capacity increased by 5 % of total capacity; and by 10% of total capacity in Australia during the period 1999-2014. This investment pattern suggests strong indication of the post deregulated industry to engage in exercise of market power for the sake of increased profits.

• The analyses of *Hypotheses 1, 2, 3* and *4*, and that of capacity utilisation (discussed above) show that post-deregulation electricity prices have increased inexorably yielding higher and higher profits by burdening the socially deprived segment of society. Allocative efficiency, contrary to claims, has decreased and the reasons are attributable to the significant increase in the deployment of inefficient electricity generating plants like simple cycle gas turbines for the sake of the exercise of market power. These analyses also project the spectre of more serious impending problems confronting the industry. For example,
  - Cherry picking from existing base-load generating assets has prevailed for long, and cannot continue indefinitely. Existing assets are reaching the end of their useful lives – the industry may be overtaken by sharp depletion in electricity capacity which may lead to serious threats to the security of supply. Further, with generating companies continuing

to exercise market power by artificially setting prices and resisting to invest in base-load plants, the transition to environmentally compliant outcomes appears bleak.

- Electricity prices may increase to incredulous levels – exacerbating the problems of inequity – such increases also thwart any resolution to the access challenge facing the unconnected population of developing world.
- In short, this pricing paradigm is not sustainable and requires urgent remedial policy measures.

Recommendations for alternative approach

This research showed how *value-based pricing system* and *pricing on free-market principles* can produce a distorted pricing system when applied to a commodity like electricity, which is vulnerable to price manoeuvrings. This thesis therefore argues for a replacement of existing pricing paradigm with one that takes into account the fact that electricity is, not available as a primary form of energy but has to be converted from other primary forms – hence conversion efficiency assumes paramount importance. The existing pricing paradigm has only contributed to lowering of plant efficiencies, and a deterioration of environmental performance for the sake of achieving high profits from existing assets by setting prices artificially.

- This thesis has tracked the golden period of this industry when ESIs were graced by a culture of governance that sought to achieve technical excellence, strive for reducing electricity prices and valued serving the community. This period was also marked by an institutional culture that encouraged technology improvements, sound operating practices and an unrelenting zeal for improving efficiency of producing electricity from primary energy resources. Such excellence thrived when the industry did not have concerns of financial stability and assured market. History has also shown that such provisions needed active support of the State.
- This thesis has suggested a new regulatory pricing paradigm that ensures the following:
    - a policy to effect: – continual improvements in generation and network technology – transitioning to environmentally compliant generation technology – abidance to statutory compliance of environmental norms;
    - policy guidelines for apportioning equitable tariff among consumer categories and ensuring basic minimum needs of electricity for all citizens;

- new investments are regulated based on stipulated norms that would meet the policy goals of the electricity sector; and
- cost reductions translate to price reductions without impairing the economic requirements of the industry

Recommendations for future research

This section of the thesis discusses some of the limitations of this research, and makes recommendations on how these limitations could be overcome in future research.

1) This research focuses on the electricity industries of the US, the UK, and Australia as these countries were early adopters of neoliberal principles and implemented electricity reform with full commitment. Further, much of the analyses of pricing philosophies has formed on the Western Canons of economic thinking. In view of the body of knowledge on this topic in the Eastern Canons of economic thinking, it is recommended that this question (i.e., evolution of pricing, views on profit etc.,) be considered from the Eastern point of view. This will be particularly helpful to understand issues in the developing world context where overwhelming large expansions of electricity systems are envisaged.
2) To generate alternative pricing paradigm this research has come to the view that there is a need for retracting from deregulation and reinstating regulation with a refocus on technical needs of the industry to reliably bring about cost and price reductions and supply electricity at equitable prices without disregarding environmental norms. Knowledge from the Eastern thinking could have added further value, for instance, Kautilya in his Arthasastra is known to have provided valuable insights for a regulatory approach of pricing.
3) The fixed cost element in the price of electricity is largely determined by the pricing systems adopted by few monopoly companies that supply electricity equipment for building power plants worldwide. These prices also appear to be artificial constructs and not cost reflective. Not considering analysis of this pricing is also a limitation of this research. A reduction of this cost would contribute to improve the affordability of electricity and therefore, a more in-depth study of this price would be beneficial and is recommended for future study.

In summary, this research recommends perspectives based on Eastern economic thinking should also be included in future research as it would help to obtain more broad-based insights and improved alternative pricing paradigms.

Notwithstanding the above recommendations, this research provides useful insights and ideas for designing an alternative pricing paradigm to overcome the imminent problems arising from market-based pricing and to resurrect the electricity supply industries worldwide.

7 APPENDICES

7.1 Appendix A

Data for Figure 1-1: Electricity Capacity UW, UK and Germany (1900-1930)

Historical Growth	United States Electricity Capacity	United Kingdom Electricity Capacity	Germany Electricity Capacity
Year	MW	MW	MW
1900	1458	295	312
1901	2223	402	446
1902	2987	495	579
1903	3751	575	713
1904	4516	669	891
1905	5280	775	1016
1906	6045	858	1070
1907	6809	960	1250
1908	7573	999	1426
1909	8338	1054	1536
1910	9102	1124	1604
1911	9867	1221	1783
1912	10980	1406	1961
1913	11503	1523	2063
1914	12279	1135	2496
1915	13055	1523	2788
1916	13831	1600	3079
1917	15494	1888	3484
1918	15580	2175	3890
1919	16371	2310	4206
1920	19439	2447	4862
1921	20605	2641	5190
1922	21317	3036	6240
1923	23235	3483	6583
1924	25923	3724	7131
1925	30087	4422	7293
1926	32936	4682	7941

1927	34574	5258	8272
1928	36782	5802	8752
1929	38708	6600	11815
1930	41153	6946	11669

Data Sources—Figure 1-1

US Data: (US-CENSUS 1902-1970, Neufeld 1987)

UK Data: (DOEUK 2016)

Germany data: (Miller 1936, Lagendijk 2008)

*Missing data generated by author

Data for Figure 1-6: Electricity Prices of the United States (1960-2014)

USA		Electricity Price Domestic Sector		Electricity Price Industry Sector	
	CPI	Nominal	Real 2010	Nominal	Real 2010
Year		USC/kWh	USC/kWh	USC/kWh	USC/kWh
1960	13.6	2.6	19.2	1.1	8.1
1961	13.7	2.6	19.0	1.1	8.0
1962	13.9	2.6	18.7	1.1	7.9
1963	14.0	2.5	17.8	1.0	7.1
1964	14.2	2.5	17.6	1.0	7.0
1965	14.5	2.4	16.6	1.0	6.9
1966	14.9	2.3	15.4	1.0	6.7
1967	15.3	2.3	15.0	1.0	6.5
1968	16.0	2.3	14.4	1.0	6.3
1969	16.8	2.2	13.1	1.0	5.9
1970	17.8	2.2	12.4	1.0	5.6
1971	18.6	2.3	12.4	1.1	5.9
1972	19.2	2.4	12.5	1.2	6.3
1973	20.4	2.5	12.3	1.3	6.4
1974	22.6	3.1	13.7	1.7	7.5
1975	24.7	3.5	14.2	2.1	8.5
1976	26.1	3.7	14.2	2.2	8.4
1977	27.8	4.1	14.8	2.5	9.0
1978	29.9	4.3	14.4	2.8	9.4
1979	33.3	4.6	13.8	3.1	9.3
1980	37.8	5.4	14.3	3.7	9.8
1981	41.7	6.2	14.9	4.3	10.3
1982	44.3	6.9	15.6	5.0	11.3
1983	45.7	7.2	15.8	5.0	10.9
1984	47.6	7.2	15.0	4.8	10.1
1985	49.3	7.4	15.0	5.0	10.1
1986	50.3	7.4	14.8	4.9	9.8
1987	52.1	7.5	14.3	4.8	9.1
1988	54.2	7.5	13.8	4.7	8.7
1989	56.9	7.7	13.5	4.7	8.3
1990	59.9	7.8	13.1	4.7	7.9
1991	62.5	8.0	12.9	4.8	7.7
1992	64.3	8.2	12.8	4.8	7.5

1993	66.2	8.3	12.6	4.9	7.3
1994	68.0	8.4	12.3	4.8	7.0
1995	69.9	8.4	12.0	4.7	6.7
1996	71.9	8.4	11.6	4.6	6.4
1997	73.6	8.4	11.5	4.5	6.2
1998	74.8	8.3	11.0	4.5	6.0
1999	76.4	8.2	10.7	4.4	5.8
2000	79.0	8.2	10.4	4.6	5.9
2001	81.2	8.6	10.6	5.1	6.2
2002	82.5	8.4	10.2	4.9	5.9
2003	84.4	8.7	10.3	5.1	6.1
2004	86.6	9.0	10.3	5.3	6.1
2005	89.6	9.5	10.6	5.7	6.4
2006	92.4	10.4	11.2	6.2	6.7
2007	95.1	10.7	11.2	6.4	6.7
2008	98.7	11.3	11.4	7.0	7.0
2009	98.4	11.5	11.7	6.8	6.9
2010	100.0	11.5	11.5	6.8	6.8
2011	103.2	11.7	11.4	6.8	6.6
2012	105.3	11.9	11.3	6.7	6.3
2013	106.8	12.1	11.4	6.9	6.4
2014	108.6	12.5	11.5	7.1	6.5

Data Sources for Figure 1-6:

Electricity Price Information: (EIA 2016)

Electricity Cost Information: (DOE 1994, DOE 2002, DOE 2008, DOE 2012, DOE 2014, DOE 2015)

CPI: (DBWDI 2017)

Data for Figure 1-7*:* Electricity Prices of the United Kingdom (1960– 2014)

United Kingdom	GDP Deflator	Electricity Price Average		Electricity Prices Real (2010)	
		Nominal	Real	Domestic Sector	Industrial Sector
Year		UKP/kWh	UKP/kWh	UKP/kWh	UKP/kWh
1960	5.5	6.3	11.3	-	-
1961	5.7		11.2	-	-
1962	5.9	6.2	11.1	-	-
1963	6.0	6.3	11.2	-	-
1964	6.2	6.1	10.9	-	-
1965	6.5	6.1	10.9	-	-
1966	6.8	6.0	10.7	-	-
1967	7.0	5.9	10.5	-	-
1968	7.3	6.1	10.9	-	-
1969	7.7	5.7	10.1	-	-
1970	8.6	5.4	9.1	-	-
1971	9.3	5.3	9.2	-	-
1972	9.9	5.2	9.0	-	-
1973	10.8	4.9	8.4	-	-
1974	12.4	5.3	9.2	-	-
1975	15.6	5.8	10.0	-	-
1976	17.9	6.1	10.6	-	-
1977	20.4	6.2	10.7	-	-
1978	22.7	6.1	10.6	-	-
1979	25.9			11.4	10.4
1980	31.1			12.1	8.7
1981	34.7			13.0	9.0
1982	37.2			13.3	9.2
1983	39.2			13.1	8.8
1984	41.1			12.6	8.4
1985	43.4			12.4	8.2
1986	45.3			12.1	8.0
1987	47.7			11.5	7.4
1988	50.5			11.4	7.3
1989	54.5			11.3	6.8
1990	59.0			11.3	6.8
1991	62.8			11.7	6.5

1992	64.9	11.9	6.7
1993	66.6	11.6	6.8
1994	67.4	11.8	6.5
1995	69.2	11.7	6.3
1996	72.0	11.2	5.8
1997	73.6	10.4	5.4
1998	74.8	9.7	5.2
1999	75.6	9.5	5.2
2000	77.4	9.1	4.7
2001	78.2	8.9	4.5
2002	80.2	8.8	4.3
2003	82.4	8.6	4.1
2004	84.7	8.9	4.3
2005	87.2	9.5	5.5
2006	89.8	10.8	7.1
2007	92.4	11.1	7.0
2008	95.0	12.5	8.4
2009	97.0	12.6	8.9
2010	100.0	11.9	7.8
2011	102.1	12.8	7.9
2012	103.8	13.2	8.2
2013	105.8	13.9	8.4
2014	107.8	14.4	8.7

Data sources Figure 1-7:

Electricity Price (Average) (1960-1978): (DOEUK 2016)

Electricity Price (Industry Sector) Data (1979-2014): (IEA 2017m)

Electricity Price (Household Sector) Data (1979-2014): (IEA 2017n)

Electricity Real Index Industry (1979-2014): (IEA 2017c)

Electricity Real Index Household (1979-2014): (IEA 2017b)

Data for Figure 1-8 Victoria Electricity Prices (Real 2010)

Victoria	Wholesale Price Index	Nominal Index Industry (2010)	Nominal Index Household (2010)	Electricity Price Household (Real-2010)	Electricity Price Industry (Real-2010)
Year				AuC/kWh	AuC/kWh
1960	10.69	-	-	18.59	20.95
1961	10.30	-	-	19.06	21.50
1962	10.01	-	-	19.61	22.03
1963	10.20	-	-	19.13	20.89
1964	10.43	-	-	18.55	19.10
1965	10.79	-	-	18.14	18.25
1966	11.24	-	-	18.23	17.99
1967	11.48	-	-	17.61	17.50
1968	11.55	-	-	17.64	18.11
1969	11.72	-	-	17.84	18.76
1970	12.22	-	-	17.00	17.68
1971	12.83	-	-	16.03	16.46
1972	13.44	-	-	15.02	15.86
1973	14.60	-	-	13.72	14.32
1974	16.84	-	-	13.19	13.52
1975	19.37	-	-	12.57	13.05
1976	21.56	-	-	12.23	12.86
1977	23.76	-	-	12.22	13.43
1978	25.71	20.80	18.15	12.50	13.79
1979	29.51	22.49	19.60	12.07	13.24
1980	33.65	24.00	20.40	11.57	12.82
1981	36.49	27.65	22.92	12.30	12.95
1982	39.75	32.71	26.68	13.15	13.77
1983	42.96	40.53	33.29	14.23	15.05
1984	45.28	41.25	36.13	15.46	15.22
1985	48.27	43.29	37.96	14.85	15.26
1986	50.97	44.45	40.59	14.87	15.04
1987	54.70	46.40	42.68	14.77	14.53
1988	59.65	47.73	45.15	14.45	12.88
1989	62.69	49.96	47.67	14.31	12.07
1990	66.43	52.36	49.34	14.12	11.93
1991	67.40	53.87	51.59	14.81	12.48

1992	68.43	55.47	54.06	15.70	12.47
1993	69.80	55.11	56.16	16.79	12.05
1994	70.34	55.11	57.18	17.88	11.96
1995	73.28	72.62	57.55	17.40	11.44
1996	73.51	71.65	56.96	16.63	11.47
1997	74.42	67.91	57.93	17.18	10.23
1998	71.47	66.94	58.57	17.93	10.23
1999	70.81	69.42	58.25	17.79	10.94
2000	75.88	69.34	58.57	16.67	10.41
2001	78.19	75.56	65.28	18.13	11.13
2002	78.36	79.82	65.82	18.76	13.25
2003	78.74	73.87	68.13	19.32	12.20
2004	81.86	73.60	71.83	19.59	11.69
2005	86.74	80.75	78.81	20.29	12.11
2006	93.62	88.24	86.12	20.54	12.26
2007	95.82	89.48	87.33	20.35	12.14
2008	103.76	100.66	98.24	21.14	12.62
2009	98.12	94.39	92.13	20.97	12.51
2010	100.00	100.00	100.00	22.33	13.00
2011	103.39	110.98	110.98	23.97	13.96
2012	102.89	119.11	119.11	25.85	15.05
2013	104.01	126.64	126.64	27.19	15.83
2014	107.24	128.14	128.14	26.68	15.54

Data sources Figure 1-8

Electricity Price (Household and Industry Sector) Data (1960-2003)): (ESAA 2016)

Electricity Price Nominal Index Australia (Household Sector) (2004-2014): (IEA 2017f)

Electricity Price Nominal Index Australia (Industry Sector): (IEA 2017e)

WPI Index Australia (1960-2014): (WDI 2016)

Data for Figure 1-9 New South Wales Electricity Prices (Real 2010)

New South Wales	Wholesale Price Index	Nominal Index Industry (2010)	Nominal Index Household (2010)	Electricity Price Household (Real-2010)	Electricity Price Industry (Real-2010)
Year				AuC/kWh	AuC/kWh
1960	10.69	-	-	19.32	20.29
1961	10.30	-	-	19.69	21.55
1962	10.01	-	-	20.97	22.89
1963	10.20	-	-	20.28	21.63
1964	10.43	-	-	19.49	20.00
1965	10.79	-	-	18.23	18.13
1966	11.24	-	-	17.28	17.15
1967	11.48	-	-	16.83	16.43
1968	11.55	-	-	16.76	16.26
1969	11.72	-	-	16.65	16.20
1970	12.22	-	-	16.17	15.18
1971	12.83	-	-	15.60	14.67
1972	13.44	-	-	15.47	14.79
1973	14.60	-	-	14.86	14.21
1974	16.84	-	-	13.28	12.59
1975	19.37	-	-	12.64	12.57
1976	21.56	-	-	12.70	12.94
1977	23.76	-	-	12.48	12.84
1978	25.71	20.80	18.15	12.08	12.56
1979	29.51	22.49	19.60	11.08	11.71
1980	33.65	24.00	20.40	10.50	11.20
1981	36.49	27.65	22.92	10.62	11.57
1982	39.75	32.71	26.68	11.55	12.88
1983	42.96	40.53	33.29	14.33	17.49
1984	45.28	41.25	36.13	14.30	15.96
1985	48.27	43.29	37.96	13.26	14.10
1986	50.97	44.45	40.59	13.49	13.40
1987	54.70	46.40	42.68	13.01	12.66
1988	59.65	47.73	45.15	12.65	12.37
1989	62.69	49.96	47.67	13.20	12.67
1990	66.43	52.36	49.34	12.98	12.52
1991	67.40	53.87	51.59	13.36	12.88
1992	68.43	55.47	54.06	13.68	12.97

1993	69.80	55.11	56.16	13.80	12.27
1994	70.34	55.11	57.18	13.71	11.39
1995	73.28	72.62	57.55	13.12	10.10
1996	73.51	71.65	56.96	13.04	10.06
1997	74.42	67.91	57.93	12.99	9.10
1998	71.47	66.94	58.57	13.71	9.46
1999	70.81	69.42	58.25	13.53	10.11
2000	75.88	69.34	58.57	12.82	9.49
2001	78.19	75.56	65.28	13.39	9.75
2002	78.36	79.82	65.82	14.01	10.18
2003	78.74	73.87	68.13	14.43	9.37
2004	81.86	73.60	71.83	14.64	8.98
2005	86.74	80.75	78.81	15.15	9.30
2006	93.62	88.24	86.12	15.34	9.42
2007	95.82	89.48	87.33	15.20	9.33
2008	103.76	100.66	98.24	15.79	9.69
2009	98.12	94.39	92.13	15.66	9.61
2010	100.00	100.00	100.00	16.68	9.99
2011	103.39	110.98	110.98	17.91	10.73
2012	102.89	119.11	119.11	19.31	11.57
2013	104.01	126.64	126.64	20.31	12.17
2014	107.24	128.14	128.14	19.93	11.94

Data Sources Figure 1-9:

Electricity Price (Household and Industry Sector) Data (1960-2003): (ESAA 2016)

Electricity Price Nominal Index Australia (Household Sector) (2004-2014): (IEA 2017f)

Electricity Price Nominal Index Australia (Industry Sector): (IEA 2017e)

WPI Index Australia (1960-2014): (WDI 2016)

Data for Figure 1-10 Queensland Electricity Prices (Real 2010)

