Submission No 14

COGENERATION AND TRIGENERATION IN NEW SOUTH WALES

Name: Name Suppressed

Date Received: 4/09/2013

[redacted]

4 September 2013

The Committee Manager
Public Accounts Committee
Parliament House
Macquarie Street
SYDNEY NSW 2000

Attention: John Miller

Dear John,

I write in regards to the 'Inquiry into cogeneration and trigeneration in New South Wales' which is being conducted by the NSW Legislative Assembly Public Accounts Committee.

Over the course of 2012 I conducted research into the use of, and the regulatory framework for, cogeneration and trigeneration facilities in the Sydney CBD. The research looked at both existing, small-scale cogeneration/trigeneration facilities as well as the precinct-scale cogeneration network proposed by the City of Sydney Council. This research was undertaken as part of the preparation and submission of a thesis titled 'Off the Grid – Cogeneration in Sydney' to the University of New South Wales in order to satisfy the final requirements of a Bachelor of Planning degree.

My thesis includes a review of available academic and industry literature, Commonwealth and State legislation, local environmental planning instruments and development policies. My research also included a review and analysis of the development approvals process for cogeneration facilities in the Sydney CBD and interviews with key stakeholders. International case studies of New York City, USA and Woking, UK were undertaken for comparative purposes.

The thesis makes a number of findings and recommendations which are relevant to the Terms of Reference for the Inquiry. In brief, the thesis clearly distinguishes between the risks and benefits associated with precinct-scale cogeneration/trigeneration facilities and small-scale cogeneration/trigeneration facilities, concluding that:

- the current Commonwealth and State regulatory framework for energy production is oriented towards energy generation that is integrated with the National Electricity Market (NEM) and does not readily facilitate precinct-scale energy schemes such as cogeneration/trigeneration;
- the 'greening' of the NEM grid as more small and large-scale renewable generators are brought online over time is likely to reduce the economic and environmental effectiveness of precinct-scale cogeneration;
- without a clear supply for 'sustainable gas' supply, the rollout of precinct-scale cogeneration/trigeneration threatens to 'lock-in' significant infrastructure investments that do not necessarily provide a cost-effective reduction in greenhouse gas (GHG) emissions compared to the NEM grid, particularly in light of projected increases in natural gas prices;
- small-scale urban cogeneration/trigeneration facilities (i.e. serving individual commercial/residential buildings or development sites) have significant potential to reduce GHG emissions in the short-term, without being subject to the same degree of risk in terms of the infrastructure and investment 'lock-in' associated with precinct-scale facilities;
- there is currently no clear regulatory framework for small-scale cogeneration/trigeneration at a State or Local Government level which serves as a barrier to further development of this type of energy generation.

It is noted that since the thesis was submitted, the City of Sydney Council has elected not to proceed with the first stage of the rollout of its precinct-scale cogeneration system in Green Square, whilst also releasing the *Renewable Energy Master Plan* which details the City's analysis of renewable gas supply.

I have appended a copy of my thesis to this letter for the Committee's information. It is hoped that this research will assist the Committee in its enquiry.

Please feel free to contact me if you require further information regarding my research.

Yours faithfully,

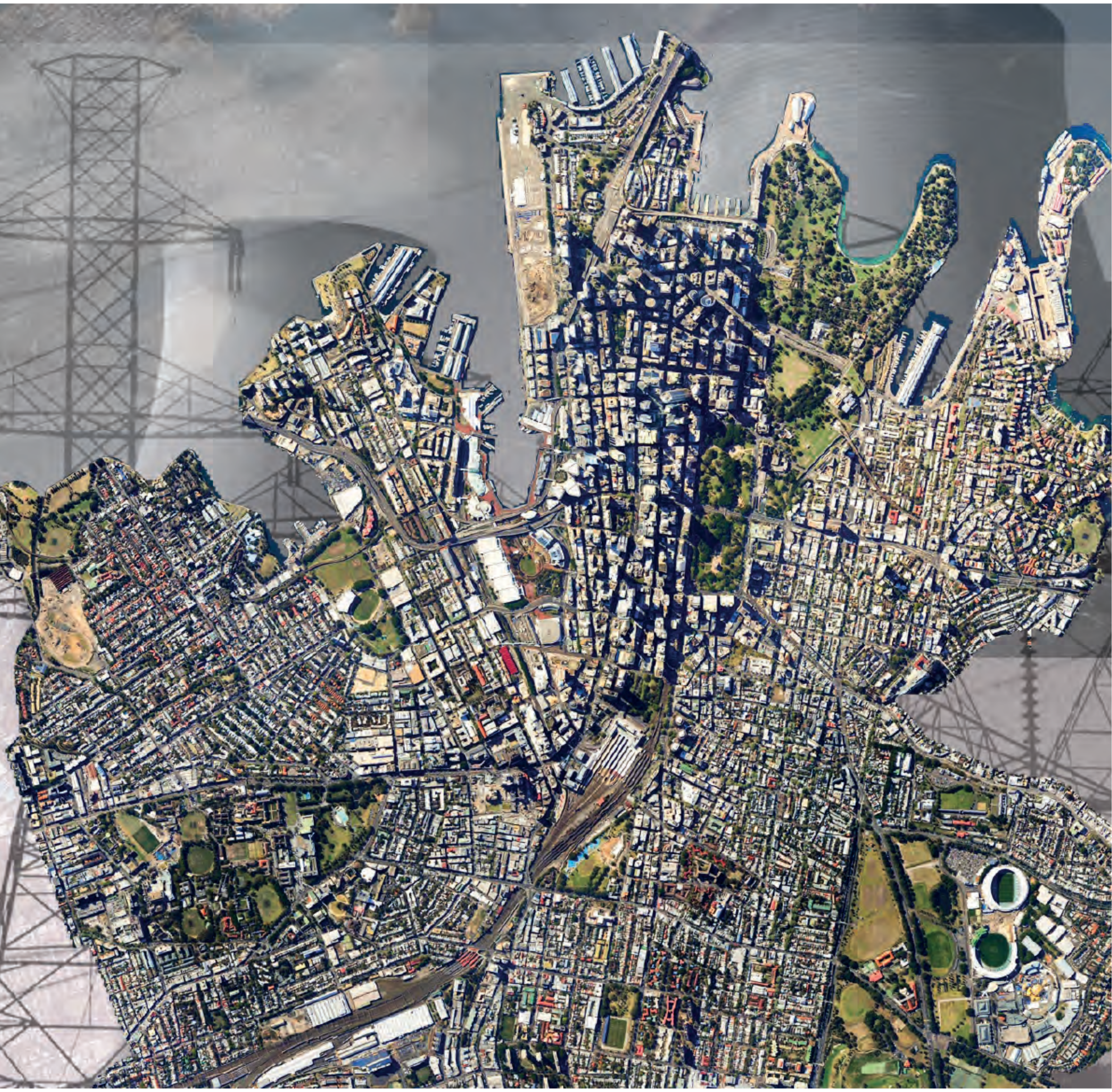
[redacted]

