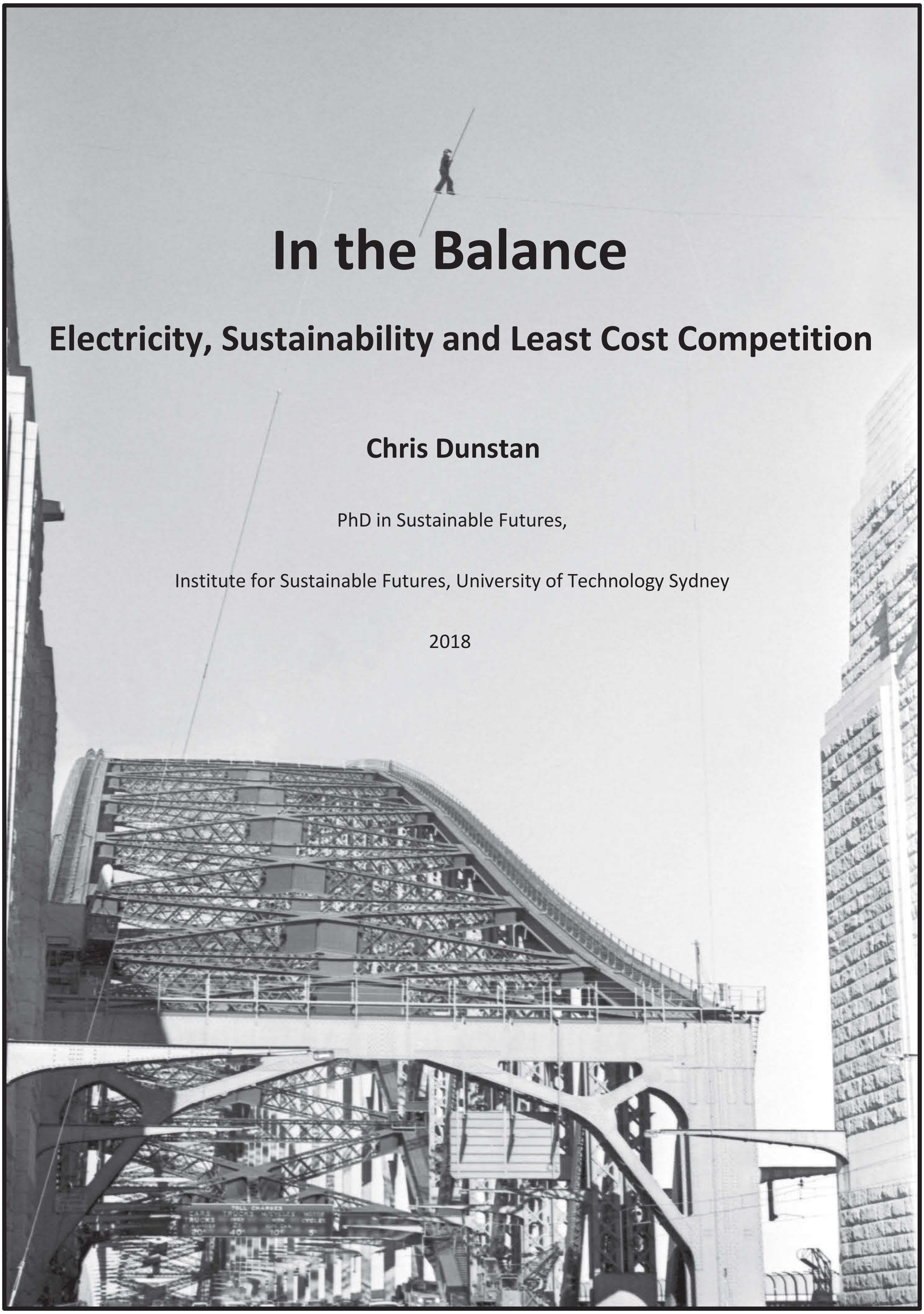

In the Balance

Electricity, Sustainability and Least Cost Competition

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PhD in Sustainable Futures,

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In the Balance: Electricity, Sustainability and Least Cost Competition

Cover image:

Philippe Petit above the Sydney Harbour Bridge, 3 June 1973 (Fairfax Syndication)

Certificate of Original Authorship

I, Christopher Gerard Dunstan declare that this thesis is submitted in fulfilment of the requirements for the award of a PhD in Sustainable Futures in the Institute for Sustainable Futures at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of student

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Acknowledgments

A key strength of my PhD research is its links with a number of collaborative research projects that I have led and been involved in since beginning my PhD in 2005. These include projects undertaken for a range of clients through the Institute for Sustainable Futures (ISF) and the Australian Alliance to Save Energy (A2SE), and in particular, the work program of the CSIRO Intelligent Grid Research Cluster ("iGrid").

