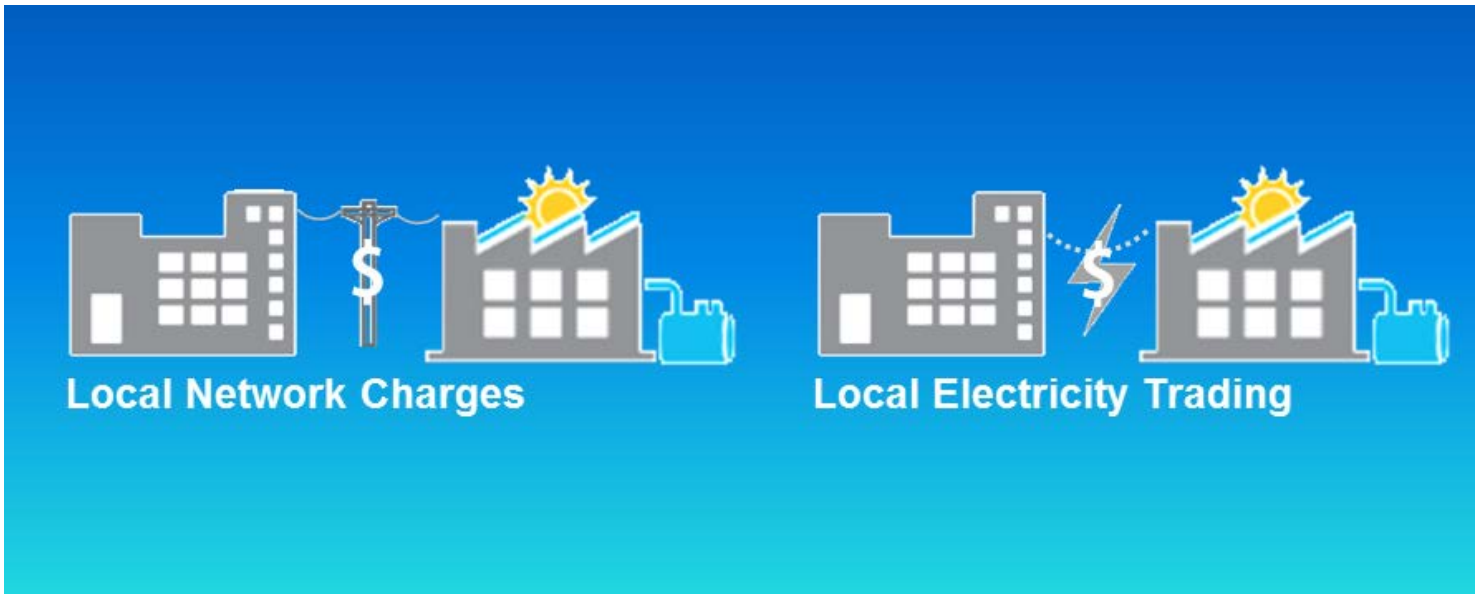

UTS: INSTITUTE FOR SUSTAINABLE FUTURES

Local network charges and Local Electricity Trading: market scan

Briefing Paper 2: September 2015

UTS:ISF
INSTITUTE FOR SUSTAINABLE FUTURES

2015

ABOUT THE AUTHORS

The University of Technology Sydney established the Institute for Sustainable Futures (ISF) in 1996 to work with industry, government and the community to develop sustainable futures through research and consultancy. Our mission is to create change toward sustainable futures that protect and enhance the environment, human well-being and social equity. We seek to adopt an inter-disciplinary approach to our work and engage our partner organisations in a collaborative process that emphasises strategic decision-making.

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LIST OF ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AIC	Average Incremental Cost
aka	Also known as
ARENA	Australian Renewable Energy Agency
CBA	Cost Benefit Analysis
CEC	Clean Energy Council
CDCM	Common Distribution Charging Methodology
CPI	Consumer Price Index
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBT	Declining Block Tariff
DCUSA	Distribution Connection and Use of System Agreement
DER	Distributed Energy Resources
DG	Distributed Generation
DMP	Distributed Marginal Prices
DNSP	Distribution Network Service Provider
DPV	Distributed Photovoltaics
DSR	Demand Side Response
DUoS	Distribution Use of System
ELCC	Effective Load Carrying Capability
ENA	Electricity Networks Association
EPRI	Electric Power Research Institute
ESCO	Energy Services Company
EY	Ernst and Young

FCAS	Frequency Control Ancillary Services
FENIX	A virtual power plant demonstration project in Europe
FiT	Feed-in Tariff
FPDI	Future Proofing in Australia's Electricity Distribution Industry
GW	Gigawatt
IBT	Inclining Block Tariff
IOUs	Investor Owned Utilities
IPART	Independent Pricing And Regulatory Tribunal
ISF	Institute for Sustainable Futures
kW	Kilowatt
kVA	Kilo Volt-Amp
LET	Local Electricity Trading
LG	Local Generation
LGNC	Local Generation Network Credit (note this is the term used in the rule change proposal discussed in Section 4)
LOLP	Loss Of Load Probability
LUoS	Local Use of System
LRMC	Long run marginal cost
MD	Maximum Demand
MTR	Multiple Trading Relationships
MW	Megawatt
nb	Note well
NECF	National Electricity Customer Framework
NEM	National Electricity Market
NERA	National Economic Research Associates
NREL	National Renewable Energy Laboratory
NSP	Network Service Provider

NSW	New South Wales
NZ	New Zealand
PPA	Power Purchase Agreement
PUC	Public Utilities Commission
PV	Photovoltaic
QLD	Queensland
RoLR	Retailer of Last Resort
SCADA	Supervisory Control And Data Acquisition
SKM	Sinclair Knight Merz
SToU	Seasonal Time of Use
TEC	Total Environment Centre
TNSP	Transmission Network Service Provider
TOU	Time of use
TUoS	Transmission Use of System
TVPP	Technical Virtual Power Plant
UK	United Kingdom
US / USA	United States (of America)
UTS	University of Technology Sydney
VNM	Virtual Net Metering
VOS	Value Of Solar
VPP	Virtual Power Plant
VPS	Virtual Power Station

1 INTRODUCTION

This report provides an overview of current literature and information relating to local network charges, local electricity trading (also called virtual net metering or VNM), and virtual power stations. The focus is information particularly relevant to Australia, as well as global precedents in each area.

A one page summary table is provided for the most relevant papers, with the report divided into six sections as detailed below. Additional reading is listed in some of the sections and a bibliography of this additional literature only is given in section nine, as other papers discussed contain full source references in that paper's summary.

This report has been prepared as part of an ARENA funded research project led by the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS), which is described in Section 2. .