[redacted]
BPlan (Hons Class 1)

Attachment – 'Off the Grid –Cogeneration in Sydney'

Off The Grid

Cogeneration in Sydney



Bachelor of Planning Thesis

[redacted]

October 2012

Abstract

Traditional methods of electricity generation and distribution in NSW are carbon intensive, expensive and inefficient, and developers and local governments in Sydney are increasingly looking at ways to disconnect from the grid to deliver greener buildings that meet market demand and regulatory requirements. Gas-fuelled cogeneration offers substantial reductions in greenhouse gas emissions, improved energy efficiency and can provide a competitive financial return to investors. Cogeneration is not a new concept in energy generation and has been successfully implemented in Europe and the US, however its adoption in Australia has been ad-hoc in the face of different energy, environmental an economic objectives as well as local technical, regulatory and feasibility barriers. Whilst cogeneration offers environmental and economic benefits compared to the status quo, the significant physical infrastructure and financial investments required to rollout this technology on any notable scale create an inherent risk of system lock-in, whereby future cleaner and cheaper energy technologies are unable to compete against the entrenched fossil-fuel based technology. Through critical analysis of the costs and benefits of cogeneration, this thesis considers the implications for Sydney's urban environment in the face of new micro-generation and precinct-scale developments such as the City of Sydney's proposed 477MW of trigeneration capacity.

Contact:

For further information relating to this thesis, please feel free to contact the author:

[redacted]

Acknowledgements

The tireless and unconditional support of my parents, David and Christina, and my brothers, Chris and Bowen, has been central throughout all of my endeavours. Without them this thesis and my completion of the B.Plan degree would not have been possible.

My sincerest thanks goes to Clare Swan and Gordon Kirkby who, along with all of my colleagues at JBA, have been so generous with their time and wisdom over the past two and a half years. Clare and Gordon's assistance throughout this thesis project, including reviewing, editing and providing their general thoughts on the thesis, has been invaluable.

Thank you all of the people who gave up their time to contribute to the research process by agreeing to be interviewed, your perspectives have played an important role in the findings of this thesis.

Finally, but not at all last, to all my friends and in particular the B.Plan Class of 2012, it has been fantastic to spend the last five years with you on this journey, and I look forward to seeing all of you out in the real world!

Contents

Contents

Figures

Contents

Tables

Appendices

Key Abbreviations

Abbreviation	Full Reference
kW	Kilowatt (1,000KW =1MW)
MW	Megawatt (1,000MW =1GW)
GW	Gigawatt

AEMO	Australian Energy Market Operator
BASIX	Building Sustainability Index
CEA	*Clean Energy Act 2011*
CHP	Combined Heat and Power
CoS	City of Sydney
DCP	Development Control Plan
DCCEE	Australian Government Department of Climate Change and Energy Efficiency
DEMT	*City of Sydney Decentralised Energy Master Plan - Trigeneration*
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
ESCO	Energy Services Company
ESD	Ecologically Sustainable Development
GBCA	Green Building Council of Australia
OEH	NSW Office of Environment and Heritage
LEP	Local Environmental Plan
LGA	Local Government Area
NABERS	National Australian Built Environment Rating System
NEM	(Australian) National Electricity Market
NOx	Nitric Oxides
NSW	New South Wales
NPFF	*National Planning Policy Framework 2012* (United Kingdom)
NYC	New York City, New York, United States of America
PV	Photovoltaic
RET	Renewable Energy Target
SEPP	State Environmental Planning Policy
UK	United Kingdom
USA	United States of America

1.0 Introduction

This thesis is an investigation of the current and future role of the use of cogeneration in the City of Sydney Local Government Area. This chapter establishes the context for this research, key concepts, problem setting and research objectives. The chapter concludes with a description of the research methodology and an outline of the thesis structure.

1.1 Problem Setting – Climate Change, Energy and Buildings

The global response to anthropogenic climate change will require Australia to cut its per capita greenhouse gas (GHG) emissions by at least 10% by 2020 from 2000 levels in order to assist in global efforts to prevent GHG atmospheric concentrations rising to 'unsafe' levels (Garnaut 2008).To achieve a reduction of this magnitude a concerted effort is required across all sectors of the economy. Australia's GHG emissions associated with electricity production (stationary energy) grew nearly 50% between 1990 and 2006 and account for nearly half of all greenhouse gas emissions (**Figure 1**). Per capita GHG emissions associated with stationary energy are more than three times the OECD average (Garnaut 2011), which is attributable to a range of factors including affluence, lifestyle, development types, local climate patterns and energy fuel sources.

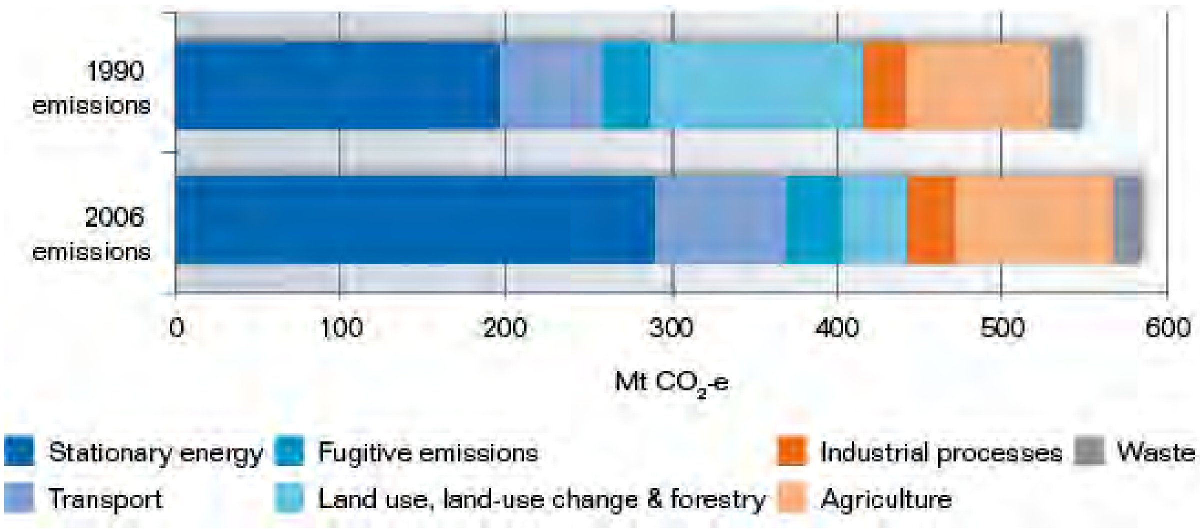


Figure 1 – Australia's greenhouse gas emissions by sector, 1990 and 2006

Source: *Garnaut 2008, p155*

In order to achieve the emission reduction targets required to avert adverse anthropogenic climate change, significant emission reductions will be required to be achieved across all sectors, including in stationary energy.