The Intelligent Grid Research Cluster involved seven projects from five Australian universities over three years 2008–2011. The Cluster was established through the Collaborative Fund of the CSIRO Energy Transformed Flagship, within its Low Emissions Distributed Energy Theme.

In early 2006, I proposed to CSIRO to undertake several key components of my PhD research as part of the iGrid Research Cluster. This proposal was accepted by CSIRO and formed one of seven parts of the iGrid research program. This research program involved researchers from CSIRO and five universities: the University of Queensland, Queensland University of Technology, the University of South Australia, Curtin University and the University of Technology Sydney. I am grateful to Professor Anthony Vassallo and Professor Stuart White for their work in coordinating the application proposal for the iGrid Research Cluster. I also gratefully acknowledge the support for this project provided by the CSIRO Energy Transformed Flagship.

The Research Cluster ran from late 2007 to late 2011. My PhD supervisor, Professor Stuart White was the overall leader of the research cluster. I wish to thank Ms Louise Boronyak who was the very capable executive officer for the cluster. I led Project 4 of the Research Cluster on "Institutional barriers, stakeholder engagement and economic modelling".

IGrid Project 4 comprised five streams as follows:

1. a review of the benefits of and barriers to the development of Intelligent Grid and its components
2. a report of economic regulatory barriers to Intelligent Grid development and mechanisms to overcome them
3. a deliberative utility and customer engagement process to address cultural and perceived technical issues regarding the development of Intelligent Grids
4. development of an avoidable network infrastructure cost analysis model
5. development of a robust and transparent decentralised energy evaluation model.

Each of these streams comprised an element of my PhD work program.

The research outputs from the iGrid research cluster included two complex models, a series of working papers and a final report, the Australian Decentralised Energy Roadmap (December 2011). These reports are included in the list of related publications, below.

In addition to the iGrid Cluster, I had a leading role in another major research program which contributed to my PhD, A2SE's research program, *Scaling the Peaks: Demand Management and Electricity Networks*. I led two research projects for this program, which contributed to my PhD research: the *Survey of electricity demand management in Australia* and the *Barriers to demand management: a survey of stakeholder perceptions.*

The steering committee of the A2SE research project on the *Potential for energy efficiency, demand side management and distributed generation in electricity network planning*, for which the survey was undertaken, provided me with invaluable advice and feedback, as did colleagues at Energetics Pty Ltd, Energy Futures Australia and Climateworks Australia.

A2SE (now the Australian Alliance for Energy Productivity – A2EP) is a not-for-profit coalition of prominent business, government, environmental and consumer leaders. They have come together to raise the profile of energy efficiency and to ensure that the best possible information on energy is available.

I particularly wish to thank Mark Lister, then managing director of A2SE and the late Peter Szental, then president of A2SE, who were both very supportive of the initial proposal to undertake this research and led the efforts to raise the funds which made it possible.

In each of these research projects, I led in the development and execution of the research, but I also relied on major contributions from many stakeholders, particularly my research collaborators who are listed as co-authors for each of the reports which contributed to this thesis. Without the contributions of these colleagues, the projects would not have been possible. The following chapter-by-chapter acknowledgments outline the contributions of my collaborators.

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Chapter 2 draws heavily on the D-CODE model development that I led for the Intelligent Grid Research Program. I wish to thank my collaborators in the development of the D-CODE model and my co-authors of the D-CODE Report – ISF colleagues: Chris Cooper, John Glassmire, Nicky

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In undertaking and documenting the ***Survey of Electricity Demand Management in Australia (SENDMA)***, I was greatly assisted by two ISF colleagues, Nicole Ghiotto and Katie Ross. Nicole and Katie assisted in the design of the survey instrument, engaging with network businesses to encourage participation, collating data and writing the final report that this chapter draws on.

