Development of a Comprehensive Decision Making Framework for Power Projects in New South Wales (NSW)

AYSE TOPAL

A dissertation submitted to the University of Technology, Sydney in fulfilment of the requirements for the degree of Doctor of Philosophy (Engineering)

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Certificate of Authorship

I certify that the work in this thesis has not previously been submitted for a degree, nor has it been submitted as part of the requirements for a degree, except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Candidate

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Abstract

In the backdrop of emerging concerns about sustainability, the contribution of electricity generation to sustainability, the complexity of power projects, and the narrowness of existing decision approaches for selecting power projects – this research develops a comprehensive decision-making framework that can be applied to select power projects for meeting future electricity needs in NSW. This framework is based on Multi-Attribute Decision Analysis (Analytical Hierarchy Process). This framework will assist with complex decisions regarding projects typified by multiple objectives, multiple decision makers, multiple attributes, conflicts, and socio-economic concerns.

The appropriateness of this framework is established in this research in terms of its ability to assist with project choices (from among several alternatives), to meet medium (2035) and long term (2050) electricity needs of NSW, in a sustainable manner. The backdrop for the application of this approach is provided by five scenarios, representing alternative technological pathways, energy & environmental and socio-political settings. Fourteen attributes, reflecting major areas of concern relating to economic, environmental, technical, and socio-political issues are considered, guided by literature review and expert opinion.

The overall ranking for each alternative is developed on the basis of, first, assessing the economic, environmental, and social impacts of the alternatives; second, incorporating decision makers' (expert) preferences for selected attributes, through a pair-wise comparison of various attributes; next, developing a weighted average across all attributes. These individual scenario rankings are then used to compare alternatives represented by various scenarios.

The analysis suggest that, overall, the BAU scenario, representing a continuation of existing trends in generation-mix is likely to be the most detrimental scenario for achieving sustainable outcomes in NSW, as it will result in highest levels of levelized cost, GHG emissions, total waste, air pollution, visual impact, water use,

resource (fuel) use, severe accidents; and lowest levels of new jobs, and political and social acceptance. The best option in the medium term (2035) for NSW will be the HR-1 scenario (40% share of renewables, with nuclear), as it will result in the highest levels of new jobs, political and social acceptance; and lowest levels of levelized cost, GHG emissions, total waste, air pollution, resource (fuel) use. The best option in the long term (2050) for NSW will be the HR-2 scenario (80% share of renewables, without nuclear), as it will result in the highest levels of new jobs, political and social acceptance; lowest levels of total waste, water use, severe accidents; and moderate levels of levelized cost, air pollution, water and resource use. It is interesting to note the change of preference from HR-1 scenario in the medium term, to HR-2 scenario in the long term, as informed by trade-offs between various attributes. The above insights clearly demonstrate the usefulness of the proposed framework for making complex decisions about power projects.

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Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACT	Australian Capital Territory
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
AETA	Australian Energy Technology Assessment
AGL	Australian Gas Light Company
AHP	Analytical Hierarchy Process
AIRP	Air Pollution
APH	Parliament of Australia
ARENA	Australian Renewable Energy Agency
AWEO	Australian Wind Energy Association
BAU	Base as Usual Scenario
BREE	Bureau of Agricultural and Resource Economics
CBA	Cost Benefit Analysis
CC	Combined cycle
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Sequestration
CEF	Clean Energy Future
CEFC	Clean Energy Finance Corporation
CETP	China Energy Technology Program
CIEGPNSW	Commission of Inquiry into Electricity Generation Planning in NSW
CO_2	Carbon Dioxide
COAG	Council of Australian Governments
CPRS	Carbon Pollution Reduction Scheme
CR	Consistency Ratio
CSM	Coal Seam Methane
DALY	Disability adjusted life years
DCCEE	Department of Climate Change and Energy Efficiency
DECCW	Department of Environment, Climate Change and Water
DGRs	Director General's Assessment Requirements
DLG	Department of Local Government
DME	Department of Minerals and Energy
DoE	Department of Energy
DoP	Department of Planning
DoPI	Department of Planning and Investment
DPI	Department of Primary Industries
EAC	Electricity Advisory Committee
EANSW	Electricity Authority of New South Wales
ECNSW	Electricity Commission of NSW
EIA	Energy Information Administration (US)
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement

ELPSC	Electric Light and Power Supply Corporation
EnANSW	Energy Authority of NSW
EP& A	Environmental Planning and Assessment
EPA	Environment Protection Authority
ESAA	Electricity Supply Association of Australia
ESD	Ecologically Sustainable Development
ESDSC	Ecologically Sustainable Development Steering Committee
ETF	Energy Task Force
g	Gram
GDP	Gross Domestic Product
GGAS	Greenhouse Gas Reduction Scheme
GHG	Greenhouse Gas
GWh	Gigawatt-hour
HR	High Renewables Scenario
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle
IPART	Independent Pricing and Regulatory Tribunal
IRENA	International Renewable Energy Agency
ISO	International Organization for Standardization
JOCR	Job Creation
kg	Kilogram
kl	Kilolitre
kWh	Kilowatt-hour
LAUS	Land Use
LCA	Life Cycle Assessment
LCOE	Levelised Cost of Electricity
LEPs	Local Environmental Policies
LRET	Large-scale Renewable Energy Target
MADA	Multi Attribute Decision Analysis
MADM	Multi Attribute Decision Making
MCDA	Multi Criteria Decision Analysis
MODM	Multi-Objective Decision Making
MR	Moderate Renewables Scenario
MRET	Mandatory Renewable Energy Target
MURAME	Multi-criteria Ranking Method
MW	Megawatt
MWh	Megawatt-hour
NEA	Nuclear Energy Agency
NEEDS	New Energy Externalities Developments for Sustainability
NEL	National Electricity Law
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company
NER	National Electricity Rules
NGMC	National Grid Management Council
NOx	Nitrogen Oxides
NOIS	Noise Impact
NPV	Net Present Value

NRET	NSW Renewable Energy Target
NSC	National Sustainability Council
NSW	New South Wales
OCGT	Open Cycle Gas Turbine
OECD	Organisation for Economic Co-operation and Development
PAC	Planning Assessment Commission
PAOP	Political acceptance of the project
PDF	Potentially Damaged Fraction
POE	Probability of Exceedence
PV	Photovoltaic
PWD	Public Works Department
QGCPO	Queensland Government Chief Procurement Office
RA	Risk Assessment
RD	Railway Department
REC	Renewable Energy Certificate
RET	Renewable Energy Target
RUFU	Resource Use-Fuel
SAOP	Social acceptance of the project
SCC	Sydney County Council
SCER	Standing Council on Energy and Resources
SEAC	Severe Accidents (Fatalities)
SEPPs	State Environmental Planning Policies
SES	Southern Electricity Supply
SFP	Solar Flagships Program
SMC	Sydney Municipal Council
SMHEA	Snowy Mountains Hydro-Electric Authority
SO_x	Sulphur Dioxide
SOC	State-owned Corporation
SRES	Small-scale Renewable Energy Scheme
SSD	State Significant Development
TEMA	Technological Maturity
TOWA	Total Waste
TWh	Terra Watt-hour
UN	United Nations
VIC	State of Victoria
VISU	Visual Impacts
WACO	Water consumption
WCED	World Commission on Environment and Development
WNA	World Nuclear Agency
WWI	World War I
WWII	World War II
YOLL	Years of Life Lost