In NSW, black coal thermal generation is the primary source of grid base-load power and accounts for over 70% of installed energy generation capacity in the state (**Figure 2**). Black coal has a number of advantages over other fuel sources in NSW in that there is an abundant local supply in proximity to the key energy markets (Wollongong-Sydney-Newcastle) and entrenched transmission infrastructure (Mangoya et.al 2011), however it is also one of the most CO2 emission-intensive fossil fuels available. In Australia a black coal fired power plant emits 88.2 kg of CO2 emissions per gigajoule of energy produced, 72% more than the emissions of a gas-fired power generator (Sinclair Knight Mertz 2011).

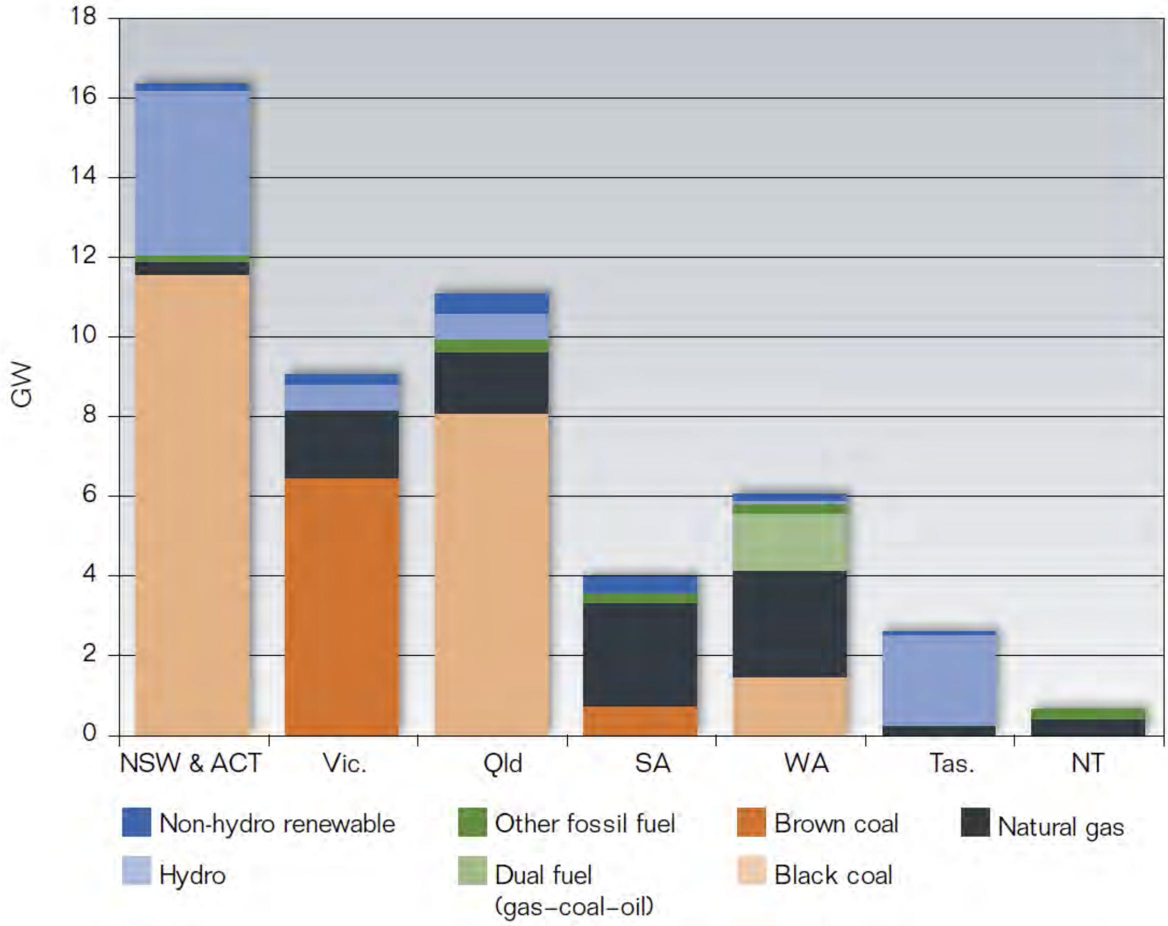


Figure 2 – Installed energy generation capacity 2006-06

Source: *Garnaut 2011, p469*

Sydney draws the bulk of its base-load electricity from black coal-fired power stations located in the Hunter Valley and Central Coast regions (**Figure 3**), which provide over 10GW of generating capacity (Department of Trade and Investment 2012) and approximately 60% of NSW's total electricity generating capacity. Unfortunately, the combination of large-scale centralised power generators that are located up to 150 kilometres from the major end-use metropolitan market is highly inefficient (Kinesis 2012).

Coal-fired power stations lose close to two-thirds of the energy produced by burning coal as waste heat that is not utilised and is lost into the atmosphere. The remaining heat produced is captured to drive the turbines and generate electricity. In order to provide the electricity generated in these centralised black coal-fired power stations to the main end-users in Sydney metropolitan area, electricity is transmitted via long-distance high voltage transmission networks. A further 7% of the electricity generated in these power stations can be lost in this transmission process (Dunstan and Langham 2010). The combination of these two inefficiencies means that only 28% of the potential energy of the coal burnt in these power stations is actually used for its primary purpose of powering residential, commercial and industrial buildings in the Sydney metropolitan area (Jones 2012).

Figure 3 – Black coal-fired electricity generators in the vicinity of Sydney

Source: *Orsome Resources 2012* (amended by Author 2012)

This model of electricity production and delivery is highly inefficient and impacts directly on the sustainability of the buildings that draw electricity from the grid to power lights, air conditioning, heating and other services. In the City of Sydney LGA, non-residential buildings account for 90% of total electricity consumption (**Figure 4**) predominately for the purpose of building lighting and space heating within commercial, retail and educational buildings, as well some light industrial uses in the South Sydney area (City of Sydney 2012).