Queensland	Wholesale Price Index	Nominal Index Industry (2010)	Nominal Index Household (2010)	Electricity Price Household (Real-2010)	Electricity Price Industry (Real-2010)
Year				AuC/kWh	AuC/kWh
1960	10.69	-	-	21.50	22.30
1961	10.30	-	-	21.64	23.09
1962	10.01	-	-	21.82	26.24
1963	10.20	-	-	20.60	24.08
1964	10.43	-	-	20.05	22.89
1965	10.79	-	-	19.06	22.12
1966	11.24	-	-	18.27	20.50
1967	11.48	-	-	17.87	19.49
1968	11.55	-	-	18.05	19.23
1969	11.72	-	-	18.74	19.55
1970	12.22	-	-	17.87	18.36
1971	12.83	-	-	16.84	17.44
1972	13.44	-	-	16.10	16.47
1973	14.60	-	-	15.28	15.87
1974	16.84	-	-	14.16	14.79
1975	19.37	-	-	14.34	15.42
1976	21.56	-	-	15.44	16.30
1977	23.76	-	-	15.32	16.22
1978	25.71	20.80	18.15	14.70	15.74
1979	29.51	22.49	19.60	14.05	15.19
1980	33.65	24.00	20.40	13.63	14.38
1981	36.49	27.65	22.92	13.65	14.89
1982	39.75	32.71	26.68	14.15	15.23
1983	42.96	40.53	33.29	15.39	15.03
1984	45.28	41.25	36.13	16.09	13.15
1985	48.27	43.29	37.96	16.89	13.03
1986	50.97	44.45	40.59	17.44	12.89
1987	54.70	46.40	42.68	16.82	12.35
1988	59.65	47.73	45.15	15.52	11.73
1989	62.69	49.96	47.67	14.90	11.45
1990	66.43	52.36	49.34	13.94	10.83
1991	67.40	53.87	51.59	13.82	10.81

1992	68.43	55.47	54.06	13.98	10.94
1993	69.80	55.11	56.16	13.85	10.80
1994	70.34	55.11	57.18	13.84	11.26
1995	73.28	72.62	57.55	13.32	10.03
1996	73.51	71.65	56.96	13.27	9.14
1997	74.42	67.91	57.93	13.04	8.88
1998	71.47	66.94	58.57	13.55	8.58
1999	70.81	69.42	58.25	13.68	11.93
2000	75.88	69.34	58.57	12.69	10.70
2001	78.19	75.56	65.28	13.99	11.15
2002	78.36	79.82	65.82	14.83	10.94
2003	78.74	73.87	68.13	15.28	10.07
2004	81.86	73.60	71.83	15.49	9.65
2005	86.74	80.75	78.81	16.04	10.00
2006	93.62	88.24	86.12	16.24	10.12
2007	95.82	89.48	87.33	16.09	10.03
2008	103.76	100.66	98.24	16.72	10.42
2009	98.12	94.39	92.13	16.58	10.33
2010	100.00	100.00	100.00	17.65	10.74
2011	103.39	110.98	110.98	18.95	11.53
2012	102.89	119.11	119.11	20.44	12.43
2013	104.01	126.64	126.64	21.50	13.07
2014	107.24	128.14	128.14	21.10	12.83

Data sources Figure 1-10

Electricity Price (Household and Industry Sector) Data (1960-2003): (ESAA 2016)

Electricity Price Nominal Index Australia (Household Sector) (2004-2014): (IEA 2017f)

Electricity Price Nominal Index Australia (Industry Sector): (IEA 2017e)

WPI Index Australia (1960-2014): (WDI 2016)

Data for Figure 1-11 South Australia Electricity Prices (Real 2010)

South Australia Year	Wholesale Price Index	Nominal Index Industry (2010)	Nominal Index Household (2010)	Electricity Price Household (Rea-2010) AuC/kWh	Electricity Price Industry (Real-2010) AuC/kWh
1960	10.69	-	-	18.18	18.10
1961	10.30	-	-	18.36	20.79
1962	10.01	-	-	18.62	19.60
1963	10.20	-	-	17.55	19.62
1964	10.43	-	-	17.06	19.69
1965	10.79	-	-	16.12	18.08
1966	11.24	-	-	15.10	16.49
1967	11.48	-	-	14.63	16.39
1968	11.55	-	-	14.50	15.27
1969	11.72	-	-	14.08	15.29
1970	12.22	-	-	13.54	14.46
1971	12.83	-	-	12.86	14.11
1972	13.44	-	-	12.75	14.43
1973	14.60	-	-	11.73	12.92
1974	16.84	-	-	10.80	12.20
1975	19.37	-	-	10.57	12.19
1976	21.56	-	-	10.77	12.36
1977	23.76	-	-	10.54	11.69
1978	25.71	20.80	18.15	10.95	11.73
1979	29.51	22.49	19.60	10.38	11.33
1980	33.65	24.00	20.40	10.17	10.97
1981	36.49	27.65	22.92	10.83	11.56
1982	39.75	32.71	26.68	11.69	12.84
1983	42.96	40.53	33.29	13.49	14.16
1984	45.28	41.25	36.13	14.67	15.71
1985	48.27	43.29	37.96	15.68	16.45
1986	50.97	44.45	40.59	15.92	16.18
1987	54.70	46.40	42.68	15.14	15.78
1988	59.65	47.73	45.15	15.08	15.61
1989	62.69	49.96	47.67	15.00	15.02
1990	66.43	52.36	49.34	14.58	14.43
1991	67.40	53.87	51.59	14.99	14.29

1992	68.43	55.47	54.06	15.55	14.73
1993	69.80	55.11	56.16	15.68	14.28
1994	70.34	55.11	57.18	15.87	13.12
1995	73.28	72.62	57.55	15.25	11.54
1996	73.51	71.65	56.96	15.41	11.25
1997	74.42	67.91	57.93	16.05	10.54
1998	71.47	66.94	58.57	17.56	11.56
1999	70.81	69.42	58.25	18.08	12.07
2000	75.88	69.34	58.57	19.66	14.44
2001	78.19	75.56	65.28	19.63	15.21
2002	78.36	79.82	65.82	18.33	16.54
2003	78.74	73.87	68.13	18.73	16.04
2004	81.86	73.60	71.83	19.00	15.37
2005	86.74	80.75	78.81	19.67	15.92
2006	93.62	88.24	86.12	19.92	16.12
2007	95.82	89.48	87.33	19.73	15.97
2008	103.76	100.66	98.24	20.50	16.59
2009	98.12	94.39	92.13	20.33	16.45
2010	100.00	100.00	100.00	21.65	17.10
2011	103.39	110.98	110.98	23.24	18.35
2012	102.89	119.11	119.11	25.06	19.79
2013	104.01	126.64	126.64	26.36	20.82
2014	107.24	128.14	128.14	25.87	20.43

Data sources for Figure 1-11

Electricity Price (Household and Industry Sector) Data (1960-2003): (ESAA 2016)

Electricity Price Nominal Index Australia (Household Sector) (2004-2014): (IEA 2017f)

Electricity Price Nominal Index Australia (Industry Sector): (IEA 2017e)

WPI Index Australia (1960-2014): (WDI 2016)

Data for Figure 1-12 France Electricity Prices (Real 2010)

France		Electricity Prices	
		Household Sector	Industry Sector
	WPI	Real 2010	Real 2010
Year		USD/kWh	USD/kWh
1978	30.76	26.18	10.54
1979	34.04	27.57	11.14
1980	38.65	29.53	12.42
1981	43.80	22.39	9.35
1982	49.05	20.10	7.96
1983	53.68	16.80	7.07
1984	57.80	14.83	5.95
1985	61.18	14.19	5.56
1986	62.73	17.81	6.75
1987	64.79	19.66	7.23
1988	66.54	19.63	7.25
1989	68.87	17.74	6.64
1990	71.20	21.09	7.92
1991	73.49	19.21	7.33
1992	75.23	20.39	7.59
1993	76.81	19.07	7.12
1994	78.09	19.22	6.81
1995	79.47	20.97	7.57
1996	81.07	20.21	6.99
1997	82.06	16.32	5.94
1998	82.55	15.63	5.66
1999	82.99	14.54	5.25
2000	84.40	12.05	4.24
2001	85.77	11.47	4.05
2002	87.42	11.96	4.18
2003	89.26	14.18	5.01
2004	91.17	15.53	5.46
2005	92.75	15.27	5.37
2006	94.31	15.25	5.37
2007	95.71	16.34	9.63
2008	98.41	16.70	10.65
2009	98.49	16.16	10.83
2010	100.00	16.53	10.69
2011	102.12	18.31	11.89

2012	104.11	16.82	11.16
2013	105.01	18.41	12.00
2014	105.55	19.62	11.93

Data sources for Figure 1-12

Nominal Electricity Price Household Sector (Period: 1978-2014): (IEA 2017n)

Nominal Electricity Price Industry Sector (Period: 1978-2014): (IEA 2017m)

WPI France (Period: 1978-2014): (WDI 2016a)

Data for Figure 1-13 Steam Electricity Generation Plant Cost per kW

United States Year	WPI	Steam Plant Indexed Capital Cost UKP/kW	Power Capital Cost Index	USD-UKP Exchange rate
1960	17			
1961	17			
1962	17			
1963	17			
1964	17			
1965	17			
1966	18			
1967	18			
1968	19			
1969	19			
1970	20			
1971	21			
1972	22			
1973	24			
1974	29			
1975	32			
1976	33			
1977	35			
1978	38			
1979	43			2.1
1980	49			2.3
1981	53			2
1982	54			1.7
1983	55			1.5
1984	56			1.3
1985	56			1.3
1986	54			1.5
1987	56			1.6
1988	58			1.8
1989	61			1.6
1990	63			1.8
1991	63	1116		1.8
1992	63	1123		1.8
1993	64	1211		1.5
1994	65	1306		1.5

1995	68	1329		1.6
1996	69	1300		1.6
1997	69	1074		1.6
1998	67	892		1.7
1999	68	827		1.6
2000	72	966	100	1.5
2001	73	1068	103	1.4
2002	71	1134	108	1.5
2003	75	821	114	1.6
2004	79	800	124	1.8
2005	85	793	136	1.8
2006	89	903	181	1.8
2007	93	1129	233	2
2008	103	1392	224	1.8
2009	94	3004	214	1.6
2010	100	2712	217	1.5
2011	109	2756	221	1.6
2012	109	2813	225	1.6
2013	110	2850	228	1.6
2014	111	2881	231	1.6

Notes for Figure 1-12

1) The US Steam Plant cost trend was constructed in three parts 1, 2 and 3.
2) Part 1-Period 1960-1990 was constructed from data utilizing from source: (FPC 1964); missing data were projected by the author
3) Part 2-Period 1991-2010 was constructed from UK plant updated costs provided from source: (MacDonald 2012) and exchange rate from IEA database
4) Part 3-Period 2011-2014 was constructed by calculating the missing data utilizing power capital cost index provided by: (IHSCERA 2018)
5) Utilizing WPI (2010=100) the US steam plant capital cost data has been converted to reflect in terms of real 2010.

7.2 Appendix B

7.2.1 Review of studies supportive of reforms

This review includes the following works: ((Galal, Jones et al. 1994, Newbery and Pollitt 1997, Pollitt 1997, Steiner 2000, Hattori and Tsutsui 2004, Zhang, Parker et al. 2008).

The welfare consequences of selling public sector enterprises (1994)

Brief context and objectives of the studies

Galal, Jones et al. (1994) have compared the effects of privatisation of ESIs of Chile. CHILGENER publicly owned ESI adopted market-based reforms in the year 1988. The aim of the study was to assess the impact of divestiture. The methodology adopted by this study was one of comparison of performance of the enterprise after divestiture with what performance would have been had the enterprise not been divested. The study constructs a counterfactual scenario.

Findings of the studies

The study brings out that multinational private companies benefitted largely and the government faced significant losses. High electricity prices (based on marginal principles) helped the private companies to reap huge profits. Reduction in labour and commercialised operation helped to reduce the factor costs and enhanced the profits. Private shareholders were the biggest winners who obtained a net gain of Ch$5.6 billion; foreign investors made a net gain of Ch$2.7 billion. The Chilean Government became poorer to the extent Ch$2.7 billion; the fiscal impact of divesting the ESI was (-) 22 percent of the sale price.

Integrity of elements of reforms

Despite the increased electricity prices, loss of employment, and revenue losses to the government the authors hold views that are favourable to adoption of market based reforms. They opine that divestiture will ease the debt crises and provide an impetus to drive economic growth. Further, they hold that if conditions such as pricing based on marginal principles, competition, coordination of operation and investment are ensured across all the market participants regardless of type of ownership benefits will accrue.

Pollitt (1997)

Brief context and objectives of the studies

Pollitt (1997) is an international survey on the impact of liberalization on the performance of the ESIs. The study provides theoretical insights for the market-based reforms as well discussion on the types of empirical studies that are adopted for assessing the impact of electricity liberalization.

Findings of the studies

- Large productivity gains have been achieved by Chile and the UK following reforms.
- Privatization has discouraged large-scale capital investments. In the UK reforms brought a halt to investments in nuclear power plants.
- Privatization leads to environmental impact—deregulation encourages use of power from relatively cheap and dirty power station—deregulation will encourage this trend
- Cost of introduction of reforms are high—the restructuring and reform costs in the UK were around UKP 3 billion
- Transmission and Distribution segments have been allowed high prices by the incentive regulation price systems both in the US and in the UK
- Reforms have allowed private businesses to reap greater benefits, competition needs to improve to pass on benefits to consumers
- Privatization has led to increase in unemployment
- Reform has yielded significant gain in economies in the UK, Chile and Argentina and this is largely attributable to divestiture

Integrity of elements of reforms

Author acknowledges that in the UK, significant re-distributional effects have arisen in the economy, shareholders and private companies have profiteered at the cost of consumers by exercising market power and by regulators allowing a more than generous pricing for networks, and workers in significant numbers have lost their jobs.

Author is strongly of the opinion:

- that state-owned firms caused inefficiency; they engaged in maximizing their own importance by building up their capital stock; managers were more concerned with their own interests rather than those of the corporation or the society
- that CEGB was inflexible, bureaucratic, secretive, and independent with a tendency to be engineering dominant rather than focus on finance
- the decision to deregulate and privatise the ESI as inevitable in view of the growing obstinacy of the setup and the ineffectiveness of the government control
- emergence of privatization and deregulation cannot be entirely attributed to the agenda of the right-wing governments leaning on neoliberalism ideology
- the changes in economic thinking call for a deeper understanding of property rights, bureaucracy and regulation theories
- deregulation and privatisation lead to more efficient firms that are likely to minimize costs, operate commercially and help maximize allocative efficiency in the economy.
- Pollitt maintains that the advantages derived from reforms such as improvements in productivity by introduction of natural gas fired CCGT plants, reduction of coal usage for power generation as significant benefits. He proceeds to affirm that the problems cited above can be resolved by strengthening regulation and further disaggregation of electricity generating companies to generate competition.

Newbery and Pollitt (1997)

Brief context and objectives of the studies

Newbery and Pollitt (1997) undertook the task of determining *'whether restructuring and privatisation of CEGB was socially beneficial'*. The study adopted a methodology similar to that which was adopted by (Galal, Jones et al. 1994) and constructed a counterfactual model of the UK ESI by assuming that it had continued to remain under public ownership.

Findings of the studies

- Gains from labour productivity improvement was partially offset by the expenses incurred for restructuring the ESIs
- Switch to gas and moving away from nuclear investments provided benefit
- Reduction in coal prices provided benefit

- The fall in the unit cost of electricity did not translate into corresponding fall in prices but led to increased profits for the privatised electricity industry and their shareholders. A gain in the range of £ 4-9 billion accrued to the electricity generation companies.

Integrity of elements of reforms

- Authors acknowledge:
    - that *'dash for gas'* accelerated decline of the British Coal Industry which rendered 24000 coal miners jobless
    - reductions in the factor costs did not translate as fall in electricity prices but rather contributed to the increased profits of electricity generating companies and their shareholders
    - in the five years after privatization, electricity share prices rose by over 250%, and outperformed the stock market by over 100% which provide an indication of the enormity of profits earned
    - unfettered competition among electricity generating companies was not realised even after the passage of six years
- Authors are confident that gains to consumers following productivity gain will begin to flow after effective competition is achieved
- Authors emphasise on the revival of nuclear power plants based on AGR technology (a technology that was declared as failed before reforms) following implementation of reforms and go on to project that with increasing competition among generating companies
- More such potential benefits are likely to accrue with improved competition

Steiner (2000)

Brief context and objectives of the studies

Steiner (2000) seeks to assess the impact of liberalisation and privatisation on performance in the generation segment of the ESIs. Generation costs according to author represent significant costs and improvements in efficiency can enable significant improvement in consumer welfare by way of reduced electricity prices. Author contends that electricity reform as elaborate, and implementation would take time and various elements of reform do not get implemented at the same time. Hence to carry out an impact assessment of electricity reforms empirically provisions must be made to reflect the actual status of reform implementation. Author has conceived distinctive metrics – a multilevel score technique that can quantify the extent of reform implementation – factors like extent of: deregulation of generation segment; the existence of unfettered electricity market; the extent of availability of unvitiated transmission access; the extent of commitment to privatization; the extent of commitment to providing consumer choice. Author econometric assessment has utilized ‘panel data techniques’, covering 19 OECD countries and covered the period 1986-1996. For measures on efficiency of generation of electricity the model chose capacity utilization and reserve margins. Author has utilized industrial price as the measure of consumer welfare and the industrial-price differential as a measure of price discrimination across customer groups. The empirical model conceived by the author examined the impact of specifically designed indicators of regulation and industry structure on efficiency and prices.

Findings of the studies

- Presence of wholesale market, transmission, and third-party access lowered electricity prices for the industrial users (increases consumer welfare according to author) and increases the differential of price between industry and residential users
- Unbundling of generation and transmission and private ownership serve to improve utilization factor (generation costs are reduced). Reserve margins also come closer to their optimal level.
- Price differential between industrial and residential users disproportionately increased
- This study also showed that electricity prices (both industrial as well as residential) increase under private ownership. This study essentially revealed that while industry electricity prices have reduced following the introduction of electricity reforms (introduction of wholesale market), had the effect of disproportionately increasing the electricity retail price of residential consumers.

Integrity of elements of reforms

The author has highlighted the danger of market power and has also warned about the possibility of this phenomenon of market power intensifying and causing further deterioration in price discrimination between residential and industrial users.

The author recommends greater regulation to control market power and timely actions to rein the electricity markets. Disaggregation of generation segment to enable competition has been the important recommendation of the author.

Hattori and Tsutsui (2004)

Brief context and objectives of the studies

Hattori and Tsutsui (2004) not agreeing with conducted a renewed study after modifying the choice of regulatory indicators that characterise unbundling of generation from transmission and the extent of retail access. The contended that findings of Steiner that availability of wholesale market has been responsible for decline in the electricity price for industry as incorrect. The objectives of this study were like that of Steiner, that is to empirically examine the impact of the specifically designed indicators of regulation and industry structure on efficiency and prices.

Findings of the studies

- The findings of this study differed from that of Steiner
- Whereas Steiner's study showed establishing of wholesale electricity market lowered the industry electricity prices and increased the differential between industry and residential users—the results of this study were quite the opposite, the results here showed increasing of industry prices.
- The authors of this study reported:
    - reduction in retail industrial electricity and increase in the differential between industrial and residential electricity with expanding retail access
    - decreasing electricity prices with private ownership in sharp contrast to what has been observed in the case of Steiner
    - increasing of electricity prices for both industry as well as residential users in the presence of wholesale market (indicating presence of market power)

Integrity of elements of reforms

- The authors are of the opinion that assessment of electricity reforms in a realistic manner would call for estimation of a longer time series.