Australian Context

Section three summarises two background papers on the future of the grid looking at the 'Death Spiral' and other future scenarios. Further additional reading for the Australian context such as tariff trend and the recent energy white paper are also provided as relevant context

Calculating costs and benefits: primary relevance to local network charges

Section four summarises six papers on methodologies for calculating the cost and benefit of DG are presented, with an additional four listed under additional reading.

Tariff setting

Section five summarises five papers on tariff setting, and the associated price signals and economic efficiency. These papers provide useful context to how an LGNC, as a negative tariff, might operate efficiently. Five additional papers are provided as further reading

Global local network credit examples

Section six summarises three overseas examples of local network credits, one from the UK and two from the United States. Significant work has been done in Australia and around the world on valuing the impact of local generation on the electricity grid and other parts of the electricity supply system. As this value is a key part of the LGNC it provides an important basis for considering how a value calculation may be done in the Australian context.

Local Electricity Trading (Virtual Net Metering)

Section seven summarises three papers which give examples of local electricity trading (LET (aka VNM), or outline the benefits of multiple trading relationships and the Australian regulatory context insofar as it applies these trading relationships. It should be noted that these are also relevant to those interested in virtual power stations.

Virtual Renewable Power Station

Section eight summarises five papers covering Virtual Power Stations (VPS), including some information on concepts and definitions. Examples from Denmark, Germany, Spain and the UK are included. There are also references to market aggregators and technical and commercial trials. An additional seven papers are listed under additional reading.

2 THE PROJECT

The one year research project *Facilitating Local Network Charges and Virtual Net Metering* (the ISF project) started in June 2015, and investigates two measures aimed at making local energy generation more economically viable: local network charges for partial use of the electricity network, and local electricity trading (LET) between associated customers and generators in the same local distribution area. The project brings together a partnership of consumers, researchers, electricity providers and government to help level the playing field for local energy and prepare for the electricity grid of the future.

The project is due to be completed in August 2016 and the results and papers will be publicly available on the project webpage at http://bit.do/Local-Energy. ISF will publish reports and briefing papers and an open-source 'Business Case' spreadsheet tool that will be freely available for use by anyone interested in how local network charges and LET affect the economics of local generation projects.

2.1 Aims and outputs

The objective of the project is to create a level playing field for local energy, by facilitating the introduction of local network charges and local electricity trading. The key outputs are:

a. Improved stakeholder understanding of the concepts of local network charges and Local Electricity Trading;

b. Five 'virtual trials' of local network charges and Local Electricity Trading in New South Wales, Victoria, and Queensland (see Figure 1);

c. Economic modelling of the benefits and impacts of local network charges and Local Electricity Trading;

d. A recommended methodology for calculating local network charges;

e. An assessment of the metering requirements and indicative costs for the introduction of Local Electricity Trading, and consideration of whether a second rule change proposal is required to facilitate its introduction; and

f. Support for the rule change proposal for the introduction of a Local Generation Network Credit submitted by the City of Sydney, the Total Environment Centre, and the Property Council of Australia (see Section 6).

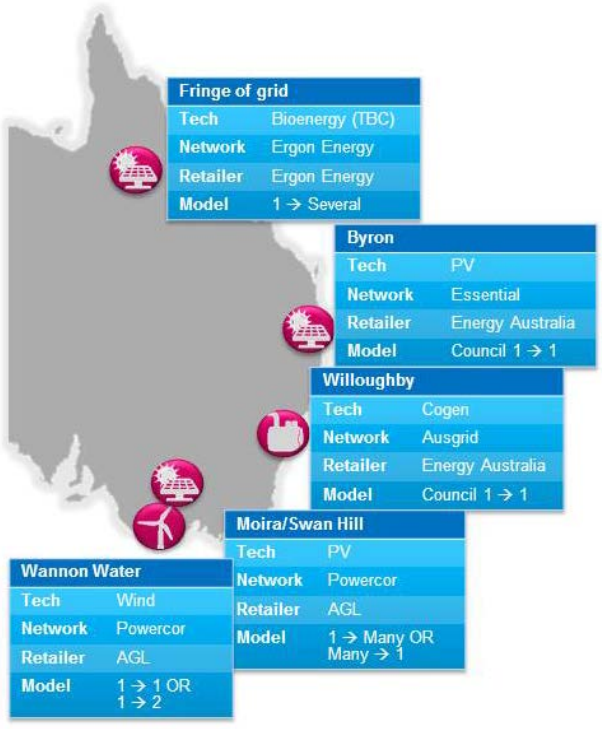

Figure 1 The virtual trials

3 AUSTRALIAN CONTEXT

CSIRO (2013) Change and Choice The Future Grid Forum's analysis of Australia's potential electricity pathways to 2050	
Objective	Explores four scenarios regarding what might Australia's electricity system look like in 2050
Geographic Focus	Australia
Technologies covered	All
Stakeholder perspective	Any stakeholder to the Australian electricity sector
Market context	Australia (Regulated)
Relevance to local network charges Relevance to LET (aka VNM) Relevance to VPS	The future grid forum provides good context for the potential changes to the Australian electricity system. One scenario in particular, 'rise of the prosumer' has strong significance to LET (aka VNM), local network charges and virtual power stations which are all enablers of prosumer type activities
Details of approach	Mega shifts are identified which are affecting the sector such as • Storage • Greenhouse gas abatement targets • Low growth or declining demand • Changes in consumer knowledge, comfort-ability with new technologies The scenarios presented show different combinations of consumer choices and industry responses. They are 1. Set and forget 2. Rise of the prosumers 3. Leaving the grid 4. [Large scale] Renewables thrive For each scenario, demand growth is modelled on a per capita basis and multiplied by population growth estimates.
Terminology	none
Organisation/s	CSIRO
Source link	Download report

Grace (2014) Exploring the death spiral. AUDRC	
Objective	Examine the issues affecting the South West Interconnected System (SWIS), model the influence of private generation (primarily PV) and energy efficiency.
Geographic Focus	Western Australia
Technologies covered	Solar PV and storage, residential and commercial
Stakeholder perspective	Policy makers
Market context	State owned
Relevance to local network charges	LNC are proposed to assist with a transition to networks taking advantage of distributed generation to incentivise them to stay on and support the grid.
Relevance to LET (aka VNM) / VPS	none
Details of approach	A causal loop model is established with four main loops 1. high network prices incentivising load defection to PV resulting in higher (per unit) network prices 2. PV owners adopting storage and using storage to address peak events (but not necessarily change volume from grid demanded) leading to lower network costs and reducing the incentive to defect load (balancing) 3. high network prices incentivising load defection resulting in lower peak infrastructure needed (balancing) 4. The merit order effect (balancing) The modelled outputs of greatest interest are network costs, network unit prices, ultimate cost of electricity to users & GHG emissions. Results show that: • As early as 2025 demand on centralised generation could reduce to zero as DG supply would outstrip demand • Annual system costs are expected to rise only 3.8% by 2030 with the storage case. As compared with 7.7% with PV only growth case and 15% base case. • While total system costs have less increase with the solar only and solar & storage case the per unit costs are considerably higher due to the significantly lower demand The paper recommends that the network itself adopt storage to level out the supply from generation and retain its relevance, also potentially 'heading off' private storage investment.
Organisation/s	Australia Urban Design Research Centre
Source link	Download report