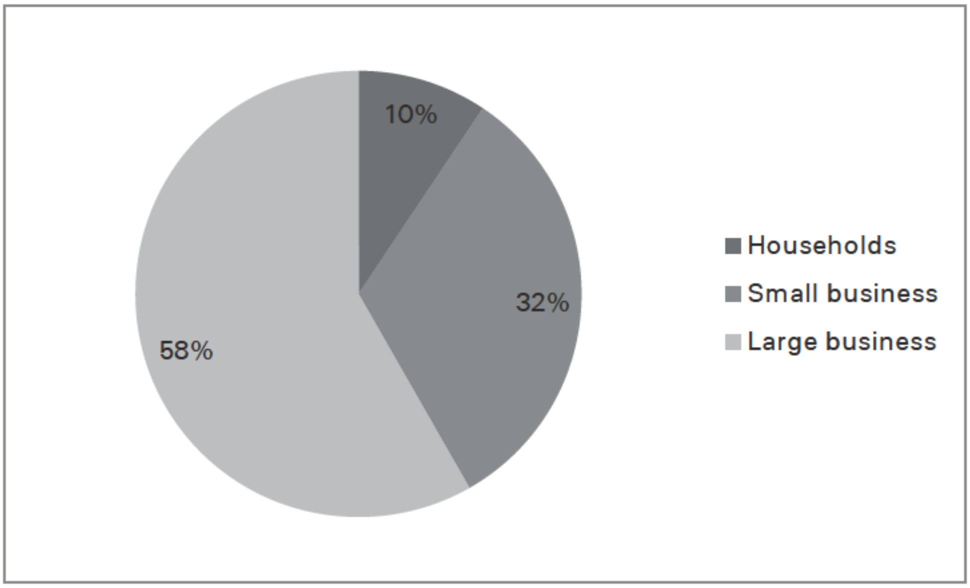


Figure 4 – Electricity consumption within City of Sydney LGA by sector 2008/09

Source: *Author with data from City of Sydney 2012*

At the same time as the environmental impacts of the City of Sydney's current electricity generation source are coming under scrutiny, the economic costs of the traditional energy model are also coming under increased scrutiny. Electricity prices have risen significantly over the past 4-5 years to keep pace with the significant cost associated with maintaining and upgrading ageing electricity transmission infrastructure to supply electricity during peak demand periods. These peak demand periods occur only a few times each year and are driven largely by space cooling requirements on extreme heat days (IPART 2011). These costs are passed directly onto businesses and households and impact directly upon the financial costs of operating buildings. The Prime Minister, Julia Gillard, has recently sought to draw attention to the inefficiencies of this traditional model and to promote the consideration of alternate energy investment models (Gillard 2012). A shift to decentralised energy systems and responsive energy supply offers one possibility to make more efficient investments that avoid the need for capital-intensive upgrades to the transmission network, and could save the government and consumers billions of dollars (Kinesis 2012).

The economic inefficiency of utilising only 28% of the potential energy for each tonne of black (thermal) coal consumed is self-evident, however, compounding this is the rapid rise in the cost of black coal itself over the past decade due to increased export demand as shown in **Figure 5** (World Bank 2012). Whilst the majority of coal fired power plants in Australia source their fuel either from purpose-built mines or on long-term contracts, and as a result may not be immediately affected by spot-prices for coal, these changes nonetheless significantly reduce the economic benefit in using this coal for electricity production.

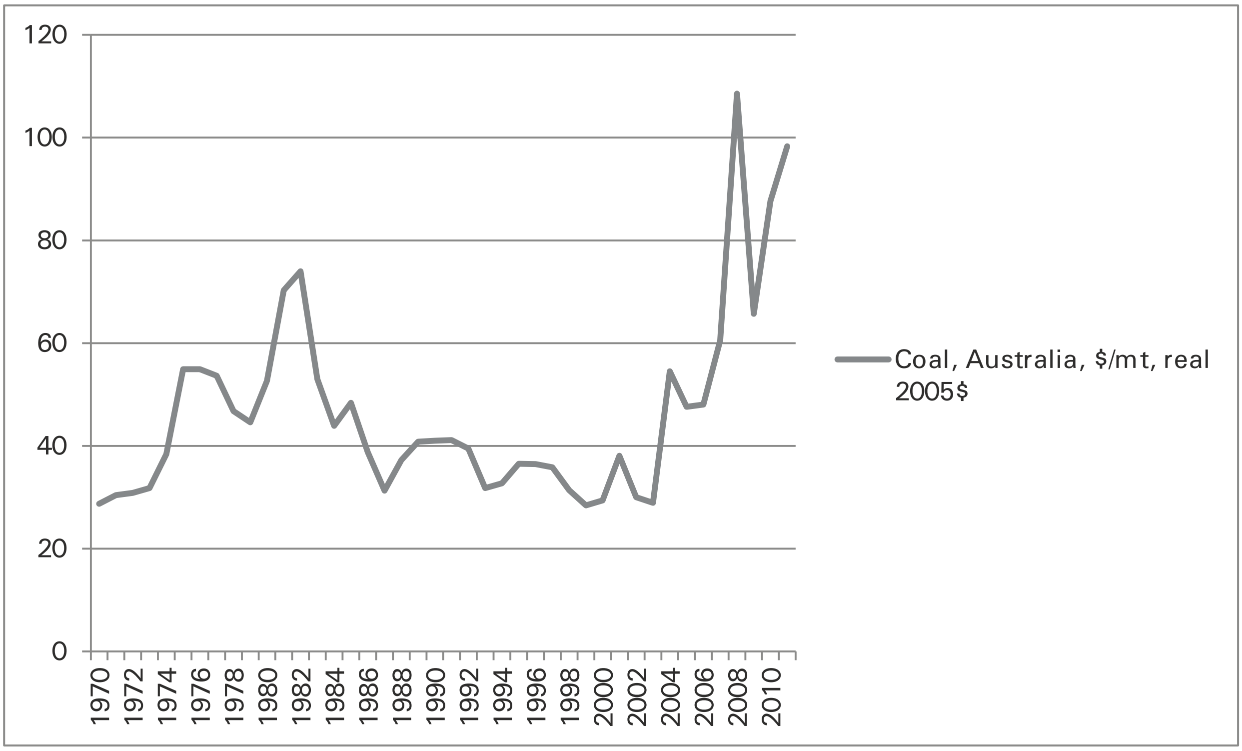


Figure 5 – Australia black (thermal) coal export price in 2005 terms, 1970-2011

Source: *Author with data from World Bank 2012*

In addition to the existing market forces that impact upon the cost of electricity drawn from the grid, the commencement of the Federal Government's price mechanism (initially as a direct tax and transitioning to an emissions trading scheme) for greenhouse gas emissions on 1 July 2012 will further increase the cost of carbon-intensive energy generation. It is expected that over time this price mechanism will increase the competitiveness of low-emissions electricity generation technologies, such as renewables and cogeneration, in comparison to the existing centralised coal-fired generation plants (Treasury 2011).

1.2 Defining Decentralised Energy and Cogeneration

1.2.1 Decentralised Energy

The definition of distributed energy in *Distributed generation: a definition* (Ackermann, Andersson et al. 2001) has been generally accepted in academic literature and defines this term as "an electric power source connected directly to the distribution network or on the customer site of the meter". This distinguishes distributed generation from the traditional transmission network model which transmits electricity from centralised, remote power stations. 'Distributed energy' is used interchangeably with the term 'decentralised energy' in academic and technical literature and as such is taken to have the same meaning (Woodman and Baker 2008), although a review of the literature shows a trend towards the increased use of 'decentralised energy' and this term is henceforth adopted in this thesis (LCCA 2007).

Decentralised energy generation can range from 1W (i.e. a domestic solar panel) to 300MW (i.e. 100x 85m high wind turbines) in generating capacity and encompasses a range of typically less carbon-intensive or renewable technologies including cogeneration, hydro, tidal, wind, solar and geothermal generation (Skoufa and Tamaschke 2011). Decentralised energy production offers a number of advantages over the centralised energy production model, such as the existing electricity grid in Sydney, in that it:

- is located significantly closer to consumers and hence avoids energy loss in transmission, ensuring a more efficient use of the fuel source;
- bypasses the transmission grid and avoids expensive transmission grid construction and maintenance and upgrade costs;
- can be integrated into an intelligently controlled network to be more responsive and efficient in meeting network demand; and
- builds in greater network redundancy whereby scheduled and unscheduled shutdowns of local generators can be more readily absorbed by other facilities.