Zhang, Parker et al. (2008)

The authors Yin-Fang Zhang, David Parker, and Colin Kirkpatrick (YFZ, DP and CK) subscribe to the benefits of all the individual reform elements but emphasise on the adequate presence of competitive and regulatory elements before embarking up on the introduction of the privatization element. The authors cite various studies that have examined performance of ESIs against proclaimed benefits of reforms and caution discretion in the choice of reform elements while undertaking ESI reforms—this they consider is vital for achieving the best benefits from reforms. The various empirical studies conducted so far, the authors contend, provide clues to a strong possibility that competition and regulatory framework are key ingredients of the reform that help achieve the proclaimed benefits.

This study cautions on privatisation without competition and notes the vulnerability of the developing countries who in their eagerness to raising immediate revenue (without adequate institutional strength to manage the reform process ably) tend to easily accept the advocacies of reform by international lending institutions. The authors examine the separate effects of privatisation, competition and regulation as components of electricity sector reform on performance of ESIs of developing countries by carrying out an econometric assessment—the econometric model utilizes panel data of 36 developing countries and covers the period 1985-2003. The authors developed hypotheses on the individual reform elements based on economic theory that portray their respective importance. The econometric model comprises of the following performance variables: Electricity generation per capita; Installed generation capacity per capita; Electricity generation per employee; and Utilisation factor.

The econometric assessment provides results as below:

- The study establishes competition as the potential reform element for realising reform benefits. All the four performance variables show improvement with increasing competition the most significant being generation capacity per capita, and this is followed by electricity generation per employee.
- The combination of competition and regulation shows significant potential for improving capacity utilisation.
- Privatisation alone, appears to be unhelpful in respect of realising benefits from reform.

- Regulation appears to be supportive in the realisation of benefits from reform.

The authors contend that the results have policy implications for electricity reformers in developing countries. Performance improvements in electricity generation are more assured when competition is promoted. Improvements are further augmented with the presence of independent regulation. The authors provide specific guidelines to IPPs and caution them not to succumb to luring tactics adopted by the lending institutions.

7.2.2 Review of studies sceptical of reforms

This section Part (B) has put together the views of such authors who are sceptical about the outcome of the market-based electricity reforms authors and consider that electricity reforms are not suitable and have identified various problems.

Divestiture of ESIs and its ill effects (countries UK and Australia)

Neoliberalism stigmatised government debt and repudiated the idea of government loans being used for financing investment in public infrastructure (Surrey 1996, Beder 2003, Beder 2007). This was one of the main drivers for the adoption of ESI reforms in the UK, and Australia among the developed countries. ESIs of UK, and those of Victoria and South Australia (states of Australia) were unbundled; the competitive segment and monopoly segments were de-integrated and put up for sale even though, none of these ESIs had strictly caused any debt burden to their governments. According to Beder the State owned ESIs of the Western Industrialized countries always provided a revenue that was in excess of debt repayments as can be seen from the following details (Beder 2007).

The ESI of State Victoria had paid the state government around in the last year before privatisation AUD 1 billion in interest, and around AUD 191 million as dividend and a profit of Au$ 207 million and the ESI of State South Australia (which was at its historically low level of debt) had contributed to the government a revenue of over AUD 2 billion (Beder 2003, Beder 2007).

According to (Thomas 1996) British publicly owned ESI (CEGB) had been a regular significant contributor to the public finances and the chances of this trend continuing in the absence of electricity reforms was a certainty. In the last normal year before privatization (1987/88) the ESI in England and Wales made net contribution to the public finances of £1.47 billion, consisting of

£356 million of Corporation Tax, £304 million of interest repayment, and £808 million of post-tax profit (Thomas 1996).

Conventional economists strongly opposed stigmatisation of debt. According to them: debt funding to infrastructure industry like ESIs, is advantageous and crucial to the economy. This funding approach provides a macro-economic path with the highest gains from the investment, and also that which encourages high economic and employment growth (Beder 2007).

Both the Australian States Victoria and South Australia had not benefitted from its sale of the ESIs; in the UK the State had to bail out the failed privatized ESI British Energy as a part of their moral responsibility (Thomas 1996, Beder 2007).

In the UK, following implementation of electricity reforms, during the first decade witnessed windfall profits accruing to the privatised companies both in the competitive and monopoly segments. The total profits roughly doubled from under £2.5 billion to over £5 billion in the first four years. The profits were due to precipitous reduction in coal prices. This benefit was not passed on to the consumers. In contrast, 22 million domestic electricity consumers were made to bear the burden of the differential costs arising between the price of British coal and International coal prices during the initial three years following the introduction of reforms (MacKerron and Watson 1996). Reserve margin reduced from 27 percent to 18 percent by closing down existing generation capacities; a trend of investment shunning for the sake of profit clearly emerged (Thomas 1996).

Beder also points to the futility of the adoption of the neoliberal fiscal discipline which prescribes besides reducing budget deficits by privatising, the abolishing of barriers to foreign investment and deregulation of sectors of economy (Beder 2003). Adoption of this fiscal discipline led to—serving the business interests of transnational companies at the costs of local communities in the developed countries. In the less developed countries, the transnational companies who brought in their investment often resorted to buying up existing state-owned facilities at bargain prices and repatriated their profits in dollar terms. Power Purchase Agreements provided to the transnational companies were very lucrative and this resulted in the less developed countries to incur far more than required expenditures in dollar terms.

Market power (Impressions of different authors)

Where the reforms had involved privatisation of nationalized assets as was the case in the UK and Australia, the governments had pre-emptively resorted to increasing the electricity prices and reached a target increase of over 15 percent above the cost of generation in order to make the assets attractive for sale. Post electricity reforms, electricity market price signals replaced the electricity dispatch systems that usually scheduled electricity supplies to consumers guided by the principles of marginal cost and environmental norms.

Beder argues against this approach; she considers electricity market as an inefficient and contradictory mechanism for scheduling dispatch of electricity; clear evidences have emerged that this resulted in generating a trend of creating real or artificial scarcity of generation availability for the sake of increasing profits and not any cost reduction from improved efficiency. The inflexible demand of electricity clearly provides an upper hand for the sellers over buyers. Electricity sellers clearly follow the notion that their success in achieving higher prices depends on how successfully they are able sustain inadequacy. They go to the extent of creating artificial scarcity by withholding their available generation capacity during periods of high demand. This leads to wholesale prices spiking at hundreds of times of the actual cost. When limits are set to price spikes, the private companies resort to creating power shortages even during the off-peak periods. Electricity markets have thus brought a disjuncture between price and the cost of production. This also leads to the notion that investments are to be shunned as they will lead to erosion of profit (Beder 2007).

The introduction of market reforms began to allay a fear of possible low investment in the electricity sector; to combat this problem, major institutions like the IEA began to highlight the importance of high electricity prices for the sake of continuing investment; they even went to the extent of endorsing moderate market power to sustain the growing electricity price trend. Ulrik Stridbaek, Senior Policy Advisor of IEA was all praise for those countries wherein public outcry were ignored and electricity prices were allowed to soar. According to him higher prices are necessary to encourage investment (Stridbaek 2006, Beder 2007). It is an irony that these very institutions had argued that competition would bring about efficiency improvements resulting in cost reductions which will eventually be passed on to consumers. Beder wonders, whether this acclaimed efficiency of reforms actually meant increasing of electricity prices. (Dubash and

Bouille 2002) are circumspect about the market's credibility and ascribe deregulation to have led to denial of access to electricity to over half the rural population in the world.

There are evidences that excessive profitability following deregulation has been the norm; over 61 privatized companies belonging to 18 countries have accrued profits on an average profits of 45 percent (Beder 2007). The privatized and deregulated companies shun any investment and only resort to building cheap peaking power plant that comes with low investment and low thermal efficiency and comes handy to justify higher marginal costs.

Impact of Market Power

Sale price of Victorian ESI was unprecedented (almost 3 to 4 times the estimated price). Supporting such a high recapitalization clearly spelled a high price regime that was to follow. However, the freezing of retail price by Victoria for a period of 5 years at the time of deregulation prevented this in the beginning, but led to losses to shareholders and consequent resale of the debt burdened companies often at huge losses (Beder 2007).

Sudden soaring of electricity prices began in 2001/02 in Australia; this was contemporaneous with ending of retail price freeze period in Victoria, emergence of National Electricity Market (NEM), and a spurt of market power techniques of rebidding initiated by all the States following an institutional endorsement of moderate market power by the electricity companies in the name of financial optimization (Beder 2007). NEM prices climbed by over 60 percent. NEM began to assume to the form much like what is seen in highly speculative stock market (Beder 2007).

South Australia witnessed the sharpest increase in prices. It had increased to almost double the levels of Victoria during the year 2000. South Australia had registered an increase in the residential electricity prices by over 40 percent during the period 1994-2002 (Beder 2003). Deliberate increasing of pool prices became a very common practice (Beder 2007). The soaring electricity prices overwhelmed the large businesses as well and forced them to curtail their businesses to avoid the high electricity prices. The large businesses were the very reasons for ushering in deregulation and privatisation of the ESIs—and now they have turned out to be the victims of their own creation. (Mountain 2016) in their report prepared for raising awareness on the increasing Australian electricity prices have shown that Australian electricity prices are poised to become the highest when compared internationally (OECD, the UK, the US, Israel and Japan).

The UK

In the UK the credibility of the electricity market came under severe criticism. The precipitous cost reductions of coal did not reflect in the electricity market as a reduction in electricity price. The phenomenal profits went to the shareholders of the private companies (Surrey 1996, Thomas 1996). The private companies not content with the profits accruing from coal cost reductions resorted to resisting new investment and closing down of capacities in order to sustain tight reserve margins and enable their profit inflow. Over passage of time, this practice has led to an ironic, but sad situation of huge investment crisis in the UK with the old assets reaching their retirement stage. (Economist 2011) reports that the current electricity sector in the UK is facing a dire need for £ 110 billion to replace the retiring ESI capacities by year 2020. (Economist 2015, Economist 2017) also further corroborate to this crisis situation in the UK. Electricity prices in the UK are continuously on the ascent from around mid-2000, in the year 2008 electricity prices in the UK were 30 percent higher than other comparable European countries like Germany and France (Beder 2003, Pearson 2012).

Market price was set by the larger generating companies National Power and Power Gen that were operating depreciated power plants at 10-20 percent above the cost of production of newly introduced CCGT plants (Chick 2011). (Chick 2011) also brings out the glaring differing price differences charged for the industrial users of electricity and the domestic electricity consumers—fixed charges for domestic consumers of electricity rose by 47 percent during the period 1987 and 1995 compared with a retail price increase of 38% while those to the industrial users' electricity prices fell by 25 percent during the period 1985 to 1995. (Chick 2011) points to the deterioration in income inequality to a greater extent in the UK compared to other OECD countries—in the 1980s the percentage population below the median income was 5 percent whereas in 1997 it was around 15 percent.

The US

Beder points out that the very people (ELCON) who had strongly lobbied along with neoliberal proponents for deregulation and influenced the government to legislate Energy Policy Act of

1992 which allowed deregulation of ESIs are now disillusioned (Beder 2007). ELCON had joined this movement with the objective of securing cheaper electricity supply, but this turned out to be a far cry. As observed by the president of ELCON in the year 2009 the 'auction based electricity markets' made it easy for generators to manipulate and increase prices regardless of cost. Eminent economists of the like of Paul Krugman, opined that fostering market-based pricing for electricity is misplaced (Beder 2003).

(Dubash and Bouille 2002) describe how the assumptions made in California at the time of introduction of electricity reforms about adequate supply reserves, the optimism about achieving robust competition both in the wholesale as well as in the retail markets proved to be so very wrong. The deregulation proceeded on the assumption of more than adequate reserve margins and a definite significant declining wholesale price. However, this did not prevent a mid-2000 problem of apocalyptical magnitude that overwhelmed the Californian electricity market and led to its crash and subsequent closure (Borenstein and Bushnell 1999). A group of unscrupulous power companies undermined this adequacy by deliberate withdrawal of capacity and strategically exercising market power to increase electricity prices in a phenomenal manner leading to the bankruptcy of the market and its eventual crash (Beder 2003).

Impacts of Retail Market deregulation

Retail deregulation was intended to provide the choice of electricity suppliers to the consumers; this arrangement was intended to make suppliers to vie for consumers.

Large energy intensive consumers were the drivers for the retail deregulation as they were confident of their ability to negotiate with retailers to secure very favourable deals for themselves at the expense of other consumers. This practice eventually led to cherry picking of customers by the suppliers and the burden of the remaining costs being passed on mostly to the household segment. The governments also endorsed this practice as it wanted electricity to be priced advantageously to the energy intensive industry customers to price their products competitively in the international markets (Beder 2003, Beder 2007).

The Government generally adopted a phased introduction of deregulation of the retail market. With cherry picking taking place, the task of distributing the left-over cost among the remaining consumers meant, making increases in prices for the lower end customers. Wholesale prices always tended to go higher and higher; fall in profit levels always prompted particularly those who were affected by high debt burdens not only to meet their debt service expenses but also for their profits by exercising market power. The governments and funding institutions were more concerned at the viability of the businesses established; governments pre-emptively increased the retail rates to ensure smooth transition toward retail deregulation. Thus, increase in electricity prices became synonymous with introduction of retail deregulation (Beder 2003, Beder 2007, Pearson 2012).

The extremeness in the volatility of wholesale prices were experienced predominantly in South Australia, followed by Victoria. Residential electricity rates have also phenomenally increased. The synonymous increases of electricity prices with retail market introduction is quite glaringly seen this retail market was introduced for middle sized business in South Australia during 2001 (the increase was in the range of 30-80 percent) (Beder 2007).

Beder also points to additional benefits being passed on to the industrial consumers—for instance the removal of cross subsidies leads to the most disadvantaged households bearing the burden of paying for non-commercial objectives such as environmental goals. Also, the governments tend to take a lenient view while determining policies in this regard to metropolitan domestic ratepayers while disregarding the rural consumers.

Impacts of network pricing

In Australia and the UK, post reforms, the privatised owners of transmission and distribution networks were provided with a regulatory pricing formula that allowed profits at rates much higher than that were earned by most listed companies. The share values of the private companies rose by over 200 percent in the UK. Thus, this regulatory pricing system in the realm of private ownership continues the legacy of incentivizing the Averch-Johnson inefficiencies (Beder 2003, Booth and Booth 2003, Beder 2007). In effect this meant allowing an artificial construct of pricing method for assets that have very little growth potential but seek to sustain this phenomenon of profiteering.

Impacts on Efficiency

At the time of introduction of electricity reforms competition in the generation and retail segment of the ESI was professed as the major rationale for effecting efficiency related cost reductions. The advantages of competition among privatised companies was portrayed as the ultimate in bringing about cost reductions. It was argued that innovative technologies, innovative ways of operation and maintenance, and operations based on commercial lines would bring in substantive cost reductions which eventually will get passed on to the electricity consumers as price reduction (Thierer and Walker 1997, IEA 2000a, IEA 2000b).

Reality, however, was strikingly different. The deregulated generating companies went for aggressive cost reduction programs that would yield quick results. The traditional system of strict adherence to quality maintenance, safe operational practices were dismantled and replaced by short-term commercially driven strategies. Technical operational norms of large-sized power generating units were compromised for the sake of commercial gains. The deregulated ESIs which had gone through workforce reduction before sale was further subject to more intense staff reductions for the sake of cutting costs (Beder 2003, Beder 2007).

Technological innovations that had traditionally provided productivity improvements and reductions in costs during the initial phases of ESIs has been made irrelevant and replaced by the notion of cutting costs by any means. Safety, maintenance, training, and research budgets have been drastically reduced. Commercial approach replaced the ethos of public-spiritedness—the commitment to safety, quality, and socially responsible activities disappeared. The claims that were made at the time of advocating electricity reforms that deregulated ESIs would bring about managerial excellence were no longer valid (Beder 2003, Beder 2007).

Australia

In Australia employment in the electricity sector fell from about 83,000 in the mid-1990s to 33,000 workers in 2003. Victoria which had shed 11,000 jobs before adopting reforms to make their ESI look lean and attractive for sale; private companies had shed an additional 2000 jobs for enabling further cost cuts. Post deregulation, in Victoria the frequency of blackouts increased by 32% between years 1995 and 1999 (Beder 2003, Beder 2007).

With deregulation electricity sales assumed a radical profit mongering culture. This is well illustrated by an incident that took place in South Australia – in deep summer when households were going without power the power companies preferred to sell power to Victoria as the NEM prices had soared to Au$ 5000 per MWh and this could fetch money in millions.

The operating standards of the power generating plants in Australia began to declining efficiency. Authorities of Australian Conservative Foundation have reported that Australia is among the "least energy efficient countries of the world" (Beder 2007).

The UK

ESI reforms and coal mine privatisation made around 40,247 (31 percent) of ESI workforce and 250,000 coal mine workers redundant respectively (Thomas 1996). Employee reductions have not resulted in any significant reduction in the operating costs of the privatised companies presumably on account of the extraordinary pay packages offered to the executives of the new private companies (MacKerron and Watson 1996). (Beder 2007) evidences as to how the productivity of the UK electricity sector which was superior to that of the US and European countries declined following deregulation and privatization to become about 20 percent lower than the US and France.

Privatisation of British Coal and resorting to purchases of coal from International market led to substantial reduction in fuel costs. This however, as stated elsewhere did not produce any benefit to consumers. The expenditures towards support for technology has been virtually eliminated (MacKerron and Watson 1996).

The US

Private deregulated ESIs in the US resorted to massive reduction of their utility workforce; US Department of Energy and Utility Workers Union of America have estimated 150,000 people losing their jobs, and these included those who were responsible for safety and reliability of electricity supplies, as private deregulated utilities shed staff so as to cut costs. This approach of cost cutting has led to fewer inspections, deferral of repairs, and less worker training, all of which threaten worker and public safety as well as system reliability (Beder 2007). Lack of maintenance contributed to the blackouts in New York City, Chicago, Long Island, New Jersey, New England, and Texas (BEDER 2003). During the period of crisis in California it is also reported that generating companies which were largely controlled by commercial mavericks made the large size power generating units to be operated ‘like a yo-yo, virtually sabotaging these costly plants’ (BEDER 2003)

Environmental Impact

Electricity Market competes for lowest up-front price. Deregulation encourages maintenance of old polluting power plants. Privatisation allows, and in many instances, encourages, the maintenance of old polluting coal-fired power plants that are highly detrimental from environmental perspective. International reviews have acknowledged that there has been a 31 percent increase in GHG following deregulation (Beder 2007). (IEA 2005) reports that Australia emissions of CO2 are the second highest in the IEA and this is 43 percent above the IEA average.

Australia

The amount of electricity generated by brown coal increased from about 23 percent to 31 percent of sources between 1992 and 2001. The increasing dependence on brown coal plants can produce electricity at low marginal costs, after paying off their loans, because brown coal is cheap. As a result, greenhouse gas emissions have increased in Australia. Peak plants in Australia are simple cycle gas fired power plants as their fixed costs are low and variable costs are high and can justify higher marginal costs.

UK

UK committed itself in the year 1988 to international environmental norms. The rapid and large-scale switch to gas proved of great benefit to Britain to meet their international environment commitment. This also helped UK to halve the Flue Gas Desulphurization (FGD) requirement. Privatisation and shrinking of the British Coal company for the sake of breaking the National Union of Mineworkers led to avoidance of 30MT of coal for electricity generation.

US

(Dubash and Bouille 2002) ascribe the discontinuation of successful energy efficiency programs in the mid-1990s as one of the contributing factor for the California electricity market crash. (BEDER 2003) also points to the regulatory commission bowing to the pressures of the deregulated ESIs and cancelling the already planned addition of 1500 MW of renewable and co-generation capacity in the year 1995.

Mergers, Acquisition and Vertical Integration

(Dubash and Bouille 2002, Beder 2007) raise concern at the emergence of energy conglomerates on a worldwide basis. (Beder 2007) points to strategic reintegration of energy companies internationally to achieve a poise of restrained competition, increased market power to meet their increasing profit objectives. (Economist 2011) evidenced that UK electricity sector is comprised of only six vertically integrated oligopolists and the total number of energy conglomerates serving the entire European Union as only around 12. As per (Beder 2007) the dominant energy conglomerates in Australia are only 3 and together they serve over 8 million customers. Thus, it is seen that overtime a reversal is taking place and the virtues of disaggregation appear to have been belied.