3.1 Additional Reading – Australian Context

Paper	Note	Link
Possible Future Trends in Residential Electricity Prices 2014-24 through 2015-16: Network Cost Drivers (Harris & Hoch, 2013)	Oakley Greenwood examines trends and drivers of network costs based on inputs costs (capital, labour, and materials) and the influence of macroeconomic drivers on these (changes in residential demand, the extent of likely future augmentation and possible changes in network pricing). The report was prepared for the AEMC and concludes: • Capital costs would go down while labour and materials costs would increase. • Augmentation would decrease due to demand easing and reliability standards possibly decreasing. • Replacement capital expenditure would rise as would prices due to overexpansion during last regulator period not spread across the forecast level of consumption.	Download report
Towards a national approach to electricity network tariff reform (Electricity Networks Association (ENA), 2014)	ENA looks at how Australia could adopt a national approach to tariff setting, potentially along the lines of the UK CDCM	Download report
Energy White Paper (Department of Industry and Science, 2015)	This report details the federal government's approach as a vision for competition, energy productivity and investment.	Download report
Final Determination: Distribution Network Pricing Arrangements (Australian Energy Market Commission, 2014)	AEMCs rule determination on the Power of Choice rule change (cost reflective pricing). This paper refers to the two NERA papers covered in the market scan.	Download report
Electricity Networks Access Code (Government of Western Australia, 2004)	Chapter 7 allows for prudent discounts to be provided to ensure economic efficiency. It also requires discounts to be given for distributed generation plant if this results in lower costs to Western Power. As a consequence of this it appears that a lowest avoided cost approach reference price for one to one LET (aka VNM)/LGNC is allowed for.	Download report

4 CALCULATING COSTS AND BENEFITS: PAPERS MOST RELEVANT TO LOCAL NETWORK CHARGES AND DG COSTS

ACIL ALLEN (2014) Network Value and Cost Sharing Arrangements	
Objective	Serve as a discussion paper to generate industry feedback and input into report to be served to Victorian Government
Geographic Focus	Victoria
Technologies covered	Technology neutral approach, however acknowledges that by quantity solar PV is most prevalent, so most examples are in solar PV context as well as cogen, gas etc.
Stakeholder perspective	DNSP, DG proponent, AER
Market context	Regulatory change to National Customer Energy Framework (NECF) in Victoria, Stakeholder consultation to DG proponents and DNSPs on how regulations are currently adhered to in practice now and how they are likely to be adhered to under NECF.
Relevance to local network charges	The report pays particular attention to areas of the current arrangements and new arrangements that seek to unlock efficient market outcomes by realising DG support payments to the DGs and realising network augmentation (or extension) payments and the net of these being incurred by, or paid to, the DG. The main source of support identified is delayed augmentation, which lends itself to the capacity method or locational method for determining support payment The augmentation costs consider shallow and deep costs (i.e. before and after the HV side of the first transformer), as well as advancements in expenditure of augmentation due to fault level rises and pioneer customers. The report also compares treatment of load and DG customers and the efficiency and equity effect of smearing deep costs across all customers.
Relevance to LET (aka VNM)	None
Details of approach	Before and after comparisons of the introduction of the NECF in Victoria (underway in 2015)
Terminology	None
Organisation/s	ACIL ALLEN

EY (2015) Calculating the value of small-scale generation to networks

Report to the Clean Energy Council

Objective	Evaluate the methodologies for valuation of small scale generators and the cost/benefits they provide to the networks.
Geographic Focus	Australia, however the report draws precedents from the US
Technologies covered	All DG, as well new / developing technologies such as EV loads
Stakeholder perspective	DNSP
Market context	Australian Market
Relevance to local network charges	Considers a range of valuation methodologies and recommends one for the Australian context
Relevance to LET (aka VNM)	None
Details of approach	EY considers the following attributes as important • A national framework • Annual quantification of value summaries as a single amount. • Technology neutrality • Consideration of timing, both in terms of network cost/augmentation expenditure timelines and generator technology uptake rates. • Scalability in calculation (i.e. implementable and calculable at scale) • Forward looking (i.e. valuing future value-categories such as islanding) The selected methodology proposes to: • create a set of well-defined cost/benefit categories (network augmentation, network support, voltage regulation, power quality, protection, reliability, islanding capability) • establish a consistent valuation measure, being a net present value defined at the distribution feeder level • use a time horizon equivalent to the expected operational lifetime of DERs • create of a valuation library (of feeders) in order to manage the computational burden and avoid the duplication of effort.
Terminology	None
Organisation/s	Clean Energy Council
Source link	http://www.cleanenergycouncil.org.au/dam/cec/policy-and-advocacy/ARENA/FPDI/the-value-of-small-scale-generation.pdf

EPRI (2015) The Integrated Grid: A Benefit-Cost Framework Palo Alto, CA: 3002004878.	
Objective	To develop a framework for cost benefit analysis of DER at local and system wide levels (nb includes distribution and transmission). Primary objective to aid assessment of policy and to aid investment decisions by utilities.
Geographic Focus	USA
Technologies covered	Solar PV, PV + batteries, small wind, diesel or gas generators, fuel cells, micro turbines
Stakeholder perspective	Utilities, regulators, third party stakeholders (all)
Market context	Vertically integrated utilities
Relevance to local network charges	Proposes a framework to do CBA for DG in the network Very similar to the approach proposed by EY as part of the FPDI project
Relevance to LET (aka VNM)	None
Details of approach	The method takes a scenario approach to valuation, starting with identification of the "hosting capacity" of each feeder for each type of DER. The hosting capacity identifies the MW of a particular type of DER that can be installed without compromising safety standards; then there is a cost and a step change in what can be installed. For a given feeder, the EPRI approach models incremental increases to penetration until breach of the reliability and power quality criteria occur. At this point, a mitigation strategy is selected (and costed) and DER penetration is incrementally increased again until the next violation. In this way, a DER penetration versus cost curve is developed for the feeder. CBA is then undertaken for the base case plus scenarios for different levels of DER penetration (note that penetration will exceed the hosting capacity, but will include the costs of any upgrades). Benefits are also identified, such as avoided augmentation, and also bulk system (which includes energy generation), customer and societal benefits. Scenarios assumptions must be clearly identified, and can be used to assess policy targets or just to compare penetration levels – assuming the hosting capacity studies have already been done. Distribution system, bulk supply system, customer services, and societal services should be included. EPRI acknowledge this is highly labour and data intensive, and suggest that feeders can to some extent be categorized into types.
Terminology	DER distributed energy resources
Organisation/s	EPRI

Source link	Download report

Denholm, P. Et al (2014) Methods for analysing the benefits and costs of distributed Photovoltaic generation to the US electricity utility system.