1.2.2 Cogeneration and Trigeneration

Tindale and Vaze (2011) define cogeneration neatly as:

> *Technology that means that when anything is burnt to generate electricity, the heat is also used, for either industrial or domestic heating.*

At its simplest, cogeneration is the simultaneous production of electricity and heat using some form of engine or turbine, and making both the electricity and heat available for distribution in a useable form.

Trigeneration refers to the simultaneous production of heating, cooling and electricity. This is achieved by processing some of the water heated by the gas-fuelled process through an absorption chiller to provide and distribute both chilled and hot water.

The only significant distinction between a cogeneration facility and a trigeneration facility is the addition of an absorption chiller prior to the distribution of thermal energy. An absorption chiller can still be used to provide cold water at the point of consumption using the hot water which has been distributed. For the purpose of this thesis both cogeneration and trigeneration are referred to as cogeneration except where an explicit distinction is made in the text.

Further to the above, this thesis distinguishes between on-site cogeneration facilities and precinct cogeneration systems as follows:

- On-site cogeneration provides electricity and heating/cooling to a single building or located on the same property as the cogeneration plant. On-site plants generally do not export any electricity or heating beyond the property boundary and meet only the needs of the serviced buildings.
- Precinct cogeneration is provided through a local cogeneration plant which distributes electricity and heating/cooling to any number of separate properties, and may or may not also export surplus electricity or heat to the existing grid where available. Precinct scale plant are generally owned and operated by a utility company or local government agency who meters and charges customers for energy drawn from this distribution network.

The key economic and environmental benefits provided by cogeneration (Kinesis 2012, Property Council of Australia 2011, Vaze and Tindale 2011) include:

- up to 60% reduction in carbon emissions compared to drawing electricity from the existing grid as a result of the use of cleaner fuels (gas) and the capture and use of heat;
- one of the most efficient means of generating energy using fossil fuel;
- can be readily converted to biogas or landfill gas if this is supplied in the future;
- potential to be cheaper than grid electricity due to low current cost of natural gas;
- can offset the need for plant equipment such as boilers; and
- all of the common benefits of decentralised energy facilities identified in **Section 1.2.1**.

Most modern cogeneration plants are fuelled by natural gas, which provides benefits in terms of ease and cost of fuel transport and favourable pricing, however it must be noted that whilst cogeneration can provide significant emission reductions it is still reliant on fossil fuels. A typical roof-mounted on-site cogeneration setup for a commercial building is shown in **Figure 6**.

Figure 6 – A typical on-site roof-top plant configuration for a 770kW cogeneration installation

Source: *Author 2012*

1.3 Problem Statement and Research Objectives

The energy policy and climate change mitigation issues described in **Section 1.1** of this report have traditionally been dealt with at the international and national levels, with some action at the state level but to date with little involvement from local government in Australia. This situation has shifted over the past five years as widespread community support for action on climate change has manifested in the political direction of all levels of government (Hobson and Niemeyer 2011), including within the City of Sydney Council. The release of *Sustainable Sydney 2030* in 2007 with its proposals for a series of 'Green Transformers' providing precinct-scale cogeneration throughout the City of Sydney LGA was one of the first serious forays into this area by a major local government body in Australia. At a smaller scale, a number of on-site cogeneration facilities have been included in new commercial buildings and retrofits in order to improve results in mandatory and voluntary rating tools such as BASIX, NABERS and the Green Building Council of Australia's Green Star.

The technologies and concepts involved in cogeneration developments are largely untried in the Australian urban context and will require planners and other built environment professionals to assess a raft of environmental and economic impacts that are unique to this emerging type of development. At present the NSW Planning System does not clearly address decentralised energy development in urban areas through either strategic or development assessment policies, leaving assessment authorities without appropriate guidance and creating barriers to the implementation of such systems by both government authorities and the private sector. This failure in the planning system is due primarily to the relatively recent emergence of urban cogeneration facilities in Sydney, and hence the absence of any local understanding of the environmental, economic and social effects associated with this type of development. Clear, relevant and practical planning guidance is required to support the emergence of this development type in Sydney.

The central problem statement of this thesis is:

Cogeneration is a well-established technology used in cooler climates as a solution to the social and economic imperatives of delivering heat and electricity to cities. In the warm climate of Sydney, the use of the technology is still in its infancy but is being promoted as a means to address a primarily environmental objective – the reduction of greenhouse gas emissions. In the absence of an established framework for reducing emissions at the 'street-

level' of our major cities, cogeneration has been developed in an opportunistic and sporadic way by individual actors seeking to achieve one-off economic or environmental objectives rather than as part of a coordinated response. The challenge for urban planners is to facilitate the development of cogeneration in a way that achieves the overarching environmental objective without producing adverse economic, environmental and social impacts. Addressing this challenge requires further understanding of the current planning policy settings for cogeneration and the implications of existing and future cogeneration development patterns.

This thesis examines why on-site cogeneration is being incorporated in existing and new buildings and how precinct-scale cogeneration will impact upon the urban environment of the City of Sydney. Existing planning assessment processes and policy settings will be analysed in the context of academic literature and international precedents. In order to address the problem statement the following research objectives have been defined:

- identify the extent to which the planning and environmental considerations relating to decentralised energy and cogeneration have been addressed within academic and literature;
- examine how decentralised energy and cogeneration have been implemented in the international context and assess the impact of the governance frameworks on these developments;
- analyse the policy, legislative and development assessment frameworks for the development of cogeneration facilities in NSW and the City of Sydney LGA;
- establish the presence of small-scale cogeneration in buildings within the City of Sydney LGA and analyse the development assessment processes applied to these developments;
- examine the planning implications and environmental impacts of the use of cogeneration as an alternate energy supply for buildings and precincts in the City of Sydney LGA; and
- identify where the existing governance framework could be improved to provide a more effective assessment framework for cogeneration development.

1.4 Research Approach and Methodology

In order to address each research objective adequately, a range of data sources and research methodologies have been utilised. Primary data has been gathered in the form of in-depth interviews and attendance at public and professional forums, whilst secondary data such as existing development consents for cogeneration in developments in the City of Sydney LGA, legislation and policy documents, case study material and academic literature have all been reviewed.

1.4.1 Review of Literature

Academic literature relating to sustainability, planning, energy markets, decentralised energy and low carbon buildings has, where available, been utilised in this thesis. Data sources for the literature review component have included journal articles, books, academic and industry reports and conference papers. Given the relatively small take-up of decentralised energy projects and particularly cogeneration in Australia's cities, the majority of academic and technical literature relating to the research topic is internationally focused. This has limitations in that it is not always directly relevant to the Sydney context, but also benefits in that it can provide lessons for new development in the City of Sydney LGA and assist in avoiding learnt mistakes.