The proponents of electricity reform claimed that ESIs would enter an era of excellence with the adoption of market-based pricing system, that the industry would become nimble, operate and maintain innovatively, bring down the factor costs, and compete for supplying electricity at competitive prices. The actuals however, do not subscribe to this sublimity. (Beder 2003, Sharma 2004, Beder 2007) see significant disparity between the claims and outcomes of the reforms—they see the ESIs transformed to serve narrow economic and business interests. They consider the claims of achieving electricity pricing regime consonant with competitive market principles farfetched. (Sharma 2004) questions the credibility of the Australian Electricity Market and holds the electricity price outcomes as incredulous and contrary to any well-meaning objectives of a society.

7.3 Appendix C

Data for Figure 4-1: Profit Trends (US)

United States	Average nominal cost (partly estimated)	Average Electricity Price per kWh	Household electricity per kWh	Industry electricity price per kWh	Profit Trend
Year	USC/kWh	USC/kWh	USC/kWh	USC/kWh	USC/kWh
1960	1.1	1.8	2.6	1.1	0.70
1961	1.1	1.8	2.6	1.1	0.70
1962	1.1	1.8	2.6	1.1	0.70
1963	1	1.8	2.5	1	0.80
1964	1	1.7	2.5	1	0.70
1965	1	1.7	2.4	1	0.70
1966	1	1.7	2.3	1	0.70
1967	1	1.7	2.3	1	0.70
1968	1	1.6	2.3	1	0.60
1969	1	1.6	2.2	1	0.60
1970	1	1.7	2.2	1	0.70
1971	1.1	1.8	2.3	1.1	0.70
1972	1.2	1.9	2.4	1.2	0.70
1973	1.3	2	2.5	1.3	0.70
1974	1.7	2.5	3.1	1.7	0.80
1975	2.1	2.9	3.5	2.1	0.80
1976	2.2	3.1	3.7	2.2	0.90
1977	2.5	3.4	4.1	2.5	0.90
1978	2.8	3.7	4.3	2.8	0.90
1979	3.1	4	4.6	3.1	0.90
1980	3.7	4.7	5.4	3.7	1.00
1981	4.3	5.5	6.2	4.3	1.20
1982	5	6.1	6.9	5	1.10
1983	5	6.3	7.2	5	1.30
1984	4.83	6.25	7.15	4.83	1.42
1985	4.97	6.44	7.39	4.97	1.47
1986	4.93	6.44	7.42	4.93	1.51
1987	4.77	6.37	7.45	4.77	1.60
1988	4.7	6.35	7.48	4.7	1.65
1989	4.72	6.45	7.65	4.72	1.73
1990	5.41	6.57	7.83	4.74	1.16

1991	5.56	6.75	8.04	4.83	1.19
1992	5.65	6.82	8.21	4.83	1.17
1993	5.79	6.93	8.32	4.85	1.14
1994	5.78	6.91	8.38	4.77	1.13
1995	5.70	6.89	8.4	4.66	1.19
1996	5.75	6.86	8.36	4.6	1.11
1997	5.75	6.85	8.43	4.53	1.10
1998	5.67	6.74	8.26	4.48	1.07
1999	5.62	6.64	8.16	4.43	1.02
2000	6.12	6.81	8.24	4.64	0.69
2001	6.65	7.29	8.58	5.05	0.64
2002	6.20	7.2	8.44	4.88	1.00
2003	6.50	7.44	8.72	5.11	0.94
2004	6.60	7.61	8.95	5.25	1.01
2005	7.26	8.14	9.45	5.73	0.88
2006	7.93	8.9	10.4	6.16	0.97
2007	8.13	9.13	10.65	6.39	1.00
2008	8.71	9.74	11.26	6.96	1.03
2009	8.69	9.82	11.51	6.83	1.13
2010	8.71	9.83	11.54	6.77	1.12
2011	8.72	9.9	11.72	6.82	1.18
2012	8.56	9.84	11.88	6.67	1.28
2013	8.73	10.07	12.13	6.89	1.34
2014	9.06	10.44	12.52	7.1	1.38

Notes for Figure 4-1

US Electricity Nominal Average Price data was obtained from (EIA 2017)

1) US Electricity Nominal Average Cost data has been constructed in two parts: Part 1and Part 2
2) Part 1 provides the nominal average electricity cost data for the period 1960-1990 and has been estimated by suitably modifying industry sector price during the said period and has been obtained from (DOE 1994, DOE 2002, DOE 2008, DOE 2012, DOE 2014, DOE 2015, DOE 2016)
3) Part 2 provides the nominal average electricity cost data for the period and has been obtained from (EIA 2017)
4) Difference between nominal average price and nominal average cost provides the nominal profit

Data for Figure 4-2 Profit Trends (UK)

United Kingdom	Nominal Average Cost	Nominal Average Price	Nominal Profit	Profit/loss in percentage as per CEGB information	CCGT Plant Capacity Changes	Wind Plant Capacity Changes	Fixed cost per kWh	Estimated fuel cost per kWh	O&M Cost per kWh
Year	UKP/kWh	UKP/kWh	UKP/kWh	%	MW	MW	UKP/kWh	UKP/kWh	UKP/kWh
1978	2.11	2.41	0.31				0.40	1.03	0.69
1979	2.37	2.63	0.26				0.53	1.15	0.69
1980	2.69	2.53	-0.16	-6%			0.57	1.43	0.68
1981	2.99	2.85	-0.14	-5%			0.71	1.59	0.69
1982	3.16	3.08	-0.08	-3%			0.76	1.72	0.69
1983	3.06	3.17	0.10	3%			0.64	1.74	0.69
1984	4.01	4.13	0.12	3%			0.79	2.54	0.68
1985	3.36	3.46	0.10				0.50	2.18	0.68
1986	2.87	3.56	0.69	3%			0.48	1.70	0.68
1987	2.81	3.66	0.85	3%			0.46	1.66	0.68
1988	2.85	4.82	1.97	3%			0.44	1.72	0.68
1989	2.75	5.04	2.29	5%			0.42	1.65	0.68
1990	3.01	5.37	2.36				0.75	1.58	0.68
1991	2.97	6.01	3.04				0.72	1.56	0.68
1992	2.36	6.32	3.97		1129		0.04	1.63	0.68
1993	2.36	5.93	3.57		4334		0.18	1.49	0.68
1994	2.30	5.61	3.31		3138		0.28	1.35	0.68
1995	2.31	5.51	3.20		433		0.27	1.37	0.67
1996	2.36	5.21	2.85		3078		0.33	1.36	0.67
1997	2.34	4.70	2.36		140		0.32	1.34	0.67

1998	2.33	4.45	2.12	2386		0.35	1.31	0.67
1999	2.31	4.25	1.94	1472		0.37	1.27	0.67
2000	2.38	4.17	1.80	3239		0.42	1.29	0.67
2001	2.47	4.07	1.61	1168		0.41	1.39	0.67
2002	2.38	4.03	1.65	1284		0.42	1.29	0.67
2003	2.44	4.08	1.63	1776		0.43	1.35	0.67
2004	2.59	4.44	1.84	206		0.42	1.51	0.67
2005	2.93	5.26	2.32	480		0.41	1.85	0.67
2006	3.25	6.52	3.26	596		0.42	2.17	0.67
2007	3.35	6.40	3.05	-591	1850	0.45	2.23	0.67
2008	4.35	7.47	3.12	1935	559	0.52	3.17	0.66
2009	4.03	7.74	3.71	581	820	0.74	2.62	0.67
2010	4.33	7.28	2.96	4940	1113	0.82	2.84	0.66
2011	5.05	8.43	3.37	-1541	868	1.01	3.37	0.67
2012	5.07	10.31	5.24	2930	2409	1.31	3.09	0.67
2013	5.08	11.28	6.20	-146	1559	1.47	2.94	0.67
2014	4.72	12.08	7.36	-973	1358	1.46	2.59	0.67

Notes for Figure 4-2

1) Nominal average electricity cost has data has been constructed in two parts; Part 1 has been developed by utilizing CEGB information up to year 1989; Part 2 has been developed by estimating fixed cost per kWh; fuel cost per kWh; O&M cost per kWh for the period post deregulation (from year 1990)
    a. *fixed cost per kWh*—depreciation and interest charges year on year after deregulation have been calculated by estimating costs of capacity additions utilizing information from (MacDonald 2012, IHSCERA 2018) and assuming appropriate depreciation periods and interest rates (the factors have been chosen conservatively over the values chosen by CEGB

during their period of governance). Capital expenses thus obtained, has been divided by the total electricity sold to estimate fixed cost per kWh.

   b. *fuel cost per kWh*—has been calculated by taking into account the total fuel consumed and rates of fuel—the information have been obtained from (IEA 2017(1d), IEA 2017(1e), IEA 2017(1f), IEA 2017(1g), IEA 2017(1h), IEA 2017(1i), IEA 2017(1j), IEA 2017(1k), IEA 2017g, IEA 2017h, IEA 2017i, IEA 2017j, IEA 2017k, IEA 2017l)

   c. *O&M cost per kWh*—has been calculated by considering the historic O&M cost before deregulation and correcting it for CPI

2) Nominal Average Price has been obtained from

3) Profit has been obtained by taking the difference between nominal average price and nominal average cost

Data for Figure 4-3 Profit Trends (NSW)

NSW	Nominal Average Electricity Price	Nominal Average Electricity Cost	Nominal Profit Margin	Capital Expenses	Fuel Expenses	O&M Expenses	Total Expenses	Generation Sale
Year	AUC/kWh	AUC/kWh	AUC/kWh	MILL-AUD	MILL-AUD	MILL-AUD	MILL-AUD	GWh
1960	2.10	2.09	0.01	58	27	52	137	6538
1961	2.11	2.08	0.03	67	26	57	150	7221
1962	2.18	2.08	0.10	70	25	66	161	7726
1963	2.13	2.06	0.07	71	25	81	177	8598
1964	2.05	1.94	0.10	75	25	87	187	9622
1965	1.95	1.92	0.03	79	24	98	201	10499
1966	1.93	1.91	0.02	89	26	101	216	11313
1967	1.90	1.87	0.03	95	27	112	234	12544
1968	1.90	1.85	0.05	102	29	119	250	13520
1969	1.92	1.88	0.04	109	30	136	275	14616
1970	1.91	1.85	0.06	118	32	150	300	16241
1971	1.94	1.86	0.08	123	34	171	328	17617
1972	2.03	1.97	0.06	135	39	191	365	18561
1973	2.12	2.02	0.10	145	41	204	390	19292
1974	2.17	2.11	0.06	152	42	235	429	20271
1975	2.45	2.33	0.12	157	51	290	498	21356
1976	2.78	2.66	0.12	174	64	347	585	21999
1977	3.03	2.91	0.12	199	96	388	683	23484
1978	3.19	3.10	0.09	219	114	429	762	24584

1979	3.38	3.34	0.04	248	139	484	871	26111
1980	3.69	3.94	-0.26	285	179	633	1097	27832
1981	4.09	4.05	0.04	327	233	651	1211	29909
1982	4.91	5.25	-0.33	392	353	862	1607	30620
1983	6.94	6.78	0.17	650	375	1010	2035	30018
1984	6.95	7.01	-0.06	791	414	1040	2245	32042
1985	6.68	7.13	-0.45	776	478	1220	2474	34677
1986	6.88	7.50	-0.62	989	541	1286	2816	37542
1987	7.03	7.78	-0.75	1192	609	1243	3044	39122
1988	7.49	8.26	-0.78	1235	656	1455	3346	40487
1989	8.10	8.26	-0.16	1321	698	1407	3426	41469
1990	8.46	8.32	0.14	1483	729	1440	3652	43903
1991	8.83	8.32	0.51	1453	752	1547	3752	45109
1992	9.13	8.38	0.75	1591	748	1468	3807	45443
1993	9.01	7.83	1.18	1564	730	1403	3697	47192
1994	8.60	7.14	1.46	1344	727	1389	3460	48423
1995	8.20	7.51	0.69	1215	755	1760	3730	49648
1996	8.10	7.19	0.91	1317	783	1783	3883	51411
1997	7.72	6.63	1.08	1272	854	1820	3946	53669
1998	7.71	6.78	0.93	1212	891	1876	3979	58713
1999	8.02	6.70	1.32	1154	933	1903	3990	59544
2000	8.05	6.69	1.36	1099	991	1990	4080	60949
2001	8.52	6.67	1.85	1047	1064	2084	4195	62897
2002	8.93	6.78	2.15	997	1124	2174	4295	63329
2003	8.66	6.84	1.82	950	1169	2241	4360	63781
2004	8.90	6.85	2.05	905	1182	2377	4464	65204
2005	9.76	6.80	2.96	862	1282	2427	4570	67200
2006	10.67	6.71	3.96	821	1295	2506	4622	68910
2007	10.82	6.72	4.10	782	1386	2541	4709	70092
2008	12.17	6.69	5.47	745	1459	2587	4791	71570
2009	11.41	7.24	4.17	995	1564	2629	5188	71675

2010	12.25	7.61	4.64	950	1611	2841	5402	71011
2011	13.60	7.67	5.92	938	1585	2988	5511	71811
2012	14.59	7.80	6.79	896	1544	2980	5420	69469
2013	15.51	8.22	7.29	911	1546	2992	5449	66309
2014	15.70	8.19	7.51	870	1509	3047	5427	66269

Notes for Figure 4-3

1) Average electricity prices have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)
2) Nominal costs of electricity have been constructed in two parts: Part 1 and Part 2
    a. Part 1 provides average electricity cost data for the period (1960-1995) and has been constructed utilizing information from historical electricity statistics obtained from (ESAA 2016)
    b. Part 2 provides electricity cost data for the period (1996-2014) and has been by estimating capital expenses, fuel expenses and O&M expenses and information have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, MacDonald 2012, ESAA 2013, Frontier-Economics 2013a, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017e, IEA 2017f, IEA 2017g, IEA 2017h, IEA 2017i, IEA 2017j, IEA 2017k, IEA 2017l, IHSCERA 2018)
3) Profit has been obtained from the difference between the average electricity price and average electricity cost

Data for Figure 4-4 Profit Trends (Victoria)

Victoria	Nominal Average Electricity Price	Nominal Average Electricity Cost	Nominal Profit Margin	Capital Expenses	Fuel Expenses	O&M Expenses	Total Expenses	Generation Sale
Year	AUC/kWh	AUC/kWh	AUC/kWh	MILL-AUD	MILL-AUD	MILL-AUD	MILL-AUD	GWh
1960	2.10	1.88	0.22	32	22	37	91	4832
1961	2.08	1.95	0.13	38	24	41	102	5233
1962	2.07	2.05	0.03	41	24	46	110	5357
1963	2.04	1.96	0.08	45	21	52	119	6064
1964	1.96	1.91	0.05	52	25	56	132	6924
1965	1.96	1.81	0.14	53	24	54	141	7754
1966	2.03	1.89	0.14	62	26	59	153	8131
1967	2.01	2.05	-0.04	76	26	71	179	8742
1968	2.07	2.06	0.01	83	26	75	190	9233
1969	2.15	2.08	0.08	89	22	85	203	9768
1970	2.13	2.05	0.08	98	20	86	213	10406
1971	2.09	2.15	-0.06	102	22	102	238	11043
1972	2.09	2.18	-0.09	106	24	108	251	11511
1973	2.06	2.16	-0.10	111	25	115	267	12338
1974	2.26	2.27	-0.01	120	29	135	300	13202
1975	2.50	2.49	0.01	130	37	165	351	14070
1976	2.73	2.76	-0.03	144	44	199	408	14754
1977	3.08	2.99	0.10	161	54	229	467	15649
1978	3.42	3.38	0.04	189	68	269	548	16212

1979	3.78	3.71	0.07	206	88	317	639	17202
1980	4.16	4.16	0.00	214		492	740	17765
1981	4.66	4.39	0.27	244	150	412	845	19260
1982	5.42	5.55	-0.13	375	175	529	1125	20261
1983	6.38	6.11	0.27	452	184	554	1237	20257
1984	6.99	6.63	0.36	485	211	641	1391	20968
1985	7.35	7.60	-0.25	616	234	711	1622	21344
1986	7.70	8.14	-0.44	753	243	756	1816	22307
1987	8.07	8.24	-0.17	884	250	761	1960	23787
1988	8.06	7.93	0.13	922	273	832	2098	26445
1989	8.05	8.12	-0.07	1001	319	975	2378	29286
1990	8.43	8.75	-0.33	1416	294	895	2681	30626
1991	8.95	9.54	-0.59	1420	342	1043	2937	30778
1992	9.26	10.74	-1.47	1475	399	1216	3308	30810
1993	9.44	12.59	-3.15	1533	463	1803	3987	31660
1994	9.63	9.11	0.53	1241	455	1163	2882	31640
1995	11.12	8.35	2.77	941	403	1772	2713	32511
1996	9.60	8.69	0.92	1209	442	1819	2856	32883
1997	9.19	8.87	0.32	1163	491	1823	3007	33915
1998	8.93	9.08	-0.15	1119	594	1839	3166	34855
1999	9.43	9.18	0.25	1077	737	1866	3333	36314
2000	9.50	9.34	0.16	1037	800	1949	3509	37579
2001	10.18	9.62	0.55	1017	825	2035	3694	38395
2002	11.53	9.97	1.56	1066	992	2096	3889	39007
2003	11.18	10.72	0.46	1026	1093	2154	4273	39868
2004	11.48	10.11	1.37	987	1095	2204	4287	42412
2005	12.60	10.20	2.40	950	1128	2263	4341	42573
2006	13.76	10.22	3.54	961	1150	2343	4454	43562
2007	13.96	10.22	3.73	925	1183	2398	4505	44061
2008	15.70	10.63	5.07	889	1309	2502	4701	44221
2009	14.72	10.71	4.01	855	1331	2548	4735	44214

2010	15.81	10.94	4.87	823	1335	2620	4779	43678
2011	17.54	11.05	6.50	792	1324	2707	4823	43660
2012	18.83	11.44	7.39	784	1413	2755	4952	43281
2013	20.02	11.50	8.52	797	1375	2822	4994	43441
2014	20.25	11.56	8.69	767	1372	2892	5031	43509

Notes for Figure 4-4

Average electricity prices have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)

1) Nominal costs of electricity have been constructed in two parts: Part 1 and Part 2
   a. Part 1 provides average electricity cost data for the period (1960-1995) and has been constructed utilizing information from historical electricity statistics obtained from (ESAA 2016)
   b. Part 2 provides electricity cost data for the period (1996-2014) and has been by estimating capital expenses, fuel expenses and O&M expenses and information have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, MacDonald 2012, ESAA 2013, Frontier-Economics 2013a, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017e, IEA 2017f, IEA 2017g, IEA 2017h, IEA 2017i, IEA 2017j, IEA 2017k, IEA 2017l, IHSCERA 2018)
2) Profit has been obtained from the difference between the average electricity price and average electricity cost

Data for Figure 4-5 Profit Trends (Queensland)