National Renewable Energy Laboratory (NREL)

Objective	Seeks to identify methods for estimating the benefits and costs of distributed PV.
Geographic Focus	USA
Technologies covered	Solar PV
Stakeholder perspective	Focus is on benefits and costs to the electricity utility. Benefits or costs accruing to owners, the economy and public health are not included.
Market context	Vertically integrated
Relevance to local network charges	Methods for calculating: • distribution capacity value; • transmission capacity value; generation capacity value (relevant to Economic modelling); • avoided losses value; and • ancillary services; are presented, along with other methods for estimating other cost & benefits categories less relevant to LGNC.
Relevance to LET (aka VNM)	None
Details of approach	• Several calculation methods are presented for each category of cost or benefit. Methods most relevant to LGNC or economic modelling are highlighted here. • Losses - Average combined loss rate - Marginal combined loss rate. This method includes correction for loss rates that change as a function of system load. Peak & off peak times could be used as a proxy for system load levels • Generator Capacity Value - Capacity factor approximation using Loss of Load Probability (LOLP) - Effective Load Carrying Capacity • Distribution capacity value - Average deferred investment for peak reduction
Organisation/s	National Renewable Energy Laboratory

Source link	Download report

Hansen L, Lacy C, Glick D. (2013) A review of Solar PV Benefits and Cost Studies, 2nd Edition

Electricity Innovation Lab Rocky Mt Inst.

Objective	Review of 16 CBA studies of distributed PV to identify methodological best practice, categorization, and gaps.
Geographic Focus	USA, mostly high penetration areas
Technologies covered	Solar PV
Stakeholder perspective	All (PV customer, other customers, utility, society)
Market context	Vertically integrated utilities
Relevance to local network charges	Gives good breakdown of potential value, including energy, capacity, grid services, financial risk, societal, and environment. The potential grid services (which may be costs or benefits) are: • Reactive supply and voltage control • Frequency Regulation • Energy balancing • Operating reserves • Scheduling, forecasting The report summarises the calculated cost and benefit found in each of the different studies, which may be useful in assessment of appropriate technology adjustments for PV.
Relevance to LET (aka VNM)	Not relevant
Details of approach	Review of distributed PV cost benefit studies.
Terminology	DER DPV – distributed energy resources, distributed PV
Organisation/s	Rocky Mountain Institute
Source link	Download report

IPART (2012) Solar feed-in tariffs: Setting a fair and reasonable value for electricity generated by small-scale solar PV units in NSW New South Wales	
Objective	Provide a 'fair and reasonable' recommendation as to solar energy payments
Geographic Focus	New South Wales
Technologies covered	Solar PV
Stakeholder perspective	Regulator
Market context	Australia
Relevance to local network charges	IPART recommends TUoS, DUoS and avoided losses are not included. IPART considered PV unlikely to produce network benefits, considered them to be location and time specific, and at current levels of generation likely to be small. The report does however suggest a policy framework which incentivises DNSPs, installers and customers to seek network opportunities and be compensated. Its recommends The National Electricity Rules and guidelines governing DNSPs should be reviewed to ensure they appropriately incorporate small-scale embedded PV generation into the policy and regulator framework IPART argues against avoided TUoS as there is a TNSP revenue cap. TUoS not recovered from one period will increase per unit charges in subsequent periods so that the required revenue will still be received despite lower volume.
Relevance to LET (aka VNM)	None
Relevance to VPS	None
Details of approach	IPART considers two methods for FiT price setting 1) basing payments on direct financial gains of retailers 2) basing payments on wholesale market value of PV exports and the time of day of the export IPART's terms of reference also state that no electricity price rises to other consumers should occur due to the policy.
Terminology	N/A
Organisation/s	Independent Pricing and Regulatory Tribunal
Source link	Download report

4.1 Additional Reading: LGNC and DG Cost Benefit Studies

Paper	Note	Link
Maine Distributed Solar Valuation Study (Vannoy et al., 2015)	Maine's study on the value of distributed solar includes a much broader range of values than considered for the Australian LGNC. Pages 33 and 34 show the methodology for distribution capacity and voltage regulation costs/benefits. Forecasted loads are flat for Maine however so distribution capacity augmentation is not expected in the forecast future.	Download report
Issues Paper: A level Playing Field for Local Energy, Prepared for the city of Sydney (Rutovitz, Langham, & Downes, 2014)	Paper on local charging and valuing local energy. A precursor to the Local Network Charges Calculation methodology discussion paper	Download report
Value of net-FiT PV policies for different electricity industry participants considering demand-side response (Sebastián Oliva & Macgill, 2014)	Identifies peak demand potential for PV and DSR to increase or reduce network expenditure as a promising but particularly complex issue. The paper highlights that jurisdictional arrangements including those in Australia still do not provide an appropriate framework for non-network options to receive the potential network value that they can bring. Identifies a greater role for energy service providers who can aggregate a range of activities such as energy efficiency and distributed generation including PV and DSR to maximise both its energy market and network value.	Download report
Proposed Decision (State of California, Paget-brown, & Hall, 2012)	This rulemaking is opened to establish policies, procedures, and rules to guide California investor-owned electric utilities (IOUs) in developing their Distribution Resources Plan Proposals, This rulemaking also will evaluate the IOUs' existing and future electric distribution infrastructure and planning procedures with respect to incorporating Distributed Energy Resources into the planning and operation of their electric distribution system	Download report

5 PAPERS ON TARIFF SETTING

Energia (2014) Network Pricing and Enabling Metering Analysis Report to Electricity Networks Association	
Objective	Energia assesses the bill impacts to customers of cost reflective pricing options.
Geographic Focus	Australia
Technologies covered	Solar PV and Batteries
Stakeholder perspective	Distributors
Market context	Regulated, not vertically integrated (Australia)
Relevance to local network charges	A max demand seasonal time of use is recommended
Relevance to LET (aka VNM)	None
Relevance to VPS	None
Details of approach	Tariffs considered were Inclining & Declining Block Tariffs (IBT/DBT) Seasonal Time of Use Energy (SToU) and Seasonal Time of Use Max Demand (MD+SToU). The modelling suggests that MD+SToU will lead to the lowest uptake of solar and storage. SToU modelled to have greatest impact on capex and avoided network costs. Modelling compares the savings shared by residential and commercial customers due to DER uptake as compared with the savings the network realises due to these technologies. Modelling shows that largest network capex is avoided under SToU but that SToU means even greater revenue losses to networks. Meaning that networks must increase prices to recover costs and that these are spread to others in the community.
Terminology	None
Organisation/s	Electricity Networks Association, Energia
Source link	Download report