Two key Australian studies have investigated the technical and energy market issues associated with the rollout of cogeneration in urban development – *Cogeneration in NSW: Review and analysis of opportunities* (Riedy et.al. 2008) and a Victorian study *Unlocking Barriers to Cogeneration: Project outcomes report* (ClimateWorks 2011). Both of these studies adopted a technical approach which looked primarily at the energy market framework and cogeneration system design and sizing. The focus of these studies leaves a research gap relating to the urban planning and development assessment frameworks which are required to facilitate the development of cogeneration facilitates in urban environments, a gap which this thesis seeks to address in part.

1.4.2 Review of Plans, Policies and Statutes

An array of government policies, legislation, environmental planning instruments and development policies were reviewed in order to understand and critically analyse the existing framework that underlies the planning assessment of cogeneration in the Sydney context.

Key documents reviewed included:

- Garnaut Climate Change Review 2008 and Garnaut Climate Change Update 2011;
- *Clean Energy Act 2011 (Commonwealth)*;
- *Renewable Energy (Electricity) Act 2000 (Commonwealth);*
- *Building Energy Efficient Disclosure Act 2010 (Commonwealth);*
- *Environmental Planning and Assessment Act 1979 (NSW);*
- NSW State Environmental Planning Policy (Infrastructure) 2007;
- NSW State Environmental Planning Policy (State and Regional Development) 2011;
- NSW State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004;
- Sustainable Sydney 2030;
- City of Sydney Decentralised Energy Master Plan – Trigeneration;
- Sydney Local Environmental Plan 2005;
- Draft Sydney Local Environmental Plan 2011;
- Central Sydney Development Control Plan 1996; and
- Draft Sydney Development Control Plan 2010.

1.4.3 Review of Development Consents

In order to develop a thorough understanding of the environmental impact assessment process which trigeneration and cogeneration proposals undergo in the City of Sydney, a thorough review and analysis of planning approvals issued in accordance with Part 3A and Part 4 of the *Environmental Planning and Assessment Act 1979* was conducted for all cogeneration facilities (both approved and constructed) in the City of Sydney. For each development approval the following documents were reviewed:

- Development Consent and Conditions;
- Consent Authority Planner's environmental assessment report;
- Statement of Environmental Effects;
- Architectural Drawings;
- Environmentally Sustainable Development Report (where provided); and
- Air Quality Assessment (where provided).

These documents were selected as, when read in conjunction, they give a strong understanding of the overall project, the trigeneration/cogeneration design, the environmental assessment of the cogeneration facility, the approvals process and the final regulation of the plant's operation. The quantitative data from this review is located at **Table 4** in **Chapter 5**, whilst the qualitative findings are discussed in **Chapter 5** also.

1.4.4 Review of Public Submissions to City of Sydney regarding Decentralised Energy Master Plan – Trigeneration

In order to gain the widest possible understanding of stakeholder reactions to the City of Sydney's *Decentralised Energy Master Plan – Trigeneration* proposal for precinct cogeneration in Sydney, an Informal Information Access Application was made to the City of Sydney Council under *Government Information (Public Access) Act 2009* for access to all copies of public submissions made during the exhibition period. A total of 14 submissions were provided by the City of Sydney Council in response to this application and were reviewed as part of this thesis. These included submissions by:

- Australian Energy Market Operator;
- Australian Hotels Association NSW
- Ausgrid;
- Big Switch Projects;
- Clean Energy Council;
- City of Melbourne;
- GDF SUEZ Energie Services International;
- Green Building Council of Australia
- The GPT Group;
- Knight Frank Australia;
- NSW Department of Planning and Infrastructure;
- Property Council of Australia;
- South Australian Department of Premier and Cabinet; and
- Sydney Business Chamber.

1.4.5 In-Depth Interviews

A total of six in-depth interviews were conducted with key stakeholders from government and the private sector as detailed in **Table 1**. Two interview subject did not wish to be named in this research and will referred to as Interviewee A and Interviewee B. Whilst these interview subjects did not wish for their organisations to be identified, they were willing for some contextual information to be provided and this is contained in **Table 1.**

Table 1 – Outline of In-Depth Interviews Conducted

Interview Subject	Position Description	Organisation
Nalin Wickramasinghe	Manager, Business Development New South Wales/ Queensland	Cogent Energy
Nik Midlam	Carbon Strategy Manager	City of Sydney Council
Bruce Precious	National Sustainability Manager	The GPT Group
Interviewee A	Development Manager	Requested not to identify– a property development company which has been involved in a number of 'green' building developments in Sydney
Interviewee B	Assessment Officer	Requested not to identify – State Government Department
Ken Wyse*	Workplace Coordinator	Lowy Cancer Research Centre

* This 'interview' was carried out informally in the context of a conversational style site inspection and tour of the cogeneration plant and workspace at the Lowy Cancer Research Centre.

1.4.6 Professional and Public Forums

Having been put prominently on the public agenda by the City of Sydney Council, the implementation of cogeneration in Sydney is an area of considerable interest to both industry and the general public. In order to gain access to the widest possible range of views held by key stakeholders and thought-leaders and attain a deeper understanding of the key issues ascertaining to cogeneration, the public and professional events detailed in **Table 2** were attended.

Table 2 – Outline of Professional and Public Seminars attended

Name of Seminar	Organiser	Date	Event Format	Key Speakers
Existing Buildings, Future Technologies	Property Council of Australia	2 June 2011	Presentations, Audience Questions, Panel Discussion and Small-group workshops	– **Craig Roussac**, General Manager Sustainability, Safety and Environment, Investa Property Group – **Adam Cullen**, Director of Commercial Building Disclosure, Commonwealth Department of Climate Change and Energy Efficiency – **Robin Mellon**, Executive Director Advocacy and international, Green Building Council of Australia – **Professor Paul Cooper**, Director, Retrofitting for Resilient and Sustainable Buildings Program, University of Wollongong * only key speakers relevant to thesis identified
Clean Energy Week –Day 3 Morning Session 2 – Cogeneration and Trigeneration	Clean Energy Council	27 July 2012	Presentations and Audience Questions	– **Allan Jones**, Chief Development Officer – Energy and Climate Change, City of Sydney – **Rohan Zauner**, Principal, Sinclair Knight Mertz – **Derek Simons**, Simons Green Energy – **John Thwaites**, Chair, ClimateWorks Australia

Name of Seminar	Organiser	Date	Event Format	Key Speakers
Sustainability and Building Services Forum – Risks and returns of trigen: does it stack up commercially?	Property Council of Australia	16 August 2012	Presentations, Panel Discussion and Audience Questions	– **Rob Murray-Leach**, CEO, Energy Efficiency Council – **Jonathan Jutsen**, Executive Director, Energetics – **Alan Davis**, Associate Director, WSP Built Ecology – **Robert Dupont**, CEO and Director, Preston Rowe Paterson – **Bruce Precious**, National Sustainability Manager, The GPT Group – **Steve Hennessy**, Director, WT Sustainability
Climate Futures 2012 Seminar Series – Sustainable Sydney, Moving Sydney Towards a Sustainable Low Carbon Future	Climate Futures Institute, Macquarie University	21 August 2012	Presentation and Audience Questions	– **Allan Jones**, Chief Development Officer – Energy and Climate Change, City of Sydney Council
Utzon Lecture Series 2012 – Envisioning Low Carbon Cities	Faculty Built Environment, University of New South Wales	19 September 2012	Presentation	– **Deo Prasad**, Program Director Sustainable Development, Faculty of Built Environment UNSW and CEO Cooperative Research Centre for Low Carbon Living