Queensland	Nominal Average Electricity Price	Nominal Average Electricity Cost	Nominal Profit Margin	Capital Expenses	Fuel Expenses	O&M Expenses	Total Expenses	Generation Sale
Year	AUC/kWh	AUC/kWh	AUC/kWh	MILL-AUD	MILL-AUD	MILL-AUD	MILL-AUD	GWh
1960	2.34	2.27	0.06	18	11	12	41	1816
1961	2.31	2.26	0.05	21	12	13	45	2000
1962	2.41	2.38	0.04	22	13	16	51	2127
1963	2.29	2.32	-0.02	24	13	16	53	2275
1964	2.27	2.27	0.00	26	13	18	57	2518
1965	2.25	2.31	-0.06	29	14	20	63	2747
1966	2.21	2.23	-0.02	32	15	21	68	3044
1967	2.17	2.23	-0.06	35	16	24	75	3365
1968	2.18	2.14	0.04	39	15	27	80	3762
1969	2.27	2.16	0.11	44	15	30	89	4131
1970	2.24	2.21	0.03	49	16	33	98	4427
1971	2.23	2.27	-0.04	55	17	38	109	4824
1972	2.21	2.31	-0.10	60	19	45	123	5333
1973	2.30	2.29	0.01	62	22	50	134	5837
1974	2.47	2.44	0.02	65	30	63	158	6474
1975	2.93	2.86	0.06	75	46	80	201	7008
1976	3.47	3.22	0.24	82	54	93	228	7089
1977	3.80	3.61	0.18	93	65	123	281	7766
1978	3.97	3.63	0.33	101	73	130	303	8349

1979	4.37	3.94	0.43	131	78	135	344	8723
1980	4.77	5.02	-0.25	228	91	159	478	9514
1981	5.29	5.58	-0.29	269	106	188	563	10089
1982	5.91	5.97	-0.05	299	114	243	655	10983
1983	6.56	6.72	-0.16	338	170	330	837	12458
1984	6.45	7.25	-0.79	486	227	339	1052	14521
1985	6.95	7.45	-0.51	545	240	385	1170	15702
1986	7.36	7.83	-0.47	702	226	378	1306	16678
1987	7.57	8.06	-0.48	671	221	533	1425	17687
1988	7.77	8.36	-0.59	894	253	419	1566	18743
1989	7.90	8.29	-0.39	932	276	442	1650	19898
1990	7.88	8.37	-0.50	905	281	595	1781	21265
1991	7.95	8.91	-0.96	1211	291	465	1967	22083
1992	8.16	8.50	-0.35	1177	313	458	1948	22909
1993	8.23	6.42	1.81	710	318	509	1536	23920
1994	8.53	5.95	2.58	622	326	480	1428	24001
1995	7.94	7.00	1.40	824	354	555	1732	26497
1996	7.66	6.88	1.23	790	395	594	1778	27642
1997	8.94	6.67	1.30	755	424	619	1797	28731
1998	9.03	6.69	2.77	783	537	699	2019	32210
1999	9.17	6.58	2.99	752	570	733	2055	33268
2000	8.70	6.51	2.57	737	622	817	2176	35505
2001	9.37	6.99	2.83	857	685	897	2439	37348
2002	9.39	7.93	2.40	1010	773	979	2761	39544
2003	9.10	8.22	1.79	969	913	1004	2887	39487
2004	9.34	7.80	2.36	931	923	1100	2955	42282
2005	10.25	7.83	3.19	921	993	1165	3079	43608
2006	11.21	7.74	4.17	884	1061	1261	3206	45571
2007	11.36	8.22	3.91	990	1103	1282	3375	45275
2008	12.78	8.22	5.28	952	1125	1349	3426	45657
2009	11.98	8.11	4.53	916	1191	1426	3533	47415

2010	12.87	8.39	5.13	912	1294	1469	3675	47473
2011	14.28	8.82	6.13	877	1302	1404	3583	43934
2012	15.33	8.82	7.14	844	1333	1434	3611	44091
2013	16.30	8.88	8.03	812	1344	1456	3612	43690
2014	16.49	8.83	8.25	819	1283	1489	3590	43588

Notes for Figure 4-5

1) Average electricity prices have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)
2) Nominal costs of electricity have been constructed in two parts: Part 1 and Part 2
    a. Part 1 provides average electricity cost data for the period (1960-1994) and has been constructed utilizing information from historical electricity statistics obtained from (ESAA 2016)
    b. Part 2 provides electricity cost data for the period (1995-2014) and has been by estimating capital expenses, fuel expenses and O&M expenses and information have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, MacDonald 2012, ESAA 2013, Frontier-Economics 2013a, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017e, IEA 2017f, IEA 2017g, IEA 2017h, IEA 2017i, IEA 2017j, IEA 2017k, IEA 2017l, IHSCERA 2018)
3) Profit has been obtained from the difference between the average electricity price and average electricity cost

Data for Figure 4-6 Profit Trends (South Australia)

South Australia	Nominal Average Electricity Price	Nominal Average Electricity Cost	Nominal Profit Margin	Capital Expenses	Fuel + O&M Expenses	Total Expenses	Generation Sale
Year	AUC/kWh	AUC/kWh	AUC/kWh	MILL-AUD	MILL-AUD	MILL-AUD	GWh
1960	2.05	2.11	-0.06	11	19	30	1440
1961	2.14	2.12	0.01	11	19	30	1434
1962	2.03	2.05	-0.02	12	21	33	1621
1963	2.02	2.13	-0.11	15	22	37	1749
1964	2.05	2.05	0.00	15	24	39	1880
1965	1.97	1.97	-0.01	17	26	43	2162
1966	1.89	1.93	-0.04	20	28	48	2502
1967	1.89	1.90	-0.01	21	29	50	2654
1968	1.83	1.82	0.01	23	32	55	3015
1969	1.83	1.85	-0.02	25	35	60	3224
1970	1.80	1.84	-0.04	28	37	65	3505
1971	1.82	1.86	-0.04	29	40	69	3679
1972	1.93	2.03	-0.10	31	44	75	3718
1973	1.89	1.97	-0.08	32	48	80	4067
1974	2.03	2.04	-0.02	33	54	87	4276
1975	2.30	2.40	-0.10	35	71	106	4434
1976	2.59	2.64	-0.05	39	86	125	4718
1977	2.75	2.78	-0.03	44	103	147	5279
1978	3.02	2.98	0.04	58	107	165	5527

1979	3.32	3.24	0.08	65	120	185	5713
1980	3.69	3.73	-0.04	73	144	217	5801
1981	4.23	4.06	0.17	83	162	245	6030
1982	5.06	4.63	0.43	100	189	289	6243
1983	6.14	6.20	-0.06	173	241	414	6683
1984	7.12	7.87	-0.75	229	269	498	6328
1985	8.01	9.36	-1.36	298	333	631	6737
1986	8.27	10.01	-1.74	350	340	690	6894
1987	8.57	10.32	-1.75	356	356	712	6904
1988	9.27	10.74	-1.47	388	394	782	7276
1989	9.50	9.61	-0.10	299	433	732	7623
1990	9.72	8.58	1.14	223	467	690	8048
1991	9.91	8.08	1.83	234	429	663	8207
1992	10.40	7.82	2.58	226	408	634	8106
1993	10.44	8.10	2.34	217	465	682	8423
1994	10.06	7.75	2.31	210	456	666	8603
1995	9.56	5.16	4.40	212	266	478	9257
1996	9.51	5.91	3.60	272	270	543	9184
1997	9.84	5.77	4.04	267	280	547	9489
1998	9.86	6.25	3.61	325	296	621	9939
1999	10.10	5.42	4.68	250	316	566	10456
2000	10.11	6.06	4.05	321	349	670	11045
2001	13.85	5.96	7.89	305	377	682	11442
2002	13.16	6.35	6.81	331	381	712	11213
2003	13.40	6.23	7.17	323	411	734	11775
2004	13.76	6.22	7.55	307	414	721	11600
2005	15.10	6.96	8.14	385	428	813	11668
2006	16.50	6.84	9.66	370	461	831	12142
2007	16.74	6.67	10.07	353	493	846	12684
2008	18.82	7.68	11.14	461	514	975	12691
2009	17.65	7.55	10.10	441	531	972	12878

2010	18.95	8.21	10.74	512	547	1059	12897
2011	21.03	8.50	12.53	535	570	1105	13000
2012	22.57	8.59	13.99	529	572	1101	12824
2013	24.00	8.52	15.48	507	587	1094	12849
2014	24.28	9.30	14.98	574	582	1156	12430

Notes for Figure 4-6

Average electricity prices have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)

1) Nominal costs of electricity have been constructed in two parts: Part 1 and Part 2
    a. Part 1 provides average electricity cost data for the period (1960-1995) and has been constructed utilizing information from historical electricity statistics obtained from (ESAA 2016)
    b. Part 2 provides electricity cost data for the period (1996-2014) and has been by estimating capital expenses, fuel expenses and O&M expenses and information have been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, MacDonald 2012, ESAA 2013, Frontier-Economics 2013a, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017e, IEA 2017f, IEA 2017g, IEA 2017h, IEA 2017i, IEA 2017j, IEA 2017k, IEA 2017l, IHSCERA 2018)

Profit has been obtained from the difference between the average electricity price and average electricity cost

Data for Figure 4-7 Price Trends (US)

United States	Nominal Average Electricity Price	Percentage Price increase over year 1962
Year	USC/kWh	%
1962	1.8	
1963	1.8	0%
1964	1.7	-10%
1965	1.7	-10%
1966	1.7	-10%
1967	1.7	-10%
1968	1.6	-20%
1969	1.6	-20%
1970	1.7	-10%
1971	1.8	0%
1972	1.9	10%
1973	2	20%
1974	2.5	70%
1975	2.9	110%
1976	3.1	130%
1977	3.4	160%
1978	3.7	190%
1979	4	220%
1980	4.7	290%
1981	5.5	370%
1982	6.1	430%
1983	6.3	450%
1984	6.25	445%
1985	6.44	464%
1986	6.44	464%
1987	6.37	457%
1988	6.35	455%
1989	6.45	465%
1990	6.57	477%
1991	6.75	495%

1992	6.82	502%
1993	6.93	513%
1994	6.91	511%
1995	6.89	509%
1996	6.86	506%
1997	6.85	505%
1998	6.74	494%
1999	6.64	484%
2000	6.81	501%
2001	7.29	549%
2002	7.2	540%
2003	7.44	564%
2004	7.61	581%
2005	8.14	634%
2006	8.9	710%
2007	9.13	733%
2008	9.74	794%
2009	9.82	802%
2010	9.83	803%
2011	9.9	810%
2012	9.84	804%
2013	10.07	827%
2014	10.44	864%

Notes

Nominal electricity price data for the period (1962-2014) has been obtained from (EIA 2017)

1) Percentage increase over year 1962 has been estimated

Data for Figure 4-8 Price Trends (UK)

United Kingdom	Nominal Average Electricity Price	Percentage Price Increase over Year 1978
Year	UKP/kWh	%
1978	2.41	
1979	2.63	22%
1980	2.69	27%
1981	2.99	58%
1982	3.16	75%
1983	3.06	65%
1984	4.13	172%
1985	3.46	105%
1986	3.56	115%
1987	3.66	124%
1988	4.82	240%
1989	5.04	263%
1990	5.37	296%
1991	6.01	359%
1992	6.32	391%
1993	5.93	351%
1994	5.61	319%
1995	5.51	310%
1996	5.21	279%
1997	4.70	228%
1998	4.45	204%
1999	4.25	184%
2000	4.17	176%
2001	4.07	166%
2002	4.03	162%
2003	4.08	166%
2004	4.44	202%
2005	5.26	284%
2006	6.52	410%
2007	6.40	398%
2008	7.47	505%
2009	7.74	532%

2010	7.28	487%
2011	8.43	601%
2012	10.31	790%
2013	11.28	887%
2014	12.08	967%

Notes for Figure 4-8

1) Nominal electricity price data for the period (1978-2014) has been obtained from (DOEUK 2016)
2) Percentage increase over year 1978 has been estimated

Data for Figure 4-9 Price Trends (NSW)

New South Wales	Nominal Average Electricity Price	Increase of Electricity Price over year 1960
Year	AUC/kWh	%
1960	2.10	
1961	2.11	1%
1962	2.18	4%
1963	2.13	1%
1964	2.05	-3%
1965	1.95	-7%
1966	1.93	-8%
1967	1.90	-9%
1968	1.90	-9%
1969	1.92	-8%
1970	1.91	-9%
1971	1.94	-8%
1972	2.03	-3%
1973	2.12	1%
1974	2.17	4%
1975	2.45	17%
1976	2.78	32%
1977	3.03	44%
1978	3.19	52%
1979	3.38	61%
1980	3.69	76%
1981	4.09	95%
1982	4.91	134%
1983	6.94	231%
1984	6.95	231%
1985	6.68	218%
1986	6.88	228%
1987	7.03	235%
1988	7.49	257%
1989	8.10	286%
1990	8.46	303%
1991	8.83	321%

1992	9.13	335%
1993	9.01	329%
1994	8.60	310%
1995	8.20	291%
1996	8.10	286%
1997	7.72	267%
1998	7.71	267%
1999	8.02	282%
2000	8.05	283%
2001	8.52	306%
2002	8.93	325%
2003	8.66	312%
2004	8.90	324%
2005	9.76	365%
2006	10.67	408%
2007	10.82	415%
2008	12.17	479%
2009	11.41	443%
2010	12.25	483%
2011	13.60	547%
2012	14.59	595%
2013	15.51	639%
2014	15.70	647%

Notes for Figure 4-9

Nominal electricity price data for the period (1960-2014) has been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)

1) Percentage increase over year 1960 has been estimated

Data for Figure 4-10 Price Trends (Victoria)

Victoria	Nominal Average Electricity Price Trend	Percentage Price Increase over Year 1960
Year	AUC/kWh	%
1960	2.10	
1961	2.08	0%
1962	2.07	0%
1963	2.04	-4%
1964	1.96	-12%
1965	1.96	-12%
1966	2.03	-5%
1967	2.01	-6%
1968	2.07	0%
1969	2.15	8%
1970	2.13	5%
1971	2.09	2%
1972	2.09	1%
1973	2.06	-2%
1974	2.26	19%
1975	2.50	43%
1976	2.73	66%
1977	3.08	101%
1978	3.42	134%
1979	3.78	171%
1980	4.16	209%
1981	4.66	259%
1982	5.42	334%
1983	6.38	430%
1984	6.99	492%
1985	7.35	528%
1986	7.70	563%
1987	8.07	600%
1988	8.06	598%
1989	8.05	597%
1990	8.43	635%
1991	8.95	687%

1992	9.26	719%
1993	9.44	737%
1994	9.63	756%
1995	11.12	905%
1996	9.60	753%
1997	9.19	711%
1998	8.93	686%
1999	9.43	736%
2000	9.50	743%
2001	10.18	810%
2002	11.53	945%
2003	11.18	910%
2004	11.48	940%
2005	12.60	1052%
2006	13.76	1169%
2007	13.96	1188%
2008	15.70	1363%
2009	14.72	1265%
2010	15.81	1373%
2011	17.54	1547%
2012	18.83	1675%
2013	20.02	1794%
2014	20.25	1818%

Notes for Figure 4-10

1) Nominal electricity price data for the period (1960-2014) has been obtained from(ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)
2) Percentage increase over year 1960 has been estimated

Data for Figure 4-11 Price Trends (Queensland)

Queensland	Nominal Average Electricity Price Trend	Percentage Price Increase over Year 1960
Year	AUC/kWh	%
1960	2.34	0%
1961	2.31	-1%
1962	2.41	3%
1963	2.29	-2%
1964	2.27	-3%
1965	2.25	-4%
1966	2.21	-6%
1967	2.17	-7%
1968	2.18	-7%
1969	2.27	-3%
1970	2.24	-4%
1971	2.23	-5%
1972	2.21	-5%
1973	2.30	-2%
1974	2.47	6%
1975	2.93	25%
1976	3.47	48%
1977	3.80	62%
1978	3.97	70%
1979	4.37	87%
1980	4.77	104%
1981	5.29	126%
1982	5.91	153%
1983	6.56	181%
1984	6.45	176%
1985	6.95	197%
1986	7.36	215%
1987	7.57	224%
1988	7.77	232%
1989	7.90	238%

1990	7.88	237%
1991	7.95	240%
1992	8.16	249%
1993	8.23	252%
1994	8.53	265%
1995	7.94	240%
1996	7.66	228%
1997	8.94	282%
1998	9.03	286%
1999	9.17	292%
2000	8.70	272%
2001	9.37	301%
2002	9.39	301%
2003	9.10	289%
2004	9.34	300%
2005	10.25	339%
2006	11.21	379%
2007	11.36	386%
2008	12.78	447%
2009	11.98	413%
2010	12.87	450%
2011	14.28	511%
2012	15.33	556%
2013	16.30	597%
2014	16.49	605%

Notes for Figure 4-11

Nominal electricity price data for the period (1960-2014) has been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)

1) Percentage increase over year 1960 has been estimated

Data for Figure 4-12 Price Trends (South Australia)

South Australia	Nominal Average Electricity Price Trend	Percentage Price Increase over Year 1960
Year	AUC/kWh	%
1960	2.05	
1961	2.14	4%
1962	2.03	-1%
1963	2.02	-1%
1964	2.05	0%
1965	1.97	-4%
1966	1.89	-8%
1967	1.89	-8%
1968	1.83	-11%
1969	1.83	-11%
1970	1.8	-12%
1971	1.82	-11%
1972	1.93	-6%
1973	1.89	-8%
1974	2.03	-1%
1975	2.3	12%
1976	2.59	26%
1977	2.75	34%
1978	3.02	47%
1979	3.32	62%
1980	3.69	80%
1981	4.23	106%
1982	5.06	147%
1983	6.14	200%
1984	7.12	247%
1985	8.01	291%
1986	8.27	303%
1987	8.57	318%
1988	9.27	352%
1989	9.5	363%
1990	9.72	374%
1991	9.91	383%

1992	10.4	407%
1993	10.44	409%
1994	10.06	391%
1995	9.56	366%
1996	9.51	364%
1997	9.84	380%
1998	9.86	381%
1999	10.1	393%
2000	10.11	393%
2001	13.85	576%
2002	13.16	542%
2003	13.4	554%
2004	13.76	571%
2005	15.1	637%
2006	16.5	705%
2007	16.74	717%
2008	18.82	818%
2009	17.65	761%
2010	18.95	824%
2011	21.03	926%
2012	22.57	1001%
2013	24	1071%
2014	24.28	1084%

Notes for Figure 4-12

Nominal electricity price data for the period (1960-2014) has been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)

1) Percentage increase over year 1960 has been estimated utilizing the above data

Data for Figure 4-13 Inequity Trend (US)

United States	Household Sector Electricity Price (Nominal)	Industrial Sector Electricity Price (Nominal)	Inequity	Percentage Increase of Inequity over Year 1962
Year	USC/kWh	USC/kWh	USC/kWh	%
1962	2.6	1.1	1.5	
1963	2.5	1	1.5	0%
1964	2.5	1	1.5	0%
1965	2.4	1	1.4	-10%
1966	2.3	1	1.3	-20%
1967	2.3	1	1.3	-20%
1968	2.3	1	1.3	-20%
1969	2.2	1	1.2	-30%
1970	2.2	1	1.2	-30%
1971	2.3	1.1	1.2	-30%
1972	2.4	1.2	1.2	-30%
1973	2.5	1.3	1.2	-30%
1974	3.1	1.7	1.4	-10%
1975	3.5	2.1	1.4	-10%
1976	3.7	2.2	1.5	0%
1977	4.1	2.5	1.6	10%
1978	4.3	2.8	1.5	0%
1979	4.6	3.1	1.5	0%
1980	5.4	3.7	1.7	20%
1981	6.2	4.3	1.9	40%
1982	6.9	5	1.9	40%
1983	7.2	5	2.2	70%
1984	7.15	4.83	2.32	82%
1985	7.39	4.97	2.42	92%
1986	7.42	4.93	2.49	99%
1987	7.45	4.77	2.68	118%
1988	7.48	4.7	2.78	128%
1989	7.65	4.72	2.93	143%
1990	7.83	4.74	3.09	159%
1991	8.04	4.83	3.21	171%
1992	8.21	4.83	3.38	188%
1993	8.32	4.85	3.47	197%