NERA (2015) Efficiency of tariffs for current and emerging technologies

Nunn, Oliver; Kemp, Adrian; Hitchins, Nina; Chow, Martin; Forrest, Sam

Objective	To investigate the efficiency of tariffs charged to electricity customers that using existing and emerging technologies.
Geographic Focus	Australia
Technologies	Solar PV, battery storage, electric vehicles and air conditioners
Stakeholder perspective	Regulatory: report complied for the AEMC
Market context	Australia
Relevance to local network charges	NERA identifies the network costs or benefits associated with each of the four technologies covered. The relevant network cost (saving) is the incremental increase in network costs incurred by increasing the use of the relevant technology, i.e., the LRMC of network services for customers with those technologies. This is done by: • estimating the effect on the annual system maximum demand of the technology; • multiplying the contribution of the technology to the system peak (in kW per annum) by network LRMC for that network. The report acknowledges that the maximum demand may shift in time due to the technologies and that savings may be made on local levels as well as the system peak. The report however does quantify these.
Relevance to LET (aka VNM) or VPS	None
Details of approach	The report uses four case studies,: an Air Conditioning customer in Victoria, a solar PV in South Australia, a solar PV + storage customer in Queensland and an Electric vehicle customer in NSW (Ausgrid area) 1. Determining the change in load profile resulting from a consumer adopting each of the four technologies. 2. Assessing the effect of each technology on network charges paid by customers. 3. Assessing the effect of each technology on network costs. 4. Comparing network costs and network charges to assess efficiency, and where appropriate the development of an alternative more efficient tariff. 5. Assessing the effect of each technology on retail bills under current and alternative tariffs.
Organisation/s	NERA, AEMC
Source link	Download report

NERA (2015) Economic Concepts for Pricing Electricity Network Services

Kemp, Adrian; Nunn, Oliver; Chow, Martin; Gainger, Stephanie

Objective	To set out the economic rationale for and concepts underpinning the distribution network pricing principles set out in the National Electricity Rules and to discuss practical approaches that can be used to estimate the long-run marginal cost (LRMC) of network services, as a measure of the costs electricity users impose on networks.
Geographic Focus	Australia
Technologies	n/a
Stakeholder perspective	Regulatory: report complied for the AEMC
Market context	Australia
Relevance to local network charges	LGNC calculation methodology needs to consider best practise efficient network pricing theory.
Relevance to LET (aka VNM)	None
Relevance to VPS	None
Details of approach	The report begins with a basic overview of infrastructure pricing economics, including introducing LRMC and avoidable incremental cost (AIC) and the perturbation method as ways of estimating LRMC. In terms of network pricing principles it also outlines historic cost recovery in ways that do not distort price signals NERA considers electricity distribution future costs to be driven by • number of customers connected to the network; • maximum demand on the network; • timing of services required (i.e., the networks load profile); and • location that services are sought. In tariff setting NERA recommends LRMC be used to set efficient signals and that the AIC method be suitable for high level pricing, but not mandated as perturbation method may be more appropriate in some instances. The general process of tariff creation is to 1. Analyse expenditure, 2. Identify network growth, 3. Group customers, 4. Estimate LRMC for each tariff class, 5. Develop tariffs based on LRMC,

	6. Mark up tariffs so as to recover historic costs
Terminology	None
Organisation/s	NERA, AEMC
Source link	Download report

Handschin, L. Et al (2000) Comparison of Pricing methodologies for wheeling transactions in liberalised energy supply systems

University of Dortmund

Objective	Analysing the effects of different pricing methodologies on the new (at the time) competitive aspects introduced into the German market.
Geographic Focus	Germany
Technologies covered	All
Stakeholder perspective	Policy makers, market
Market context	Liberalised i.e., allows vertical integration
Relevance to local network charges	Provides comparison of three postage stamp methods • Maximum system load share method • Energy based retrieval point tariff • Energy based postage stamp of voltage and transformation levels and two other methods • Locational Marginal pricing (appears to be same as nodal pricing) • Mega Watt Mile The location marginal was seen as the benchmark for comparing the others against as it was regarded as most reflective of economic efficiency.
Relevance to LET (aka VNM)	None
Details of approach	Applies 12 typical load curves {Summer, Autumn, Winter, Spring} x {Weekday, Saturday, Sunday} to a network model.
Terminology	None
Organisation/s	University of Dortmund
Source link	http://146.83.6.25/literatura/sistemas_potencia/SPME2_2000.pdf

Jamaican Office of Utilities Regulation (2012) Electricity wheeling methodologies **Jamaica**	
Objective	To examine electricity methodologies in use around the world and recommend a suitable methodology for use in Jamaica
Geographic Focus	Global examples where relevant to Jamaica
Technologies covered	Technology neutral
Stakeholder perspective	Regulator
Market context	Vertically integrated, regulated
Relevance to local network charges	Assess various methods to determine how much of a network is used in a particular transaction. Methodologies covered include: • Postage stamp • Contract path • MW-km (both load flow based and distance based are considered). • Short run • Long run • Nodal price
Relevance to LET (aka VNM)	None
Relevance to VPS	None
Details of approach	Nord pool, Ireland, South Africa, Great Britain, US, New Zealand and Brazil are all compared. A framework for Jamaica is recommended on the basis of efficiency, cost recovery, transparency, stability, non-discrimination and ease of application
Terminology	None
Organisation/s	Jamaica Public Service Company is the affected TNSP and DNSP
Source link	http://www.our.org.jm/ourweb/sites/default/files/documents/sector_documents/electricity_wheeling_methodologies_-_consultation_document.pdf

5.1 Additional Reading: LGNC methodologies

Paper	Note	Link
International Experience of Electricity Transmission Pricing (National Electricity Code Administrator, n.d.)	UK, Norway, US, NZ & South America transmission pricing regulation compared	Download report
Aligning Network Charges to the Cost of Peak Demand (Ergon Energy, 2015)	Ergon Energy's consultation paper for cost reflective pricing including LRMC and AIC methodology consultation. Ergon is also proposing to benchmark against UK CDCM	Download report
Report to Ergon Energy Estimating the Average Incremental Cost of Ergon Energy's Distribution Network (Harry Colebourn Pty Ltd, 2015)	Shows Ergon Energy's LRMC estimation using the average incremental cost method	Download report
Distributed Marginal Prices (DMPs) (Osterhus, Analytics, & Ozog, 2014)	Describes a method of economically efficient and time & location based distribution network pricing (Nodal Pricing)	Download report
Reforming the Energy Vision (New York State, 2014)	Paper considers • What should be the role of the distribution utilities in enabling system wide efficiency and market based deployment of distributed energy resources? • What changes can and should be made in the current regulatory, tariff, and market design and incentive structures in New York to better align utility interests with achieving our energy policy objectives? Considers the approach to distributed resources should be re-evaluated to determine how demand management can be used not as a last resort but rather as a cost effective, primary tool to manage distribution system flows, shape system load, and enable customers to choose cleaner, more resilient power options. Introduces the terminology of "Distributed System Platform Provider"	Download report