1.4.7 Research Limitations

The following limitations are recognised in this thesis and have influenced the research process:

- There is limited academic literature available on the use or environmental and economic impacts of cogeneration for urban development pertaining to the NSW planning context. The research instead relied on primary data through an audit of planning approvals and interviews with key stakeholders.
- Whilst key stakeholders whose views were canvassed are identifiable with the organisations and industry sectors to which they belong, the views expressed were personal views and may not necessarily be representative of the organisation or industry as a whole. Notwithstanding this the respondents have considerable expertise in their field to provide well-founded perspectives on the issues canvassed.
- As two interview subjects did not wish to be identified in this thesis it is not fully possible to contextualise their contributions to the research for readers of this document. By remaining anonymous they were however able to give more open responses to the interview questions.

- Identification of approved cogeneration facilities for the audit of planning approvals the City of Sydney LGA was based on a review of information provided by the Council, interview subjects and planning industry contacts. It is possible that a small number of installations may have been missed and hence omitted from the audit.
- The City of Sydney anticipates that it will publicly release more detailed information on its plans for resource recovery and gas harvesting in either late-2012 or early-2013. Without this information to hand this research is unable to directly analyse the implications of this information on the use of cogeneration in Sydney, and this aspect of the analysis must instead be based on the literature, comparative studies and the views of key stakeholders.

1.5 Thesis Structure

Providing a meaningful analysis of the potential and actual application of a specific energy technology (cogeneration) in a single geographic location (City of Sydney Local Government Area) first requires investigation of the broader concepts and leading examples which would inform such analysis. This thesis is structured so as to first understand and analyse the international concepts and examples of decentralised energy and cogeneration development before applying this understanding to the context of City of Sydney's policy settings and analysis of early cogeneration adopters. The thesis structure is summarised at **Figure 7**.

Chapter One – Introduction

This chapter has introduced the key concepts and context for the research, thesis objectives, and research methodology and now outlines the thesis structure.

Chapter Two – International Concepts in Decentralised Energy

This chapter explores the key theoretical and practical issues that have arisen in the study of decentralised energy production based on a review of the available literature.

Chapter Three – International Case Studies in Cogeneration

This Chapter identifies the key international case studies and provides a description and analysis of the projects and the legislative, policy and planning assessment settings that have facilitated these developments and the barriers and complications encountered in their implementation. The focus of this chapter is to provide a foundation of knowledge to allow an informed assessment of the implementation of cogeneration in Sydney.

Chapter Four – Legislative and Policy Setting for Cogeneration in Sydney

Chapter Four is a review of the national, state and local statutory and strategic planning policies that define the regulatory context for implementing cogeneration development in Sydney.

Chapter Five – Analysis of Current and Proposed Cogeneration Developments in Sydney

This chapter presents the key primary research findings on the use and planning assessment of cogeneration in Sydney. Based on a review of development consents and proposals, interviews with key stakeholders and the views expressed by stakeholders in written submissions and at public forums attended during this research, this chapter provides a critical analysis of the key characteristics, influences and planning issues associated with cogeneration.

Chapter Six – Key Research Findings and Recommendations

This chapter presents the key findings of the research on the value and utility of cogeneration for commercial buildings and precincts in Sydney and makes recommendations on the legislative and policy settings, planning instruments and development assessment systems which are required to facilitate and properly assess the impacts and benefits of cogeneration.

Chapter Seven – Conclusion

This chapter synthesises the body of research, notes the areas where further investigation is required, and provides concluding remarks.

Figure 7 – Summary thesis structure

Source: *Author 2012*

2.0 Theoretical Concepts in Decentralised Energy

The purpose of this literature review is to identify key technical and scholarly literature relating to the implementation of decentralised energy systems in urban areas. The shift to a decentralised, sustainable energy production system has been identified as one of the key technical responses required to address anthropogenic climate change in Australia (Kinrade 2007), yet there has been little investigation of the theoretical and practical effects of this transition save for narrow studies of controversial or topical issues such as wind turbines (Gross 2007).

The body of academic literature on the topic makes clear that regulatory and policy frameworks have lagged behind the on-the-ground uptake of decentralised energy technologies in other countries (Walker 1995), and much of the academic literature produced over the last five years has instead reflected on how the adoption of decentralised energy has been hamstrung by this regulatory catch-up period (Allen, Hammond et al. 2008).

This literature review seeks to identify and critically review the body of academic literature relating to the role of land use planning in decentralised energy uptake and consider the key issues, policy drivers, regulatory responses and environmental, social and economic impacts of the decentralised energy transition. This literature review has been structured in such a manner as to logically progress through the key queries:

- How does the academic literature define decentralised energy?
- What is the rationale influencing the uptake of decentralised energy?
- What policy and regulatory approaches have been or could be utilised to manage this transition?
- What are the key environmental and economic issues that must be considered by planners in addressing the development of cogeneration and decentralised energy facilities?

2.1 What is Decentralised Energy? Identifying Key Terminology and Technologies

2.1.1 Decentralised Energy

As noted previously in this thesis, decentralised energy is "an electric power source connected directly to the distribution network or on the customer site of the meter" (Ackermann, Andersson et al. 2001) and can range in size between 1kW and 300MW (Skoufa and Tamaschke 2011).

In *Distributed Energy and the American Electric Utility System: What is stopping it?* (Sovacool 2008), decentralised energy generators are broken down into three technology classes, being combined heat and power systems (cogeneration), decentralised renewable energy generators, and decentralised non-renewable energy generators (Skoufa and Tamaschke 2011). This thesis focuses on the first of these categories.

One key characteristic noted of decentralised energy is the potential for localisation in terms of ownership, management, production and marketing of renewable energy products (Mangoyana and Smith 2011). This potential for localised ownership and management has been seen as a potential strength in the utilisation for providing reliable and clean energy for communities (Bazilian, Hobbs et al. 2011).

2.1.2 Key Technologies

Ackerman et al. list he following technologies as being classed within the decentralised energy basket:

- Combine cycle gas turbines
- Internal combustion engines
- Combustion turbines
- Cogeneration
- Trigeneration
- Photovoltaic arrays
- Hydroelectric
- Wind turbines
- Fuel cells
- Solar thermal
- Biomass gasification
- Battery storage
- Geothermal
- Wave energy
- Tidal Energy

These technologies can range from anywhere between 1W and approximately 300MW when applied as a decentralised generation system (Ackermann, Andersson et al. 2001). Each of these technologies has vastly difference physical characteristics and generation profiles, which are described extensively in the literature (Walker 1995, Dicorato, Forte et al. 2008, Keirstead 2008). This thesis focuses primarily on cogeneration, however many of the technologies face common policy and technical barriers to their implementation.