The SENDMA survey would have been impossible without the support of the electricity network businesses and their staff who took the time to provide data for the survey. I would also like to thank those who provided financial support for the project including the New South Wales Office of Environment and Heritage, and the Victorian Department of Primary Industries and the Consumer Advocacy Panel.

The support of the Queensland Office of Clean Energy; the Northern Territory Office of the Chief Minister; the South Australian Department of Transport, Energy and Infrastructure; the New South Wales Minister for Energy, Mr Paul Lynch; and the Federal Parliamentary Secretary for Climate Change and Energy Efficiency, Mr Mark Dreyfus is also gratefully acknowledged.

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I wish to thank my colleagues who have assisted in the development of the Dynamic Avoidable Network Cost Evaluation (DANCE) model and the Network Opportunity Mapping Project and in particular my ISF colleagues, Ed Langham, Jay Rutovitz, Steve Mohr, Alison Atherton, Sebastian Oliva Henriquez, John Glassmire, John McKibbin and Joe Wyndham, Stuart White and Chris Loty. I also wish to thank Dustin Moore, Peter Rickwood and Steve Harris for their valuable contributions to this work.

I am especially indebted to Ed Langham who was the project manager for the DANCE model and the Network Opportunity Mapping Project since the project's inception in 2008. Ed was instrumental in shifting the model to become an interactive online tool, which has greatly expanded its reach and functionality. The ongoing success of this project is to a large degree due to Ed's project management and stakeholder engagement skills.

I also wish to thank CSIRO, Data61 and the Australian Renewable Energy Agency, the NSW Government Department of Trade and Industry, Ergon Energy who have contributed funding to the model development. The development of the DANCE model through its application to network planning was also supported by Sustainability Victoria and assisted through cooperation with Victorian network businesses, Citipower–Powercor, Jemena Electricity Networks, United Energy Distribution and AusNet Services. I gratefully acknowledge the support for this project provided by the CSIRO Energy Transformed Flagship.

I am also grateful to the staff of Energy Networks Australia, the network businesses, regulatory agencies and government departments that have supported this research.

Chapter 5

Sections 5.4 to 5.6 of Chapter 5 draw heavily on the Intelligent Grid barriers report*: Institutional barriers to intelligent grid: working paper 4.1*. I wish to thank my ISF co-authors of this report, Jane Daly, Ed Langham, Louise Boronyak and Jay Rutovitz for their research for this project and their written contributions to the report.

I gratefully acknowledge the work of my ISF colleagues Nicole Ghiotto and Katie Ross in undertaking the *Barriers to demand management: A survey of stakeholder perceptions* project. Nicole and Katie collaborated with me on the design of the survey instrument, engaging with network businesses to encourage their participation, collating data and writing the final report the survey, from which most of the text for Sections 5.7 and 5.8 was drawn.

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I also wish to express my appreciation for the guidance and advice of the steering committee of the Australian Alliance to Save Energy (A2SE) Research Project on the *Potential for energy efficiency, demand side management and distributed generation in electricity network planning*, for which this survey was undertaken. Thanks are also due to my project colleagues at Energetics Pty Ltd, Energy Futures Australia and Climateworks Australia who assisted in the survey.

Chapter 6

Chapter 6 is largely drawn from the report: *20 Policy Tools for Developing Distributed Energy.* I conceived, proposed, planned and directed this project as part of my doctoral research under the auspices of the CSIRO Intelligent Grid Research Program Project 4. However, in undertaking this project, I was very ably assisted by my ISF colleagues. I gratefully acknowledge the very valuable contributions of Edward Langham, Katie Ross and Nicky Ison who collaborated in researching the study and in writing the report.

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Other chapters

While I drew on a range of sources and influences, including from the other chapters, the remaining chapters, 1, 7, 8 and 9, were entirely researched and written by myself independent of any collaborative research projects, except as referenced in the text.

Special thanks are due to Dr David Crossley. David has not only been a leading pioneer and inspiration in demand management in Australia and globally, but has also been a generous and reliable source of wisdom and advice to me on matters demand management related and well beyond throughout this doctoral research.