6 GLOBAL LOCAL NETWORK CREDIT EXAMPLES

State of Connecticut (2013) An act concerning implementation of Connecticut's comprehensive energy strategy and various revisions to the energy statutes	
Objective	Implements the energy strategy of Connecticut, including a method for partial reimbursement of network changes for local generation
Geographic Focus	Connecticut, USA
Technologies covered	Limited to 'Class I' (Renewables) and 'Class III' (combined heat and power systems)
Stakeholder perspective	Legislature
Market context	Vertically integrated
Relevance to local network charges	Applies to generation less then 3MW, located in the same distribution territory as the 'customer host and its beneficial accounts' i.e., the accounts to which the energy is being credited.
Relevance to LET (aka VNM)	Applies to Municipal, State or Agricultural Virtual Net Metering Facilities
Details of approach	An LGNC methodology is described and applied to 'LET (aka VNM) facilities' whereby the distribution company calculates net consumption or production over a billing period from the aggregate of that customer's sites and where there is surplus generation it applies the credit for the next billing period. The credit includes a 'declining percentage of transmission and distribution charges. The declining percentage is • 80% to July '14 • 60% from July '14 to July '15 • 40 % from July '15 Credits are rolled over from billing period to billing period and any remaining credits at the end of the calendar year are paid out to the customer.
Terminology	None
Organisation/s	Connecticut Senate and House of Representatives in General Assembly
Source link	http://www.cga.ct.gov/2013/ACT/PA/2013PA-00298-R00HB-06360-PA.htm

DCUSA Ltd (2015) Schedules 16 -18 Common and EHV Distribution Charging Methodologies

Distribution Connection and Use of System Agreement v7.4

Objective	Sets out a common methodology and adopted by UK DNSPs in setting tariffs
Geographic Focus	UK
Technologies covered	n/a
Stakeholder perspective	DNSP costing and operation
Market context	Regulated distribution, retail competition
Relevance to local network charges	Details the UK approach to setting the volumetric TOU generation payments for local generation
Relevance to LET (aka VNM)	None
Relevance to VPS	None
Details of approach	A network incremental expansion is planned and costed. Effectively this estimates LRMC by the Average Incremental Cost method with a defined and fixed increment of 500MW. Expressed in Pounds/kW/year The costs of this are allocated network level The DNSP also determines a peaking probability for each network level in each of the distribution time bands. The distribution time bands are used to set different rates for the export of energy based on the probability of the peak occurring in that period A generation user is taken to make a zero contribution to load at its connection level and a full negative contribution (load reduction) to circuits at network levels above this connection level. For generators an F factor is used as an availability factor to further scale the payment received by the generator for exports based on the estimated likelihood of the generator being available and generating at the peak times. The DCUSA also contains numerous other schedules and methodologies related to other aspects of tariff setting and network operation, the authors have not attempted to review the DCUSA for anything beyond its relevance to local network charges
Terminology	n/a
Organisation/s	Ofgem
Source link	http://www.dcusa.co.uk/DCUSA Document Public Version/DCUSA v7.4.pdf

Minnesota Value of Solar: Methodology. Minnesota Department of Commerce, Division of Energy Resources	
Objective	Allow utilities to provide a Value of Solar tariff instead of Net Energy Metering (NEM) for solar customers, to reflect actual value of solar generation rather than automatic valuing at the customer retail rate. Solar customers will be billed gross for their consumption, and given a credit under the VOS tariff.
Geographic Focus	Minnesota
Technologies covered	Solar PV
Stakeholder perspective	Government (purpose is to calculate overall system value, and compensate accordingly)
Market context	Vertically integrated
Relevance to local network charges	Key aspects of the methodology include: • A standard PV rating convention • Methods for creating an hourly PV production time-series, representing the aggregate output of all PV systems in the service territory per unit capacity corresponding to the output of a PV resource on the margin, measurement methods and estimation methods are provided. • Requirements for calculating the electricity losses of the transmission and distribution systems • Methods for performing technical calculations for avoided energy, effective generation capacity and effective distribution capacity • Economic methods for calculating each value component (e.g., avoided fuel cost, capacity cost, etc.) • Requirements for summarizing input data and final calculations in order to facilitate PUC and stakeholder review Includes fuel cost for displaced gen VOS Set when installed – does not change year on year for existing customers. Includes option for utility to provide higher incentive in location specific areas. Augmentation avoidance based on demand growth expectations needing to be positive. Doesn't provide time of day varying price signal to incentivise peak load avoidance, it all happens based on data (after the fact) or estimations. Would also be expected to end up with each year of customers to be on a different tariff. Systems expansions probably not possible under the 1 meter

Relevance to LET (aka VNM)	none
Details of approach	Entirely volumetric. Full lifetime value of marginal PV installed that year is determined, and levelised, then inflation adjusted (including CPI) to set the rate for that year. Gross production is paid per kWh
Terminology	Value of system (VOS) tariff = value of solar. Could be repurposed as VOLG or LGV Effective Load Carrying Capability (ELCC)- this is basically a standing reserve reduction capacity value Peak Load Reduction (PLR) – identifies time and level of reduction. Allows for peak shifting thought force consideration of whole period.
Organisation/s	Minnesota Department of Commerce
Source link	https://mn.gov/commerce/energy/images/MN-VOS-Methodology-FINAL.pdf

7 PAPERS MOST RELEVANT TO LOCAL ELECTRICITY TRADING (ALSO CALLED VNM)

AER (2013) Retail Exempt Selling Guideline	
Objective	Describes regulatory framework for selling electricity without a retail licence
Geographic Focus	Australia
Technologies covered	n/a
Stakeholder perspective	Entity wishing to sell energy without a retailer authorisation.
Market context	Any entity selling energy in the NEM states is required to have a retailer authorisation or an exemption. Exemptions generally apply to small energy trading relationships to specific customers or classes of customers at specific sites.
Relevance to local network charges	None
Relevance to LET (aka VNM)	It is unclear under the current guidelines if LET (aka VNM) would fall under the description of energy sale.
Relevance to VPS	This is the chief regulator guideline regarding sale of energy by non-retailers. The main examples situations covered are: • Landlords selling unmetered energy to tenants (e.g. shopping centre complex or caravan park) • Businesses selling energy to a related company • This type of exemption also applies to Power Purchase Agreement (PPA) type contracts such as Solar PPAs (Australian Energy Regulator, 2015)
Details of approach	Generally, as an activity become closer in scale, scope, and profit status to electricity retailing the exemption conditions will match the retailer authorisation
Terminology	None
Organisation/s	Australian Energy Regulator
Source link	https://www.aer.gov.au/sites/default/files/AER Final decision - Exempt selling %28retail%29 guideline - version 2 - July 2013_1_1.doc