1994	8.38	4.77	3.61	211%
1995	8.4	4.66	3.74	224%
1996	8.36	4.6	3.76	226%
1997	8.43	4.53	3.9	240%
1998	8.26	4.48	3.78	228%
1999	8.16	4.43	3.73	223%
2000	8.24	4.64	3.6	210%
2001	8.58	5.05	3.53	203%
2002	8.44	4.88	3.56	206%
2003	8.72	5.11	3.61	211%
2004	8.95	5.25	3.7	220%
2005	9.45	5.73	3.72	222%
2006	10.4	6.16	4.24	274%
2007	10.65	6.39	4.26	276%
2008	11.26	6.96	4.3	280%
2009	11.51	6.83	4.68	318%
2010	11.54	6.77	4.77	327%
2011	11.72	6.82	4.9	340%
2012	11.88	6.67	5.21	371%
2013	12.13	6.89	5.24	374%

Notes for Figure 4-13

1) Nominal residential and industrial sector electricity price data for the period (1962-2014) has been obtained from (EIA 2017)
2) Percentage change in inequity has been estimated utilizing the above data

Data for Figure 4-14 Inequity Trend (UK)

United Kingdom	Household Sector Electricity Price (Nominal)	Industrial Sector Electricity Price (Nominal)	Inequity	Percentage Increase of Inequity over Year 1978
Year	UKP/kWh	UKP/kWh	UKP/kWh	%
1978	2.72	1.98	0.74	
1979	2.95	2.7	0.25	-49%
1980	3.75	2.7	1.05	31%
1981	4.51	3.14	1.37	63%
1982	4.95	3.44	1.51	77%
1983	5.13	3.46	1.67	93%
1984	5.2	3.46	1.74	100%
1985	5.37	3.58	1.79	105%
1986	5.48	3.63	1.85	111%
1987	5.46	3.52	1.94	120%
1988	5.75	3.7	2.05	131%
1989	6.17	3.73	2.44	170%
1990	6.67	3.98	2.69	195%
1991	7.34	4.11	3.23	249%
1992	7.72	4.32	3.4	266%
1993	7.7	4.55	3.15	241%
1994	7.5	4.38	3.12	238%
1995	7.46	4.34	3.12	238%
1996	7.44	4.19	3.25	251%
1997	7.14	3.95	3.19	245%
1998	6.94	3.92	3.02	228%
1999	6.86	3.94	2.92	218%
2000	6.71	3.66	3.05	231%
2001	6.66	3.34	3.32	258%
2002	6.69	3.22	3.47	273%
2003	6.75	3.12	3.63	289%
2004	7.16	3.4	3.76	302%
2005	7.88	4.56	3.32	258%
2006	9.27	6.12	3.15	241%
2007	9.73	6.28	3.45	271%
2008	11.33	7.73	3.60	286%
2009	11.68	8.34	3.34	260%

2010	11.34	7.57	3.77	303%
2011	12.43	7.81	4.62	388%
2012	13.09	8.21	4.88	414%
2013	14.02	8.65	5.37	463%
2014	14.83	9.13	5.70	496%

Notes for Figure 4-14

Nominal residential and industrial sector electricity price data for the period (1978 - 2014) has been obtained from (DOEUK 2016, IEA 2017a1)

1) Percentage change in inequity has been estimated utilizing the above data

Data for Figure 4-15 Inequity Trend (NSW)

New South Wales	Household Sector Electricity Price (Nominal)	Industrial Sector Electricity Price (Nominal)	Inequity	Percentage Increase of Inequity over Year 1960
Year	AUC/kWh	AUC/kWh	AUC/kWh	%
1960	2.07	2.17	-0.10	
1961	2.03	2.22	-0.19	-9%
1962	2.10	2.29	-0.19	-9%
1963	2.07	2.21	-0.14	-3%
1964	2.03	2.09	-0.05	5%
1965	1.97	1.96	0.01	12%
1966	1.94	1.93	0.01	12%
1967	1.93	1.88	0.05	15%
1968	1.94	1.88	0.06	16%
1969	1.95	1.90	0.05	16%
1970	1.98	1.86	0.12	23%
1971	2.00	1.88	0.12	22%
1972	2.08	1.99	0.09	20%
1973	2.17	2.07	0.09	20%
1974	2.24	2.12	0.12	22%
1975	2.45	2.44	0.01	12%
1976	2.74	2.79	-0.05	5%
1977	2.97	3.05	-0.08	2%
1978	3.11	3.23	-0.12	-2%
1979	3.27	3.45	-0.19	-8%
1980	3.53	3.77	-0.24	-13%
1981	3.87	4.22	-0.35	-24%
1982	4.59	5.12	-0.53	-43%
1983	6.16	7.51	-1.36	-125%
1984	6.48	7.23	-0.75	-65%
1985	6.40	6.81	-0.41	-30%
1986	6.87	6.83	0.05	15%
1987	7.11	6.93	0.19	29%
1988	7.54	7.38	0.16	27%
1989	8.28	7.94	0.33	44%
1990	8.62	8.32	0.30	41%
1991	9.00	8.68	0.32	42%

1992	9.36	8.87	0.49	59%
1993	9.64	8.57	1.07	117%
1994	9.64	8.01	1.63	173%
1995	9.62	7.40	2.21	232%
1996	9.58	7.39	2.19	229%
1997	9.67	6.77	2.89	300%
1998	9.80	6.76	3.04	314%
1999	9.58	7.16	2.42	252%
2000	9.73	7.20	2.53	263%
2001	10.47	7.62	2.85	295%
2002	10.98	7.98	3.00	311%
2003	11.36	7.38	3.98	409%
2004	11.98	7.35	4.63	473%
2005	13.15	8.07	5.08	518%
2006	14.36	8.82	5.55	565%
2007	14.57	8.94	5.63	573%
2008	16.39	10.06	6.33	643%
2009	15.37	9.43	5.94	604%
2010	16.68	9.99	6.69	679%
2011	18.51	11.09	7.42	753%
2012	19.87	11.90	7.97	807%
2013	21.12	12.65	8.47	857%
2014	21.37	12.80	8.57	867%

Notes for Figure 4-15

Nominal residential and industrial sector electricity price data for the period (1960-2014) has been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)

1) Percentage change in inequity has been estimated utilizing the above data

Data for Figure 4-16 Inequity Trend (Victoria)

Victoria	Household Sector Electricity Price (Nominal)	Industrial Sector Electricity Price (Nominal)	Inequity	Percentage Increase of Inequity over Year 1960
Year	AUC/kWh	AUC/kWh	AUC/kWh	%
1960	1.99	2.24	-0.25	
1961	1.96	2.21	-0.25	0%
1962	1.96	2.21	-0.24	1%
1963	1.95	2.13	-0.18	7%
1964	1.94	1.99	-0.06	20%
1965	1.96	1.97	-0.01	24%
1966	2.05	2.02	0.03	28%
1967	2.02	2.01	0.01	26%
1968	2.04	2.09	-0.05	20%
1969	2.09	2.20	-0.11	14%
1970	2.08	2.16	-0.08	17%
1971	2.06	2.11	-0.05	20%
1972	2.02	2.13	-0.11	14%
1973	2.00	2.09	-0.09	17%
1974	2.22	2.28	-0.06	20%
1975	2.44	2.53	-0.09	16%
1976	2.64	2.77	-0.14	12%
1977	2.90	3.19	-0.29	-4%
1978	3.21	3.55	-0.33	-8%
1979	3.56	3.91	-0.34	-9%
1980	3.89	4.31	-0.42	-17%
1981	4.49	4.73	-0.24	1%
1982	5.23	5.47	-0.24	1%
1983	6.11	6.47	-0.35	-10%
1984	7.00	6.89	0.11	36%
1985	7.17	7.37	-0.20	5%
1986	7.58	7.67	-0.09	17%
1987	8.08	7.95	0.13	38%
1988	8.62	7.68	0.94	119%
1989	8.97	7.56	1.41	166%
1990	9.38	7.93	1.45	171%
1991	9.98	8.41	1.57	182%

1992	10.75	8.53	2.21	246%
1993	11.72	8.41	3.31	356%
1994	12.58	8.41	4.17	442%
1995	12.75	8.38	4.37	462%
1996	12.23	8.43	3.80	405%
1997	12.79	7.62	5.17	542%
1998	12.81	7.31	5.50	575%
1999	12.60	7.75	4.85	510%
2000	12.65	7.90	4.75	500%
2001	14.18	8.71	5.47	573%
2002	14.70	10.38	4.32	457%
2003	15.21	9.61	5.61	586%
2004	16.04	9.57	6.47	672%
2005	17.60	10.50	7.10	735%
2006	19.23	11.47	7.76	801%
2007	19.50	11.64	7.87	812%
2008	21.94	13.09	8.85	910%
2009	20.57	12.27	8.30	855%
2010	22.33	13.00	9.33	958%
2011	24.78	14.43	10.35	1060%
2012	26.60	15.49	11.11	1136%
2013	28.28	16.47	11.81	1206%
2014	28.61	16.66	11.95	1220%

Notes for Figure 4-16

1) Nominal residential and industrial sector electricity price data for the period (1960-2014) has been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)
2) Percentage change in inequity has been estimated utilizing the above data

Data for Figure 4-17 Inequity Trend (Queensland)

Queensland	Household Sector Electricity Price (Nominal)	Industrial Sector Electricity Price (Nominal)	Inequity	Percentage Increase of Inequity over Year 1960
Year	AUC/kWh	AUC/kWh	AUC/kWh	%
1960	2.30	2.38	-0.09	
1961	2.23	2.38	-0.15	-6%
1962	2.19	2.63	-0.44	-36%
1963	2.10	2.46	-0.35	-27%
1964	2.09	2.39	-0.30	-21%
1965	2.06	2.39	-0.33	-24%
1966	2.05	2.30	-0.25	-16%
1967	2.05	2.24	-0.19	-10%
1968	2.08	2.22	-0.14	-5%
1969	2.20	2.29	-0.09	-1%
1970	2.18	2.24	-0.06	3%
1971	2.16	2.24	-0.08	1%
1972	2.16	2.21	-0.05	4%
1973	2.23	2.32	-0.09	0%
1974	2.38	2.49	-0.11	-2%
1975	2.78	2.99	-0.21	-12%
1976	3.33	3.52	-0.19	-10%
1977	3.64	3.85	-0.21	-13%
1978	3.78	4.05	-0.27	-18%
1979	4.15	4.48	-0.34	-25%
1980	4.58	4.84	-0.26	-17%
1981	4.98	5.43	-0.45	-37%
1982	5.62	6.05	-0.43	-34%
1983	6.61	6.46	0.16	24%
1984	7.29	5.95	1.33	142%
1985	8.15	6.29	1.86	195%
1986	8.89	6.57	2.32	241%
1987	9.20	6.76	2.45	253%
1988	9.26	7.00	2.26	234%
1989	9.34	7.18	2.16	225%
1990	9.26	7.19	2.07	215%
1991	9.31	7.28	2.03	211%

1992	9.57	7.49	2.08	216%
1993	9.67	7.54	2.13	222%
1994	9.74	7.92	1.81	190%
1995	9.76	7.35	2.41	250%
1996	9.76	6.72	3.03	312%
1997	9.71	6.61	3.10	319%
1998	9.69	6.13	3.55	364%
1999	9.69	8.45	1.24	133%
2000	9.63	8.12	1.51	160%
2001	10.94	8.72	2.22	231%
2002	11.62	8.57	3.05	313%
2003	12.03	7.93	4.10	418%
2004	12.68	7.90	4.78	486%
2005	13.91	8.67	5.24	533%
2006	15.20	9.48	5.73	581%
2007	15.42	9.61	5.81	589%
2008	17.34	10.81	6.53	662%
2009	16.26	10.14	6.13	621%
2010	17.65	10.74	6.92	700%
2011	19.59	11.92	7.68	776%
2012	21.03	12.79	8.24	832%
2013	22.36	13.60	8.76	884%
2014	22.62	13.76	8.86	895%

Notes for Figure 4-17

1) Nominal residential and industrial sector electricity price data for the period (1960-2014) has been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)
2) Percentage change in inequity has been estimated utilizing the above data

Data for Figure 4-18 Inequity Trend South Australia

New South Wales	Household Sector Electricity Price (Nominal)	Industrial Sector Electricity Price (Nominal)	Inequity	Percentage Increase of Inequity over Year 1960
Year	AUC/kWh	AUC/kWh	AUC/kWh	%
1960	1.94	1.93	0.01	
1961	1.89	2.14	-0.25	-26%
1962	1.86	1.96	-0.1	-11%
1963	1.79	2	-0.21	-22%
1964	1.78	2.05	-0.27	-28%
1965	1.74	1.95	-0.21	-22%
1966	1.7	1.85	-0.15	-16%
1967	1.68	1.88	-0.2	-21%
1968	1.67	1.76	-0.09	-10%
1969	1.65	1.79	-0.14	-15%
1970	1.66	1.77	-0.11	-12%
1971	1.65	1.81	-0.16	-17%
1972	1.71	1.94	-0.23	-24%
1973	1.71	1.89	-0.18	-19%
1974	1.82	2.05	-0.23	-24%
1975	2.05	2.36	-0.31	-32%
1976	2.32	2.67	-0.35	-36%
1977	2.5	2.78	-0.28	-29%
1978	2.82	3.02	-0.2	-21%
1979	3.06	3.34	-0.28	-29%
1980	3.42	3.69	-0.27	-28%
1981	3.95	4.22	-0.27	-28%
1982	4.65	5.1	-0.45	-46%
1983	5.79	6.08	-0.29	-30%
1984	6.64	7.11	-0.47	-48%
1985	7.57	7.94	-0.37	-38%
1986	8.12	8.24	-0.12	-13%
1987	8.28	8.63	-0.35	-36%
1988	8.99	9.31	-0.32	-33%
1989	9.4	9.42	-0.02	-3%
1990	9.69	9.59	0.1	9%
1991	10.1	9.63	0.47	46%

1992	10.64	10.08	0.56	55%
1993	10.95	9.97	0.98	97%
1994	11.17	9.23	1.94	193%
1995	11.17	8.46	2.71	270%
1996	11.33	8.27	3.06	305%
1997	11.95	7.84	4.11	410%
1998	12.55	8.26	4.29	428%
1999	12.8	8.55	4.25	424%
2000	14.92	10.96	3.96	395%
2001	15.35	11.9	3.45	344%
2002	14.36	12.96	1.4	139%
2003	14.75	12.63	2.12	211%
2004	15.55	12.58	2.97	296%
2005	17.06	13.81	3.25	324%
2006	18.65	15.09	3.56	355%
2007	18.91	15.3	3.61	360%
2008	21.27	17.21	4.06	405%
2009	19.95	16.14	3.81	380%
2010	21.65	17.1	4.55	454%
2011	24.03	18.98	5.05	504%
2012	25.79	20.37	5.42	541%
2013	27.42	21.65	5.77	576%
2014	27.74	21.91	5.83	582%

Notes for Figure 4-18

1) Nominal residential and industrial sector electricity price data for the period (1960-2014) has been obtained from (ESAA 2005, ESAA 2006, ESAA 2007, ESAA 2008, ESAA 2009, ESAA 2010, ESAA 2011, ESAA 2012, ESAA 2013, ESAA 2014, ESAA 2015, ESAA 2016, IEA 2017d, IEA 2017e, IEA 2017f)
2) Percentage change in inequity has been estimated utilizing the above data

Data for Figure 4-19: CO2 Emission Trends (US)

United States	gCO2 per kWh Electricity Generated from Coal	gCO2 per kWh Electricity Generated from Natural Gas	Percentage Change in CO2 emission from Coal Technology Norms	Percentage Change in CO2 emission from Natural Gas Technology Norms
Year	gm/kWh	gm/kWh	%	%
1990	929	552	9%	51%
1991	915	570	7%	55%
1992	946	570	11%	55%
1993	943	549	11%	50%
1994	946	544	11%	48%
1995	967	543	14%	48%
1996	964	580	13%	58%
1997	977	592	15%	61%
1998	952	573	12%	56%
1999	939	574	10%	57%
2000	941	486	10%	33%
2001	1015	478	19%	30%
2002	947	462	11%	26%
2003	945	451	11%	23%
2004	949	454	11%	24%
2005	941	451	10%	23%
2006	932	415	9%	13%
2007	951	419	12%	14%
2008	926	410	9%	12%
2009	926	405	9%	10%
2010	926	407	9%	11%
2011	928	406	9%	11%
2012	931	405	9%	10%
2013	928	402	9%	10%
2014	927	400	9%	9%

Notes for Figure 4-19

1) Gram CO_2 emission per kWh for generation of electricity by coal and natural gas fuel have been sourced from (IEA 2017x, IEA 2017y)
1) The emission norm technology wise have been sourced from (Frontier-Economics 2013a)
2) Percentage change from norm has been estimated

Data for Figure 4-20: CO_2 Emission Trends (UK)

United Kingdom	gCO2 per kWh Electricity Generated from Coal	gCO2 per kWh Electricity Generated from Natural Gas	Percentage Change in CO2 emission from Coal Technology Norms	Percentage Change in CO2 emission from Natural Gas Technology Norms
Year	gm/kWh	gm/kWh	%	%
1990	930	523	9%	43%
1991	915	491	7%	34%
1992	953	490	12%	34%
1993	914	482	7%	31%
1994	903	428	6%	17%
1995	899	429	6%	17%
1996	916	436	8%	19%
1997	960	412	13%	12%
1998	966	413	13%	13%
1999	960	401	13%	9%
2000	950	398	11%	9%
2001	938	401	10%	9%
2002	933	394	10%	7%
2003	938	396	10%	8%
2004	959	394	13%	7%
2005	964	395	13%	8%
2006	956	402	12%	10%
2007	961	390	13%	6%
2008	926	389	9%	6%
2009	911	392	7%	7%
2010	902	391	6%	7%
2011	916	384	7%	5%
2012	914	394	7%	7%
2013	923	391	8%	7%
2014	931	394	9%	7%

Notes for Figure 4-20

1) Gram CO_2 emission per kWh for generation of electricity by coal and natural gas fuel have been sourced from (IEA 2017x, IEA 2017y)
2) The emission norm technology wise have been sourced from (Frontier-Economics 2013a)
3) Percentage change from norm has been estimated

Data for Figure 4-21: CO2 Emission Trends (Australia)

United Kingdom	gCO2 per kWh Electricity Generated from Coal	gCO2 per kWh Electricity Generated from Natural Gas	Percentage Change in CO2 emission from Coal Technology Norms	Percentage Change in CO2 emission from Natural Gas Technology Norms
Year	gm/kWh	gm/kWh	%	%
1990	567.6369	967.1973	55%	14%
1991	569.1905	968.4195	55%	14%
1992	572.5182	969.4446	56%	14%
1993	559.8337	958.1141	53%	12%
1994	605.3927	940.0206	65%	10%
1995	560.7113	951.6714	53%	12%
1996	600.4427	958.3594	64%	12%
1997	636.7454	954.8004	74%	12%
1998	605.2664	995.4254	65%	17%
1999	566.1432	982.7716	54%	15%
2000	586.8842	962.9833	60%	13%
2001	600.0286	934.043	64%	10%
2002	566.9494	1046.2854	55%	23%
2003	388.7614	1008.8997	6%	18%
2004	396.6545	1017.3672	8%	19%
2005	533.3644	1025.9605	45%	20%
2006	532.9767	1026.9977	45%	21%
2007	532.0454	1025.2176	45%	20%
2008	535.5597	1024.9505	46%	20%
2009	539.3075	1064.0477	47%	25%
2010	514.156	1018.0871	40%	20%
2011	483.0821	1013.4083	32%	19%
2012	534.7533	1005.7113	46%	18%
2013	511.6194	1010.3924	39%	19%
2014	492.5867	1001.6206	34%	18%

Notes for Figure 4-21

Gram CO_2 emission per kWh for generation of electricity by coal and natural gas fuel have been sourced from (IEA 2017x, IEA 2017y)

1) The emission norm technology wise have been sourced from (Frontier-Economics 2013a)
2) Percentage change from norm has been estimated

7.4 Appendix D

7.4.1 Hypothesis 1

Econometric Test Results Hypothesis1: ***Deregulated electricity pricing system leads to disjuncture between electricity price and its cost***.