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List of key related publications:

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Glossary/Key terms

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
capex	capital expenditure
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DANCE	Dynamic Avoidable Network Cost Evaluation (model)
D-CODE	Description and Cost of Decentralised Energy (model)
DE	Decentralised energy (a.k.a. distributed energy) 'Decentralised energy' means electricity generation and management of energy use applied at or near the point of energy use. Decentralised energy includes distributed generation, load management (including energy storage) and energy efficiency technologies and practices.
DG	distributed generation
DER	decentralised energy resources
DM	demand management Electricity demand management means deliberate action by those responsible for electricity supply to reduce or shift demand for electricity, as an alternative to providing supply to meet that demand.
DMIA	Demand Management Innovation Allowance
DMIS	Demand Management Incentive Scheme
DNSP	Distribution Network Service Provider
DR	Demand Response
DRM	Demand Response Mechanism
DSP	Demand-Side Participation
energy services	'Energy services' are the benefits provided by the use of energy, such as transport, cooking, illumination and heating and cooling. 'Energy services' recognises that unlike many other goods such as water, food, shelter and clothing, energy does not offer direct benefits in consumption.
ENA	Energy Networks Australia
FCAS	Frequency Control Ancillary Services
gentailer	integrated electricity generation and retail company

GIS	geographical information system
IPART	Independent Pricing and Regulatory Tribunal (of NSW)
IRP	Integrated Resource Planning
LCC	least cost competition
LCP	least cost planning
LRMC	long-run marginal cost
MPC	maximum price cap
MRL	minimum reserve limit
MW	megawatt
MWh	megawatt hour
NEL	National Electricity Law
NEM	National Electricity Market
NEO	National Electricity Objective
NER	National Electricity Rules
NSP	network service provider
NSW	New South Wales
opex	operating expenditure
participant test	one of the metrics for assessing options in Least cost Planning, along with RIM test, TRC test, Societal cost test and PACT or UCT
PACT (or UCT)	Program Administrator Cost Test (a.k.a. Utility Cost Test)
RAB	regulatory asset base
RERT	Reliability and Emergency Reserve Trader
RIM test	Ratepayer Impact Measure test
RIT-D	regulatory investment test for distribution
RIT-T	regulatory investment test for transmission
RVT	Resource Value Test
S(C)T	Societal (Cost) Test
TNSP	transmission network service provider
TRC test	Total Resource Cost test
ToU	time of use
TUoS	transmission use of service

Abstract

This thesis assesses the potential to enhance economic efficiency and environmental sustainability by reconciling the principles of least cost planning with the competitive electricity industry. The thesis proposes a novel balanced approach of 'least cost competition'. Least cost competition aims to encourage both more effective competition in delivering energy services, and better alignment of industry practice with the public interest.

The thesis makes the case for adopting this approach through the following steps:

1. developing an innovative Description and Cost of Decentralised Energy (D-CODE) assessment model, and using the model to compare the costs and benefits of decentralised energy resources with centralised electricity supply (including network costs)

2. surveying the implementation of demand management by electricity distribution network businesses in the Australian National Electricity Market

3. surveying stakeholder perceptions of the institutional barriers to demand management and decentralised energy

4. identifying and analysing the value of monopoly network costs that are avoidable through demand management, and mapping these avoidable network costs and associated data in innovative, publicly-accessible, online 'Network Opportunity Maps'

5. developing and applying an analytical framework for describing and understanding barriers to the efficient adoption of demand management and decentralised energy resources

6. addressing these barriers by reviewing, analysing and synthesising policy options through an innovative 'Policy Palette'. The Policy Palette aims to support efficient investment in demand management and decentralised energy resources in the context of competitive electricity retail and generation markets and centrally planned monopoly distribution and transmission networks.

The thesis then develops a theory of 'least cost competition' based on five key principles: 1. Clear and appropriate purpose; 2. Public participation and accountability; 3. Cost-reflective

pricing; 4. Competition among all feasible options; and, 5. Competition based on all relevant costs.

The thesis applies these principles to the particular case of the Australian National Electricity Market. Drawing on these principles and the above research and analysis, the thesis proposes practical reforms to policy, regulation and decision-making and resource allocation processes within the electricity sector. If implemented, these reforms could lower bills and expedite the transition to a clean, low emission and affordable electricity sector, while encouraging the greater and more efficient use of demand management and decentralised energy resources.