City of Sydney (2010) Approach To Retail Exemptions **Issues Paper Submission To The Australian Energy Regulator**	
Objective	Submission to the AER on changes to retail exemptions to remove barriers to localised selling of decentralised energy.
Geographic Focus	Australia
Technologies covered	Focus is on tri-generation however all decentralised technologies are notionally included
Stakeholder perspective	City council as a proponent of decentralised energy
Market context	Australia
Relevance to local network charges	City of Sydney's proposal would allow small electricity companies to easily develop local private wire networks and be exempt from the licencing required for normal retail and network businesses. This is an example of economically inefficient outcomes that can prevail if networks are not efficiently pricing LUoS
Relevance to LET (aka VNM)	None
Relevance to VPS	Insofar as retail functions, a LET (aka VNM) enabled One to Many or Many to Many VPS would benefit from a similar exemption.
Details of approach	The paper argues for deemed exempt selling to apply to all decentralised low and zero carbon energy supply. This approach would facilitate local energy service companies (ESCO) able to supply decentralised energy directly or via private wire. The paper considers the tests that the AER would normally apply when determining an exemption. This includes the customer's size, Retailer of Last Resort (RoLR) and access to retailer of choice, profit intention, governance and other factors. Appendices include an 'issues and barriers in developing tri generation in Sydney' paper by ISF and a strategic plan for tri generation in City of Sydney's property portfolio
Terminology	Energy Service Company (ESCO)
Organisation/s	City of Sydney, Australian Energy Regulator
Source link	Download report

NREL (2015) Shared Solar: Current Landscape, Market Potential, and the impact for Federal Securities Regulation Colorado	
Objective	To provide an overview on shared solar in the US, current barriers and potential market size.
Geographic Focus	United states
Technologies covered	Solar PV – where used in a Solar garden – i.e. a jointly owned solar array located offsite from usage Onsite shared solar: a jointly owned solar array co-located with load such as in multi unit buildings
Stakeholder perspective	Policy advocates
Market context	US
Relevance to local network charges	None
Relevance to LET (aka VNM)	Solar Gardens require LET (aka VNM) to be in operation. However this report doesn't investigate LET (aka VNM) per se.
Relevance to VPS	The report estimates that 49% of households and 48% of businesses are unable to host their own Solar PV systems. The report estimates that shared solar could represent up to approx. 4GW of PV demand by 2020 indicating significant scale is achievable.
Details of approach	The paper considers the tax environment, securities regulation and market potential of Shared solar The 30% investment tax credit available to PV, at its interactions with other tax requirements is examined The classification of shared solar as a security has significant impacts on the ease of implementation. The paper examines the tests that the US federal securities regular would apply in making this assessment. A significant barrier to greater deployment existing at the present time in the uncertainty a shared solar proponent faces as to whether it will be classified as a security or not. Finally, the market potential of solar gardens is examined by assessing the rate of solar installations on properties where they are able to deployed and extrapolating this demand to similar customers who suffer the restriction of not having suitable property for hosting an array.
Terminology	Shared Solar: Solar Gardens
Organisation/s	NREL
Source link	http://www.nrel.gov/docs/fy15osti/63892.pdf

8 PAPERS MOST RELEVANT TO VIRTUAL POWER STATIONS

Velocity Energy's Smart Grid Virtual Power Solutions Queensland, Australia	
Objective	This is a marketing page for velocity energy, an aggregator in Australia. They are in effect a operating virtual power station
Geographic Focus	Australia, based in QLD
Technologies covered	Focussed on dispatchable plant, e.g. building cogen, trigen and possible backup diesel plant.
Stakeholder perspective	Velocity runs a three sided market. The opportunity lies in aggregating small peaking plant and backup generator owners (side 1) and striking contracts with retailers (side 2) and DNSPs (side 3) to enable the market place for reducing peak demand liabilities
Market context	Retail / Generation / Network separation
Relevance to local network charges	Contracts struck with DNSPs would help access the value received by a DNSP when avoiding peak demand.
Relevance to LET (aka VNM)	None
Relevance to VPS	Example of aggregation in Australia. This VPS deals with Energy sales to retailer, and with network support contracts to DNSPs
Details of approach	It appears that Velocity aren't NEM registered, this is possibly because of the difficultly registering many small generators. Instead they deal in the NEM via a retailer contract Deals with energy sales to retailer Deals with network support contracts to DNSPs
Terminology	Virtual Power Station
Organisation/s	Velocity Energy, ABN 94 526 215 543
Source link	http://www.velocityenergy.com.au/smart-grid-virtual-power-stations

Ward, J. Moore, T. Lindsay, S. (2012) The Virtual Power Station Proceedings of the 50th Annual Conference, Australian Solar Energy Society, Melbourne	
Objective	Achieving dispatchable generation from small scale solar
Geographic Focus	Australia: Trials conducted at Lake Macquarie
Technologies covered	Solar PV
Stakeholder perspective	VPS aggregator perspective
Market context	NEM
Relevance to local network charges	Includes some research on the value of augmentation avoidance and VPS size required to achieve meaningful avoidance. Suggests a 2MVA availability guarantee would be the minimum attractive in seeking network augmentation avoidance (lends itself to the Capacity Method or Locational Method in valuations) Uses a figure of $3000/kVA for peak demand avoidance value
Relevance to LET (aka VNM)	None
Relevance to VPS	A VPS of at least 200 to 1000 nodes is recommended to achieve high levels of output predictability. Findings show that a 5 minute dispatch interval combined with a 10 second control interval provided sufficient certainty in output. Site diversity importance is also highlighted
Details of approach	12 month trial was conducted to prove reliability as compared with dispatchable generation. 20 Solar PV units were coordinated with a small battery bank via the 3G network into an aggregated 50kWp generator. Results were extrapolated to 200 units.
Terminology	None
Organisation/s	CSIRO
Source link	https://solar.org.au/papers/12papers/PV13Ward.pdf

Jacobs SKM (2014) Benefits and Costs of Multiple Trading Arrangements and Embedded Networks