United States:

Dependent Variable: PROF
Method: Least Squares
Date: 03/30/17 Time: 11:42
Sample: 1962 2014
Included observations: 53

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	0.562006	0.072800	7.719885	0.0000
INFLOILSH	0.560748	0.068636	8.169851	0.0000
PURPA	0.993487	0.048533	20.47027	0.0000
DEREG	1.038718	0.051477	20.17821	0.0000

R-squared	0.472926	Mean dependent var	0.852542
Adjusted R-squared	0.440656	S.D. dependent var	0.275319
S.E. of regression	0.205909	Akaike info criterion	-0.250295
Sum squared resid	2.077523	Schwarz criterion	-0.101594
Log likelihood	10.63282	Hannan-Quinn criter.	-0.193112
Durbin-Watson stat	0.656109		

United Kingdom

Hypothesis 1

Dependent Variable: PROF
Method: Least Squares
Date: 03/30/17 Time: 12:20
Sample: 1978 2014
Included observations: 37

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	0.142328	0.615318	0.231307	0.8185
REG1	0.752008	0.435096	1.728374	0.0936
PL1	3.239634	0.502405	6.448250	0.0000
PL2	2.215171	0.550357	4.024969	0.0003
NETA	3.380280	0.328901	10.27749	0.0000

R-squared	0.550914	Mean dependent var	2.281701
Adjusted R-squared	0.494778	S.D. dependent var	1.731365
S.E. of regression	1.230636	Akaike info criterion	3.378028
Sum squared resid	48.46290	Schwarz criterion	3.595720
Log likelihood	-57.49352	Hannan-Quinn criter.	3.454774
Durbin-Watson stat	0.419598		

New South Wales

Hypothesis 1

Dependent Variable: PROF
Method: Least Squares
Date: 03/30/17 Time: 16:07
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	-0.062101	0.205833	-0.301705	0.7641
REG1	0.788380	0.460256	1.712915	0.0928
DEREG	1.061286	0.563696	1.882726	0.0654
NEM	4.136521	0.291092	14.21037	0.0000

R-squared	0.733099	Mean dependent var	1.257458
Adjusted R-squared	0.717399	S.D. dependent var	2.120744
S.E. of regression	1.127393	Akaike info criterion	3.147640
Sum squared resid	64.82175	Schwarz criterion	3.293628
Log likelihood	-82.56009	Hannan-Quinn criter.	3.204094
Durbin-Watson stat	0.321443		

Victoria

Hypothesis 1

Dependent Variable: PROF
Method: Least Squares
Date: 03/30/17 Time: 13:07
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	0.029800	0.295591	0.100815	0.9201
REG1	-1.122589	0.711877	-1.576941	0.1210
DEREG	0.773177	0.649852	1.189773	0.2396
NEM	3.921340	0.411003	9.540911	0.0000

R-squared	0.579235	Mean dependent var	1.067462
Adjusted R-squared	0.554484	S.D. dependent var	2.384837
S.E. of regression	1.591806	Akaike info criterion	3.837563
Sum squared resid	129.2262	Schwarz criterion	3.983551
Log likelihood	-101.5330	Hannan-Quinn criter.	3.894018
Durbin-Watson stat	0.330023		

Queensland

Hypothesis 1

Dependent Variable: PROF
Method: Least Squares
Date: 03/30/17 Time: 13:22
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	-0.102308	0.211515	-0.483694	0.6307
REG1	0.801347	0.480779	1.666766	0.1017
DEREG	2.355684	0.526667	4.472812	0.0000
NEM	4.067539	0.326625	12.45323	0.0000

R-squared	0.702601	Mean dependent var	1.205326
Adjusted R-squared	0.685107	S.D. dependent var	2.098650
S.E. of regression	1.177664	Akaike info criterion	3.234890
Sum squared resid	70.73152	Schwarz criterion	3.380878
Log likelihood	-84.95947	Hannan-Quinn criter.	3.291344
Durbin-Watson stat	0.382871		

South Australia

Hypothesis 1

Dependent Variable: PROF
Method: Least Squares
Date: 03/30/17 Time: 13:38
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	0.084857	0.250487	0.338769	0.7362
REG1	4.072000	0.662726	6.144315	0.0000
NEM1	6.480000	0.740951	8.745521	0.0000
NEM2	11.30545	0.446810	25.30259	0.0000

R-squared	0.908278	Mean dependent var	3.156545
Adjusted R-squared	0.902883	S.D. dependent var	4.755223
S.E. of regression	1.481901	Akaike info criterion	3.694476
Sum squared resid	111.9976	Schwarz criterion	3.840464
Log likelihood	-97.59809	Hannan-Quinn criter.	3.750931
Durbin-Watson stat	0.626984		

7.4.2 Hypothesis 2

United States

Hypothesis 2

Dependent Variable: PRINC
Method: Least Squares
Date: 06/14/17 Time: 16:44
Sample (adjusted): 1963 2014
Included observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	-0.099906	0.258247	-0.386863	0.7006
INFLOILSH	1.336246	0.258247	5.174294	0.0000
PURPA	4.299062	0.182608	23.54255	0.0000
DEREG	6.399943	0.193685	33.04301	0.0000

R-squared	0.913247	Mean dependent var	3.671332
Adjusted R-squared	0.907825	S.D. dependent var	2.551825
S.E. of regression	0.774741	Akaike info criterion	2.401227
Sum squared resid	28.81073	Schwarz criterion	2.551323
Log likelihood	-58.43191	Hannan-Quinn criter.	2.458770
Durbin-Watson stat	0.551499		

United Kingdom

Hypothesis 2

Dependent Variable: CHPR
Method: Least Squares
Date: 03/30/17 Time: 12:24
Sample (adjusted): 1979 2014
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	0.355566	1.032775	0.344282	0.7330
REG1	1.448963	0.632443	2.291057	0.0289
PL1	3.376599	0.730282	4.623691	0.0001
PL2	2.142002	0.799984	2.677556	0.0118
NETA	4.684121	0.478082	9.797737	0.0000

R-squared	0.459775	Mean dependent var	3.033492
Adjusted R-squared	0.390069	S.D. dependent var	2.290477
S.E. of regression	1.788819	Akaike info criterion	4.129234
Sum squared resid	99.19604	Schwarz criterion	4.349167
Log likelihood	-69.32621	Hannan-Quinn criter.	4.205997
Durbin-Watson stat	0.259941		

New South Wales

Hypothesis 2

Dependent Variable: PRCH
Method: Least Squares
Date: 03/30/17 Time: 16:09
Sample (adjusted): 1961 2014
Included observations: 54 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	1.654191	0.332536	4.974464	0.0000
REG1	5.857796	0.731076	8.012566	0.0000
DEREG	4.765193	0.895382	5.321968	0.0000
NEM	5.105419	0.462373	11.04177	0.0000

R-squared	0.522255	Mean dependent var	3.310377
Adjusted R-squared	0.493590	S.D. dependent var	2.516444
S.E. of regression	1.790763	Akaike info criterion	4.074348
Sum squared resid	160.3417	Schwarz criterion	4.221680
Log likelihood	-106.0074	Hannan-Quinn criter.	4.131168
Durbin-Watson stat	0.154989		

Victoria

Hypothesis 2

Dependent Variable: PRCH
Method: Least Squares
Date: 03/30/17 Time: 13:11
Sample (adjusted): 1961 2014
Included observations: 54 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	1.614895	0.467383	3.455185	0.0011
REG1	6.751481	1.106030	6.104246	0.0000
DEREG	7.576373	1.009663	7.503865	0.0000
NEM	12.39513	0.638567	19.41086	0.0000

R-squared	0.792237	Mean dependent var	5.747401
Adjusted R-squared	0.779771	S.D. dependent var	5.270056
S.E. of regression	2.473159	Akaike info criterion	4.720057
Sum squared resid	305.8257	Schwarz criterion	4.867389
Log likelihood	-123.4415	Hannan-Quinn criter.	4.776877
Durbin-Watson stat	0.244133		

Queensland

Hypothesis 2

Dependent Variable: PRCH
Method: Least Squares
Date: 03/30/17 Time: 13:11
Sample (adjusted): 1961 2014
Included observations: 54 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	1.614895	0.467383	3.455185	0.0011
REG1	6.751481	1.106030	6.104246	0.0000
DEREG	7.576373	1.009663	7.503865	0.0000
NEM	12.39513	0.638567	19.41086	0.0000

R-squared	0.792237	Mean dependent var	5.747401
Adjusted R-squared	0.779771	S.D. dependent var	5.270056
S.E. of regression	2.473159	Akaike info criterion	4.720057
Sum squared resid	305.8257	Schwarz criterion	4.867389
Log likelihood	-123.4415	Hannan-Quinn criter.	4.776877
Durbin-Watson stat	0.244133		

South Australia

Hypothesis 2

Dependent Variable: PRCH
Method: Least Squares
Date: 03/30/17 Time: 13:41
Sample (adjusted): 1961 2014
Included observations: 54 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	1.339757	0.266792	5.021727	0.0000
REG1	3.814778	0.695708	5.483300	0.0000
NEM1	5.221675	0.777826	6.713168	0.0000
NEM2	8.377519	0.469047	17.86074	0.0000

R-squared	0.780528	Mean dependent var	3.290093
Adjusted R-squared	0.767359	S.D. dependent var	3.225294
S.E. of regression	1.555651	Akaike info criterion	3.792853
Sum squared resid	121.0026	Schwarz criterion	3.940185
Log likelihood	-98.40703	Hannan-Quinn criter.	3.849673
Durbin-Watson stat	0.231637		

7.4.3 Hypothesis 3

Unites States

Hypothesis 3

Dependent Variable: INEQ
Method: Least Squares
Date: 03/30/17 Time: 11:52
Sample: 1962 2014
Included observations: 53

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	1.375000	0.211963	6.486970	0.0000
INFLOILSH	1.444444	0.199841	7.227969	0.0000
PURPA	2.975556	0.141309	21.05710	0.0000
DEREG	4.279375	0.149881	28.55187	0.0000

R-squared	0.800332	Mean dependent var	2.800566
Adjusted R-squared	0.788108	S.D. dependent var	1.302411
S.E. of regression	0.599523	Akaike info criterion	1.887107
Sum squared resid	17.61196	Schwarz criterion	2.035808
Log likelihood	-46.00833	Hannan-Quinn criter.	1.944290
Durbin-Watson stat	0.491849		

United Kingdom

Hypothesis 3

Dependent Variable: INEQ
Method: Least Squares
Date: 03/30/17 Time: 12:26
Sample: 1978 2014
Included observations: 37

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	0.852500	0.287229	2.968017	0.0056
REG1	1.873750	0.203101	9.225685	0.0000
PL1	3.118333	0.234521	13.29659	0.0000
PL2	3.086000	0.256905	12.01221	0.0000
NETA	3.955662	0.153530	25.76471	0.0000

R-squared	0.796158	Mean dependent var	2.916737
Adjusted R-squared	0.770678	S.D. dependent var	1.199597
S.E. of regression	0.574458	Akaike info criterion	1.854308
Sum squared resid	10.56005	Schwarz criterion	2.071999
Log likelihood	-29.30469	Hannan-Quinn criter.	1.931054
Durbin-Watson stat	0.527881		

New South Wales

Hypothesis 3

Dependent Variable: INEQ
Method: Least Squares
Date: 03/30/17 Time: 16:13
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	-0.109298	0.201305	-0.542946	0.5895
REG1	1.003765	0.450132	2.229936	0.0302
DEREG	2.634995	0.551297	4.779632	0.0000
NEM	5.641594	0.284688	19.81673	0.0000

R-squared	0.844726	Mean dependent var	1.780137
Adjusted R-squared	0.835592	S.D. dependent var	2.719282
S.E. of regression	1.102593	Akaike info criterion	3.103154
Sum squared resid	62.00132	Schwarz criterion	3.249142
Log likelihood	-81.33674	Hannan-Quinn criter.	3.159609
Durbin-Watson stat	0.324521		

Victoria

Hypothesis 3

Dependent Variable: INEQ
Method: Least Squares
Date: 03/30/17 Time: 16:13
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	-0.109298	0.201305	-0.542946	0.5895
REG1	1.003765	0.450132	2.229936	0.0302
DEREG	2.634995	0.551297	4.779632	0.0000
NEM	5.641594	0.284688	19.81673	0.0000

R-squared	0.844726	Mean dependent var	1.780137
Adjusted R-squared	0.835592	S.D. dependent var	2.719282
S.E. of regression	1.102593	Akaike info criterion	3.103154
Sum squared resid	62.00132	Schwarz criterion	3.249142
Log likelihood	-81.33674	Hannan-Quinn criter.	3.159609
Durbin-Watson stat	0.324521		

Queensland

Hypothesis 3

Dependent Variable: INEQ
Method: Least Squares
Date: 03/30/17 Time: 13:12
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	-0.105537	0.251609	-0.419447	0.6767
REG1	1.989750	0.605954	3.283663	0.0019
DEREG	4.642945	0.553158	8.393521	0.0000
NEM	8.069749	0.349848	23.06645	0.0000

R-squared	0.879746	Mean dependent var	2.832584
Adjusted R-squared	0.872672	S.D. dependent var	3.797197
S.E. of regression	1.354955	Akaike info criterion	3.515361
Sum squared resid	93.63109	Schwarz criterion	3.661349
Log likelihood	-92.67243	Hannan-Quinn criter.	3.571816
Durbin-Watson stat	0.357145		

South Australia

Hypothesis 3

Dependent Variable: INEQ
Method: Least Squares
Date: 03/30/17 Time: 13:44
Sample: 1960 2014
Included observations: 55

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG	-0.080571	0.115735	-0.696174	0.4895
REG1	3.684000	0.306205	12.03115	0.0000
NEM1	2.732500	0.342348	7.981651	0.0000
NEM2	4.352727	0.206443	21.08436	0.0000

R-squared	0.895866	Mean dependent var	1.352909
Adjusted R-squared	0.889741	S.D. dependent var	2.062004
S.E. of regression	0.684695	Akaike info criterion	2.150262
Sum squared resid	23.90920	Schwarz criterion	2.296250
Log likelihood	-55.13220	Hannan-Quinn criter.	2.206717
Durbin-Watson stat	0.814506		

7.4.4 Hypothesis 4

United States

Hypothesis 4a

Dependent Variable: PCHCL
Method: Least Squares
Date: 03/30/17 Time: 12:06
Sample: 1990 2014
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PURPA	0.113721	0.008138	13.97467	0.0000
DEREG	0.104200	0.006103	17.07278	0.0000
R-squared	0.036699	Mean dependent var		0.107628
Adjusted R-squared	-0.005184	S.D. dependent var		0.024350
S.E. of regression	0.024413	Akaike info criterion		-4.510779
Sum squared resid	0.013708	Schwarz criterion		-4.413269
Log likelihood	58.38474	Hannan-Quinn criter.		-4.483734
Durbin-Watson stat	1.381438			

United States

Hypothesis 4b

Dependent Variable: PCHNG
Method: Least Squares
Date: 03/30/17 Time: 12:08
Sample: 1990 2014
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PURPA	0.536725	0.035216	15.24080	0.0000
DEREG	0.197172	0.026412	7.465161	0.0000
R-squared	0.721208	Mean dependent var		0.319411
Adjusted R-squared	0.709087	S.D. dependent var		0.195877
S.E. of regression	0.105649	Akaike info criterion		-1.580772
Sum squared resid	0.256719	Schwarz criterion		-1.483262
Log likelihood	21.75965	Hannan-Quinn criter.		-1.553727
Durbin-Watson stat	0.816932			

United Kingdom

Hypothesis 4a

Dependent Variable: CHCO2CL
Method: Least Squares
Date: 03/30/17 Time: 12:35
Sample: 1990 2014
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PL1	0.078623	0.009598	8.191257	0.0000
PL2	0.115815	0.010515	11.01475	0.0000
NETA	0.096053	0.006284	15.28625	0.0000

R-squared	0.236844	Mean dependent var	0.095822
Adjusted R-squared	0.167466	S.D. dependent var	0.025768
S.E. of regression	0.023511	Akaike info criterion	-4.550514
Sum squared resid	0.012161	Schwarz criterion	-4.404249
Log likelihood	59.88143	Hannan-Quinn criter.	-4.509946
Durbin-Watson stat	0.923823		

United Kingdom

Hypothesis 4b

Dependent Variable: CHCO2NG
Method: Least Squares
Date: 03/30/17 Time: 12:36
Sample: 1990 2014
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PL1	0.290993	0.021719	13.39788	0.0000
PL2	0.123611	0.023792	5.195389	0.0000
NETA	0.072090	0.014219	5.070080	0.0000

R-squared	0.764427	Mean dependent var	0.134931
Adjusted R-squared	0.743012	S.D. dependent var	0.104946
S.E. of regression	0.053201	Akaike info criterion	-2.917299
Sum squared resid	0.062268	Schwarz criterion	-2.771033
Log likelihood	39.46623	Hannan-Quinn criter.	-2.876731
Durbin-Watson stat	1.243372		

Australia

Hypothesis 4a

Dependent Variable: PCHCL
Method: Least Squares
Date: 03/30/17 Time: 14:03
Sample: 1990 2014
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG1	0.560472	0.054515	10.28106	0.0000
DEREG	0.641152	0.066767	9.602836	0.0000
NEM	0.407939	0.034478	11.83176	0.0000

R-squared	0.359872	Mean dependent var	0.481861
Adjusted R-squared	0.301678	S.D. dependent var	0.159795
S.E. of regression	0.133534	Akaike info criterion	-1.076755
Sum squared resid	0.392289	Schwarz criterion	-0.930490
Log likelihood	16.45944	Hannan-Quinn criter.	-1.036188
Durbin-Watson stat	1.447693		

Australia

Hypothesis 4b

Dependent Variable: PCHCL
Method: Least Squares
Date: 03/30/17 Time: 14:03
Sample: 1990 2014
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
REG1	0.560472	0.054515	10.28106	0.0000
DEREG	0.641152	0.066767	9.602836	0.0000
NEM	0.407939	0.034478	11.83176	0.0000

R-squared	0.359872	Mean dependent var	0.481861
Adjusted R-squared	0.301678	S.D. dependent var	0.159795
S.E. of regression	0.133534	Akaike info criterion	-1.076755
Sum squared resid	0.392289	Schwarz criterion	-0.930490
Log likelihood	16.45944	Hannan-Quinn criter.	-1.036188
Durbin-Watson stat	1.447693		

7.5 Appendix E

Data for Figure 5-1 Total Generation, Total Capacity, Capacity Utilisation, Percentage NG capacity (US)

United States	Generation	Cap relative to 2014	Capacity Factor	Natural Gas Capacity relative to total capacity
Year	GWh	%	%	%
1974	1716856	40.5%	47%	
1975	1747091	49.9%	39%	
1976	1855246	51.8%	39%	
1977	1948361	54.5%	39%	
1978	2017922	56.7%	39%	
1979	2071099	58.5%	39%	
1980	2099762	60.4%	38%	
1981	2147101	61.8%	38%	8.00%
1982	2075684	62.7%	36%	8.00%
1983	2138848	63.2%	37%	8.00%
1984	2278372	64.8%	39%	8.00%
1985	2325702	63.3%	40%	7.00%
1986	2350835	64.1%	40%	7.00%
1987	2455440	65.0%	42%	7.00%
1988	2567949	65.4%	43%	7.00%
1989	2635985	66.1%	44%	7.00%
1990	2712555	66.6%	45%	7.00%
1991	2854260	66.9%	47%	7.00%
1992	2865559	67.1%	47%	8.00%
1993	2963142	67.5%	48%	8.00%
1994	3047324	67.8%	50%	9.00%
1995	3135807	68.3%	51%	9.00%
1996	3221305	68.7%	52%	9.00%
1997	3270628	68.9%	52%	10.00%
1998	3373860	66.5%	56%	9.00%

1999	3459621	62.8%	61%	9.00%
2000	3589779	60.4%	65%	10.00%
2001	3554396	79.0%	50%	26.00%
2002	3631904	84.5%	47%	26.00%
2003	3662327	88.6%	46%	30.00%
2004	3716318	90.1%	45%	31.00%
2005	3811487	91.5%	46%	32.00%
2006	3817560	92.3%	46%	32.00%
2007	3921940	93.2%	46%	32.00%
2008	3907229	94.7%	45%	33.00%
2009	3724658	96.1%	43%	33.00%
2010	3894367	97.3%	44%	33.00%
2011	3885019	98.5%	43%	34.00%
2012	3830933	99.5%	42%	34.00%
2013	3873143	99.2%	43%	34.00%
2014	3894055	100.0%	43%	35.00%

Notes for Figure 5-1

Electricity capacity data has been sourced from: (EIA 2016, IEA 2017o)

Net generation data has been sourced from: (IEA 2017a2)

Natural Gas Capacity data has been sourced from: (IEA 2017t)

Capacity factor, percentage capacity relative to 2014 capacity, natural gas capacity relative to total capacity in percentage have been estimated from the data obtained from sources given above.