Report to Australian Energy Market Operator

Objective	A high level cost-benefit analysis on Multiple Trading Relationships and Embedded networks rule changes
Geographic Focus	Australia
Technologies covered	Technology neutral, but considers solar PV, Electric vehicle and load control technologies
Stakeholder perspective	AEMO and AEMC – Economic consideration
Market context	Australia
Relevance to local network charges	Section 3.4.3 contains a table of estimates of DNSP peak demand benefits.
Relevance to LET (aka VNM)	None
Relevance to VPS	MTR rule change: Framework to have multiple 'settlement points' within a single connection (meter) point allowing customers to better segregate their load. The MTR Rule change would seemingly address the virtual power station issue of constituent generators needing to belong to the same retailer. If MRT allowed a different retailer to be selected for exports this issue would be overcome.
Details of approach	Embedded Network Rule Change: Finally the MTR framework is proposed to assist in establishing Embedded Networks by standardising to address barriers such as metering, retailer competition, this is less relevant to LGNC, LET (aka VNM) and VPS considerations. The modelling conducted by Jacobs SKM considered the following benefits and costs • Implementation costs • Wholesale market effects using the 'Strategist' model • Increased retail competition • Deferred network infrastructure expenditure • Changes in system costs from more efficient market services • Increases in DG uptake The paper looks at local peaks and system peaks as two separate levels. Local is considered DNSP level and System is considered TNSP.
Terminology	Multiple Trading Relationships (MTR)
Organisation/s	AEMO

Source link	Download report

Saboori, H (2011) Virtual Power Plant (VPP), Definition, Concept, Components and Types

Iran university of Science and Technology

Objective	Summarise and describe the concepts and components of virtual power plants
Geographic Focus	Global
Technologies covered	Dispatchable and non dispatchable distributed energy resources including storage.
Stakeholder perspective	Consider the perspectives of the DG unit owners, NSPs, aggregators and to a lesser degree policy makers
Market context	n/a
Relevance to local network charges	The Technical VPP definition lends itself to maximising the Local Network Benefits
Relevance to LET (aka VNM)	None
Relevance to VPS	Covers some VPS definitions. Consistent themes include aggregation of multiple units of varying type in a way that presents a single operating profile
Details of approach	Provides high level summaries definitions and concepts Covers a couple of different VPP types: Technical VPP which includes real time influences of & on the local network by DER and enables visibility to DNSPs and contribution of VPS to system operators. Commercial VPP, acting as a commercial aggregator to participate in the wholesale market including the Frequency Control Ancillary Services Market.
Terminology	TVPP – Technical Virtual Power Plant
Organisation/s	Iran university of Science and Technology
Source link	http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5749026&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5749026

OsterGaard J. Neilsen J.E. (2010) The Bornholm Power System Centre for Electrical Technology, Lyngby	
Objective	Provides an overview of the micro grid on the isle of Bornholm
Geographic Focus	Bornholm Denmark
Technologies covered	Generator units, communications methods & SCADA, Grid infrastructure, Demand side standing reserve
Stakeholder perspective	Micro grid owner / operator
Market context	Vertically integrated
Relevance to local network charges	None
Relevance to LET (aka VNM)	None
Relevance to VPS	Bornholm operates a micro grid of approx. 54MW peak load, comprising of a 60kV, 10kV and LV network, approx. 52 Generation units, 28310 customers, a control room, communications system and district heating systems
Details of approach	Provides a high-level technical overview of all aspects of the Bornholm power system. Also details the microgrid's ability to operate as a research platform in smart grids such as • Development of a micro power market • Storage • Virtual power plant implementation for demand and generation aggregation • Communications trials (IEC 61850) • Demand response as Frequency Control Ancillary Service
Terminology	None
Organisation/s	Technical university of Denmark
Source link	https://pire.soe.ucsc.edu/sites/default/files/denmark_the_bornholm_power_system_an_overview%20(1).pdf

Braun M. (2009) Virtual power plants in real applications: Pilot demonstrations in Spain and England as part of the European project FENIX. University of Kassel	
Objective	Describe the trials undertaken for the FENIX virtual power plant trials in
Geographic Focus	Spain and UK
Technologies covered	Distributed and Local generators, storage units and associated communications and control infrastructure to coordinate and create commercial and technical benefit.
Stakeholder perspective	Pilot project proponents, LG unit owners, NSPs, Policy makers,
Market context	Spain and UK
Relevance to local network charges	There is tangential relevance to LGNC through the realisation, and potentially quantification of NSP benefits such as increased visibility, control flexibility for network management, improved use of grid infrastructure and improved DNSP/TSNP coordination.
Relevance to LET (aka VNM)	None
Relevance to VPS	Fenix is intended to provide a commercial, technical and regulatory demonstration of VPS The UK (Northern) trials centred on Woking Borough Council. Woking has the benefit of having a privately owned network and a generation portfolio including dispatchable units and load control devices for some loads The Spanish (Southern) scenario uses the FENIX control and communications architecture to provide both commercial and technical benefits through • 'Day Ahead Market' Participation • Tertiary reserve • Voltage Control • Network Contingencies
Details of approach	Covers definitions of Technical (focussed on benefiting grid) and Commercial (focussed on optimising profit) VPS.
Terminology	VPP – Virtual Power Plant
Organisation/s	(Northern) Areva T&D, ZIV, EDF Energy Networks, National grid and imperial college London, Woking Borough Council (Southern) Alava, Electricité de France, National Grid, REE, Gamesa, Siemens, Areva and Tecnalia

Source link	https://www.vde-verlag.de/proceedings-en/453194005.html

8.1 Additional Reading – Virtual Power Stations

Paper	Note	Link
Rules regulating electric utilities (Colorado department of regulatory Agencies, 2011)	This is Colorado's public utilities code and among many other things it covers the community solar gardens clauses, which enables Virtual Net Metering for one to many community owned solar arrays, with minimum 10 subscribers.	Download report
Methodology used to calculate T&D investment (World Energy Outlook, 2011)	This paper considers how investment in electricity networks is driven from new growth, ageing infrastructure and renewables integration. Some useful formulas are presented to show how these investment quantities could be calculated.	Download report
Energy from Everywhere (Muller, 2012)	Good introductory article covering the rise of distributed generation. It introduces the VPS concept and uses examples of a VPS in Dortmund owned by RWE (150MW) with a Siemens control system and a second VPS called Stadtwerke Munchen (20MW)	Download report
California senate bill SB594 (Assembly committee on utilities and commerce, 2012)	Californian bill legislating meter aggregation and LET (aka VNM)	Download report
Evaluation of Net Metering in Vermont Conducted Pursuant to Act 125 of 2012 (Vermont Public Services Deparment, 2013)	Vermont considers net energy metering, including LET (aka VNM)	Download report
Community net energy metering: how novel policies expand benefits of net metering to non-generators (Varnado & Rose, 2010)	Looks at community net energy metering (Virtual Net Metering/Local Energy Trading). Examines benefits and limitations of various approaches and policies of community net energy metering. assess main benefits as financial, administrative and environmental	Download report
Reposit Power (Reposit Power, 2015)	Reposit power through their battery control system as a market interface have the ability to act as an aggregator of many small generators and are a proof of concept for many of the subsystems of a VPS in Australia	Visit website

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