Data for Figure 5-2 Total Generation, Total Capacity, Capacity Utilization, Percentage NG capacity (UK)

United Kingdom	Generation	Cap relative to 2014	Capacity Factor	Natural Gas Capacity relative to total capacity
Year	GWh	%	%	%
1974	235234	83.20%	39%	
1975	233053	83.20%	39%	
1976	237149	81.40%	40%	
1977	241250	81.30%	41%	
1978	245487	81.10%	42%	
1979	255773	82.90%	42%	
1980	243328	82.20%	41%	
1981	238620	78.00%	42%	8%
1982	233332	78.30%	41%	8%
1983	235818	75.10%	43%	8%
1984	238479	75.70%	43%	8%
1985	249824	76.80%	45%	7%
1986	258154	75.70%	47%	7%
1987	266175	76.90%	48%	7%
1988	274394	79.40%	48%	7%
1989	279399	84.70%	45%	7%
1990	284416	83.10%	47%	7%
1991	290842	79.60%	50%	7%
1992	291453	76.30%	52%	8%
1993	295746	77.40%	53%	8%
1994	291782	78.00%	51%	9%
1995	303805	79.10%	53%	9%
1996	319778	83.20%	53%	9%
1997	321066	82.30%	54%	10%
1998	325590	82.30%	54%	9%
1999	332054	84.30%	54%	9%
2000	340297	86.70%	54%	10%
2001	342504	88.50%	53%	26%

2002	344109	84.80%	56%	26%
2003	346616	86.20%	55%	30%
2004	347722	88.30%	54%	31%
2005	357196	89.10%	55%	32%
2006	353863	90.40%	54%	32%
2007	351450	92.80%	52%	32%
2008	350101	94.50%	51%	33%
2009	330019	96.20%	47%	33%
2010	337500	103.50%	45%	33%
2011	325875	102.10%	44%	34%
2012	325170	103.90%	43%	34%
2013	325089	100.90%	44%	34%
2014	311032	100.00%	43%	35%

Notes for Figure 5-2

Electricity capacity data has been sourced from: (IEA 2017o)

Net generation data has been sourced from: (IEA 2017a2)

Natural Gas Capacity data has been sourced from: (IEA 2017t)

Capacity factor, percentage capacity relative to 2014 capacity, natural gas capacity relative to total capacity in percentage have been estimated from the data obtained from sources given above.

Data for Figure 5-3 Total Generation, Total Capacity, Capacity Utilization, Percentage NG capacity (Australia)

Australia	Generation	Cap relative to 2014	Capacity Factor	Natural Gas Capacity relative to total capacity
Year	GWh	%	%	%
1974	60166	33.4%	36%	
1975	63653	33.8%	37%	
1976	66036	34.6%	38%	
1977	71025	36.0%	39%	
1978	74010	38.8%	38%	
1979	78130	41.2%	38%	
1980	82104	41.9%	39%	
1981	86828	45.0%	38%	
1982	90157	48.6%	37%	
1983	91053	49.7%	36%	
1984	97055	54.2%	35%	
1985	101899	56.7%	36%	
1986	108357	57.6%	37%	
1987	113380	59.8%	38%	
1988	120214	60.4%	39%	
1989	127312	60.8%	41%	
1990	134339	61.6%	43%	
1991	136949	60.6%	45%	5%
1992	138566	61.7%	44%	6%
1993	142690	63.7%	44%	6%
1994	146499	66.5%	44%	6%
1995	151119	68.0%	44%	6%
1996	155147	68.4%	45%	6%
1997	160346	69.7%	46%	6%
1998	170054	71.3%	47%	6%
1999	175457	73.8%	47%	8%
2000	179852	74.3%	48%	9%
2001	188035	77.0%	48%	11%

2002	197742	81.1%	48%	12%
2003	193791	81.3%	47%	12%
2004	198266	81.5%	48%	12%
2005	198660	80.9%	49%	12%
2006	202516	81.0%	49%	12%
2007	212146	85.7%	49%	16%
2008	213010	87.8%	48%	16%
2009	217362	91.9%	47%	19%
2010	220974	96.7%	45%	22%
2011	224246	98.0%	45%	23%
2012	222155	99.8%	44%	23%
2013	222373	98.0%	45%	24%
2014	221542	100.0%	44%	24%

Notes for Figure 5-3

Electricity capacity data has been sourced from: (IEA 2017o)

Net generation data has been sourced from: (IEA 2017a2)

Natural Gas Capacity data has been sourced from: (IEA 2017t)

Capacity factor, percentage capacity relative to 2014 capacity, natural gas capacity relative to total capacity in percentage have been estimated from the data obtained from sources given above.

Data for Figure 5-4: Generation capacity by fuel (USA)

US Electricity Generation Capacity Fuel-wise	Total Electricity Generation Capacity	Electricity Capacity by Coal technology	Electricity Capacity by Natural Gas technology
Year	MW	MW	MW
1974	420097	174319	0
1975	517126	183763	0
1976	536916	192745	0
1977	564983	203476	0
1978	587098	214567	0
1979	605771	225092	0
1980	625924	240016	0
1981	640859	198928	49952
1982	649961	223577	50040
1983	655324	235540	49670
1984	671693	245309	51837
1985	656118	232919	43900
1986	664807	238186	45943
1987	674144	239607	46550
1988	677654	240670	46813
1989	684619	262008	48180
1990	690465	263810	49137
1991	693017	261776	51119
1992	695059	261480	52758
1993	699971	259606	55796
1994	702658	257619	59795
1995	708191	254135	62269
1996	712073	249438	66284
1997	713940	257971	68101
1998	689124	259881	66074
1999	650803	240557	62939
2000	626251	263753	62923
2001	818650	310122	160051
2002	875633	311300	216924
2003	918630	308797	263236
2004	933423	309181	282527
2005	948567	309302	296249

2006	956184	309661	302586
2007	965741	309567	309182
2008	981261	309855	317584
2009	996200	310672	326152
2010	1008650	312563	330859
2011	1020464	313467	339981
2012	1031417	305825	346848
2013	1027776	299355	351328
2014	1036351	295316	357737

Notes for Figure 5-4

Electricity capacity data has been sourced from: (IEA 2017o)

Coal generation capacity data has been sourced from: (IEA 2017s)

Natural Gas Generation capacity data has been sourced from: (IEA 2017t)

Data for Figure 5-5: Generation capacity by fuel (UK)

UK Electricity Generation Capacity Fuel-wise	Total Electricity Generation Capacity	Electricity Capacity by Coal technology	Electricity Capacity by Natural Gas technology
Year	MW	MW	MW
1974	69142	45118	
1975	69062	44915	
1976	67611	42137	
1977	67505	41550	
1978	67357	40735	
1979	68882	40790	
1980	68311	40141	
1981	64784	39959	3719
1982	65074	38500	3178
1983	62379	36572	3121
1984	62867	36236	3121
1985	63819	36672	3331
1986	62885	34653	3303
1987	63850	35038	2843
1988	65920	34872	3024
1989	70343	34583	3356
1990	69024	34298	3130
1991	66090	32686	2968
1992	63374	30523	3668
1993	64289	29132	7481
1994	64772	27775	10496
1995	65712	27494	10924
1996	69073	25796	13749
1997	68320	25796	13778
1998	68390	25324	16130
1999	70057	25580	17443
2000	72030	24835	20672
2001	73474	24810	21808
2002	70461	22427	23233
2003	71565	22524	25114
2004	73373	22639	25278
2005	74011	22627	25619

2006	75064	22882	26303
2007	77099	23009	25758
2008	78468	23069	27844
2009	79897	23077	28563
2010	85975	23085	33503
2011	84838	23072	31889
2012	86301	23072	34764
2013	83818	21787	34750
2014	83056	19928	33781

Notes for Figure 5-5

Electricity capacity data has been sourced from: (IEA 2017o)

Coal generation capacity data has been sourced from: (IEA 2017s)

Natural Gas Generation capacity data has been sourced from: (IEA 2017t)

Data for Figure 5-6: Generation capacity by fuel (Australia)

Australia Electricity Generation Capacity Fuel-wise	Total Electricity Generation Capacity	Electricity Capacity by Coal technology	Electricity Capacity by Natural Gas technology
Year	MW	MW	MW
1974	19250	11498	
1975	19506	11527	
1976	19957	11689	
1977	20765	11915	
1978	22390	13261	
1979	23729	13970	
1980	24142	13896	
1981	25938	14833	
1982	28016	16618	
1983	28635	17287	
1984	31230	19496	
1985	32695	21347	
1986	33229	21578	
1987	34473	22668	1483
1988	34819	22939	1575
1989	35045	23177	1586
1990	35495	22140	1807
1991	34944	21358	1846
1992	35599	21877	2134
1993	36739	22445	2137
1994	38361	23875	2265
1995	39214	24664	2313
1996	39408	24676	2324
1997	40160	25817	2514
1998	41086	25806	2522
1999	42548	26808	3527
2000	42833	25360	3812
2001	44416	26663	4664
2002	46754	27260	5754
2003	46870	28375	5518

2004	46972	28430	5583
2005	46630	28660	5779
2006	46704	28420	5776
2007	49420	28449	7718
2008	50646	29199	8012
2009	52987	29407	10298
2010	55730	29682	12450
2011	56490	29897	12718
2012	57566	29897	13335
2013	56523	28906	13449
2014	57655	28969	13840

Notes for Figure 5-6

Electricity capacity data has been sourced from: (IEA 2017o)

Coal generation capacity data has been sourced from: (IEA 2017s)

Natural Gas Generation capacity data has been sourced from: (IEA 2017t)

Data for Figure 5-7: Capacity Utilization Coal-based Power Plants (US)

US Coal Capacity Utilization	Coal Generation Technology Capacity	Electricity by Coal Generation	Coal Capacity Utilization Factor
Year	MW	GWh	%
1974	174319	850173	57%
1975	183763	869578	55%
1976	192745	962543	58%
1977	203476	999791	57%
1978	214567	983467	53%
1979	225092	1081737	56%
1980	240016	1193156	58%
1981	198928	1236807	72%
1982	223577	1219815	64%
1983	235540	1022402	51%
1984	245309	1065806	51%
1985	232919	1098912	55%
1986	238186	1078862	53%
1987	239607	1138429	56%
1988	240670	1176071	57%
1989	262008	1168539	52%
1990	263810	1147881	50%
1991	261776	1142166	50%
1992	261480	1148128	50%
1993	259606	1173304	52%
1994	257619	1147523	51%
1995	254135	1147335	52%
1996	249438	1197936	55%
1997	257971	1224711	54%
1998	259881	1228269	54%
1999	240557	1168751	55%
2000	263753	1181812	51%
2001	310122	1112115	41%
2002	311300	911792	33%
2003	308797	854109	32%

2004	309181	814739	30%
2005	309302	807858	30%
2006	309661	858909	32%
2007	309567	750376	28%
2008	309855	1082968	40%
2009	310672	896399	33%
2010	312563	972685	36%
2011	313467	879413	32%
2012	305825	744395	28%
2013	299355	772919	29%
2014	295316	810722	31%

Notes for Figure 5-7

Coal based generation capacity data has been sourced from: (IEA 2017s)

Coal based generation data has been sourced from:(IEA 2017(1b), IEA 2017(1d), IEA 2017(1j))

Coal based Capacity utilisation factor has been calculated in percentage.

Data for Figure 5-8 Cap. Utilization Coal-based Power Plants (UK)

UK Coal Capacity Utilization	Coal Generation Technology Capacity	Electricity by Coal Generation	Coal Capacity Utilization Factor
Year	MW	GWh	%
1974	45118	140781	36%
1975	44915	162085	41%
1976	42137	171849	47%
1977	41550	174735	48%
1978	40735	181050	51%
1979	40790	196015	55%
1980	40141	201720	57%
1981	39959	201083	57%
1982	38500	190151	56%
1983	36572	189950	59%
1984	36236	123772	39%
1985	36672	173006	54%
1986	34653	196827	65%
1987	35038	206118	67%
1988	34872	199784	65%
1989	34583	196020	65%
1990	34298	201333	67%
1991	32686	206183	72%
1992	30523	190564	71%
1993	29132	165545	65%
1994	27775	155229	64%
1995	27494	151225	63%
1996	25796	140222	62%
1997	25796	114952	51%
1998	25324	118579	53%
1999	25580	102058	46%
2000	24835	117025	54%
2001	24810	127128	58%
2002	22427	120958	62%
2003	22524	134023	68%

2004	22639	127827	64%
2005	22627	130690	66%
2006	22882	144947	72%
2007	23009	132075	66%
2008	23069	120305	60%
2009	23077	99287	49%
2010	23085	103941	51%
2011	23072	104797	52%
2012	23072	140164	69%
2013	21787	130204	68%
2014	19928	100158	57%

Notes for Figure 5-8

Coal based generation capacity data has been sourced from: (IEA 2017s)

Coal based generation data has been sourced from:(IEA 2017(1b), IEA 2017(1d), IEA 2017(1j))

Coal based Capacity utilisation factor has been calculated in percentage.

Data for Figure 5-9 Cap. Utilization Coal-based Power Plants (Australia)

Australia Coal Capacity Utilization	Coal Generation Technology Capacity	Electricity by Coal Generation	Coal Capacity Utilization Factor
Year	MW	GWh	%
1974	11498	29952	44%
1975	11527	31698	47%
1976	11689	31559	48%
1977	11915	38726	54%
1978	13261	41329	49%
1979	13970	42859	49%
1980	13896	48866	55%
1981	14833	52249	53%
1982	16618	43879	48%
1983	17287	47847	48%
1984	19496	53188	45%
1985	21347	61819	45%
1986	21578	63947	47%
1987	22668	67010	48%
1988	22939	73039	50%
1989	23177	77980	53%
1990	22140	26991	45%
1991	21358	28625	47%
1992	21877	31212	49%
1993	22445	31551	49%
1994	23875	37066	48%
1995	24664	35812	47%
1996	24676	38154	49%
1997	25817	37699	48%
1998	25806	41991	51%
1999	26808	46051	50%
2000	25360	48322	56%
2001	26663	63940	57%
2002	27260	47901	48%
2003	28375	65167	45%

2004	28430	67289	47%
2005	28660	74844	49%
2006	28420	74868	50%
2007	28449	78101	51%
2008	29199	76218	49%
2009	29407	81333	50%
2010	29682	44115	47%
2011	29897	41699	44%
2012	29897	41594	44%
2013	28906	39753	44%
2014	28969	37714	41%

Notes for Figure 5-9

Coal based generation capacity data has been sourced from: (IEA 2017s)

Coal based generation data has been sourced from:(IEA 2017(1b), IEA 2017(1d), IEA 2017(1j))

Coal based Capacity utilisation factor has been calculated in percentage.

Data for Figure 5-10 Cap. Utilization NG based Power Plants (US)

US Natural Gas Capacity Utilization	Natural Gas Generation Technology Capacity	Electricity by Natural Gas Generation	Natural Gas Capacity Utilization Factor
Year	MW	GWh	%
1990	49137	282576	66%
1991	51119	274182	61%
1992	52758	274175	59%
1993	55796	269434	55%
1994	59795	302766	58%
1995	62269	318322	58%
1996	66284	272056	47%
1997	68101	290077	49%
1998	66074	315536	55%
1999	62939	299487	54%
2000	62923	424396	77%
2001	160051	440708	31%
2002	216924	471549	25%
2003	263236	434905	19%
2004	282527	507439	21%
2005	296249	572132	22%
2006	302586	638088	24%
2007	309182	697784	26%
2008	317584	705416	25%
2009	326152	745782	26%
2010	330859	803771	28%
2011	339981	831257	28%
2012	346848	1031680	34%
2013	351328	938957	31%
2014	357737	939717	30%

Notes for Figure 5-10

Natural Gas based generation capacity data has been sourced from: IEA (2017t)

Natural Gas based generation data has been sourced from: IEA (2017(1i))

Natural Gas based Capacity utilisation factor has been calculated in percentage.

Data for Figure 5-11 Cap. Utilization NG based Power Plants (UK)

UK Natural Gas Capacity Utilization	Natural Gas Generation Technology Capacity	Electricity by Natural Gas Generation	Natural Gas Capacity Utilization Factor
Year	MW	GWh	%
1992	3668	5760	18%
1993	7481	27259	42%
1994	10496	45694	50%
1995	10924	56580	59%
1996	13749	74349	62%
1997	13778	99378	82%
1998	16130	104532	74%
1999	17443	127093	83%
2000	20672	125711	69%
2001	21808	123507	65%
2002	23233	131615	65%
2003	25114	126884	58%
2004	25278	133745	60%
2005	25619	128238	57%
2006	26303	116792	51%
2007	25758	141209	63%
2008	27844	153007	63%
2009	28563	144982	58%
2010	33503	154036	52%
2011	31889	127150	46%
2012	34764	80369	26%
2013	34750	78630	26%
2014	33781	84222	28%

Notes for Figure 5-11

Natural Gas based generation capacity data has been sourced from: IEA (2017t)

Natural Gas based generation data has been sourced from: IEA (2017(1i))

Natural Gas based Capacity utilisation factor has been calculated in percentage.

Data for Figure 5-12 Cap. Utilization NG based Power Plants (Australia)

US Natural Gas Capacity Utilization	Natural Gas Generation Technology Capacity	Electricity by Natural Gas Generation	Natural Gas Capacity Utilization Factor
Year	MW	GWh	%
1991	1846	9266	57%
1992	2134	10108	54%
1993	2137	10827	58%
1994	2265	10739	54%
1995	2313	13460	66%
1996	2324	11060	54%
1997	2514	8500	39%
1998	2522	8789	40%
1999	3527	10530	34%
2000	3812	10618	32%
2001	4664	11283	28%
2002	5754	20594	41%
2003	5518	17229	36%
2004	5583	18600	38%
2005	5779	13939	28%
2006	5776	13429	27%
2007	7718	18721	28%
2008	8012	22330	32%
2009	10298	27029	30%
2010	12450	31159	29%
2011	12718	34242	31%
2012	13335	33945	29%
2013	13449	35680	30%

Notes for Figure 5-12

Natural Gas based generation capacity data has been sourced from: IEA (2017t)

Natural Gas based generation data has been sourced from: IEA (2017(1i))

Natural Gas based Capacity utilisation factor has been calculated in percentage.

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