Limited attempts have been made in the academic literature to define and categorise the various renewable and decentralised energy facilities into neat boxes of technologies that share common environmental, economic and social impacts based on either technology type or generation capacity (Loiter and Norberg-Bohm 1999, Ackermann, Andersson et al. 2001, Manfren, Caputo et al. 2011). Difficulties encountered in defining the scope and nature of these technologies are largely a result of the diversity of product and scalability of individual production technologies, however a number of studies identify common issues associated with emerging energy technologies and hence provide a good foundation for understanding how planning systems deal with new development types (Lovins 1977, Dinica 2011, Manfren, Caputo et al. 2011).

2.2 What is the Rationale for Decentralised Energy?

2.2.1 Climate Change

> *Energy generation based on the combustion of fossil fuels releases greenhouse gas (GHG) emissions which contribute to anthropogenic global warming (Heagle, Naterer et al. 2011).*

The need to reduce anthropogenic greenhouse gas (GHG) emissions is now the central policy driver in shifting to renewable and decentralised energy production which is radically reshaping the way in which central authorities seek to meet the energy needs of the populace (König 2011). 41% of energy-related global emissions can be directly attributed to the electricity sector (IEA 2008). To place this in the context of an increasingly urbanised built environment, energy demand from commercial and residential buildings accounts for 40% of GHG emissions in the United States (Blackhurst, Lima Azevedo et al. 2011).

2.2.2 Fossil Fuel Dependence

The issues of fossil fuel depletion, resource dependence and energy security are cited in some literature (Allen, Hammond et al. 2008) as a secondary rationale to transition away from fossil fuels, particularly in countries which are net importers of energy. Within the European Union, the depletion of domestic fossil fuel reserves within the North Sea has been one of the primary drivers in the shift away from carbon reliant energy production (Longden, Brammer et al. 2007). Electricity is a fundamental component affecting the standard of living and is one of the key drivers of economic growth, and as a result there is a need to safeguard electricity production against potential disruption resulting from fuel supply chains (Kaundinya, Balachandra et al. 2009). Drawing energy from a wide range of sources is consistent with the development of a sustainable energy system which reduces the reliance on any one fuel source to safeguard against unexpected disruption (Kinrade 2007).

2.2.3 Sustainability through Visibility

Mangoya et.al. (2011) note that large-scale energy production systems, such as coal-fired power plants, hide environmental and social costs by locating away from consumers either in terms of the generation facility itself or the chains of supply for fuel.

In the current centralised energy production model, some sources contend that energy is 'double invisible' in that it is an invisible force entering the household via hidden wire, and energy consumption is merely a by-product of inconspicuous everyday routines. As a result, despite the best intentions of some households, this invisibility of electricity production and usage makes it difficult to sustain a conscious effort to reduce energy usage (Hargreaves, Nye et al. 2010).

2.3 Methods of Implementation – Available Policy and Regulatory Approaches

Government institutions have a key role to play in coordinating the mix of decentralised energy required to regulate the characteristics and location of decentralised energy projects through land-use planning, direct investment and research and development (Mangoyana and Smith 2011).

2.3.1 Policy Formulation

In light of the significant role played by non-government actors in designing, constructing, and operating decentralised energy generators, in-depth input must be sought from potential developers during the policy-making process to understand what investors wish to see to stimulate early adoption (Dinica 2011). If this level of consultation does not occur then development of energy facilities can become opportunistic and uncoordinated, and may hinder the achievement of overarching objectives. This consultation process should also inform the operation of the environmental assessment regulatory system which directly impacts on the operational costs of decentralised energy generation. This is of particular importance given that planning and development assessment is commonly cited in the body of literature as a key barrier to uptake of this technology (Allen, Hammond et al. 2008; Dinica 2011, Heagle, Naterer et al. 2011; Sperling, Hvelplund et al. 2011).

2.3.2 Direct Government Action

As large owners of land, buildings and utility infrastructure, local government is often seen as a major player in providing district level decentralised energy through cogeneration and trigeneration systems (Sperling, Hvelplund et al. 2011). This has been seen in the City of Sydney's *Decentralised Energy Master Plan- Trigeneration* which seeks to establish 'zones' within the CBD which will be serviced by electricity and heating produced by cogeneration facilities (Kinesis 2012). There is concern however that well-intentioned and ambitious climate and energy plans being devised and implemented at the municipal level could result in too many uncoordinated actions by individual players within the national and global response to climate change (Sperling, Hvelplund et al. 2011). Sperling (2011) advocates a shift from 'parallel energy planning' model to a 'strategic energy planning model, whereby energy planners, land use planners, industry and community stakeholders and government bodies come together to develop a coordinated and integrated policy and regulatory packages which avoids duplication, confusion, conflict or misallocation of resources.

2.3.3 Assessment and Approvals

Academic literature relating to government assessment and approvals policies tend to focus on the application of assessment regimes to specific technologies, such as wind power (Gross 2007, Longden, Brammer et al. 2007, Portman 2009, Bergek 2010, Heagle, Naterer et al. 2011, Mangoyana and Smith 2011), biomass (Chicco and Mancarella 2007, König 2011, Mangoyana and Smith 2011) and solar (La Gennusa, Lascari et al. 2011), however the body of literature also includes a number of works which take an overarching view of decentralised energy more broadly (Allen, Hammond et al. 2008, Dicorato, Forte et al. 2008, Walker 2008, Woodman and Baker 2008, Kaundinya, Balachandra et al. 2009, Möller 2011) with relation to environmental and community impacts and the challenges facing the land use planning system. Examples of assessment and approvals measures used to promote decentralised energy include:

- The *Green Energy and Economy Act 2009* in Canada, for example, has created a separate development assessment and approvals stream specifically to deal with renewable energy projects(Heagle, Naterer et al. 2011) that integrates and streamlines the development approval process with a range of other environmental license processes, significantly reducing the regulatory burden on this type of development. Under this scheme, renewable energy production systems are categorised for assessment by both capacity and technology.
- In the United Kingdom, the *Town and Country Planning Order 1995* (UK) was specifically amended to include domestic wind turbines as permissible (fast-track) development subject to a set of defined criteria addressing noise, size, height, number of turbines and siting (Heagle, Naterer et al. 2011).
- Under the *2007-2013 Sustainable Energy Plan* implemented in Andalusia, Spain, local authorities are required to take into account the favourable macro-scale environmental effects (i.e. reduced GHG emissions) of renewable energy technologies during the environmental impact assessments at the development application scale, which is usually the domain of micro-scale impact assessment (Prados 2010).

An absence of local level regulatory controls on the development of decentralised energy technologies in many countries has often seen adverse effects on the local environment (such as noise and visual impact) with local authorities lacking the necessary high-level policy guidance during the assessment process to give appropriate weighting to micro and macro-scale environmental objectives (Prados 2010). An 'appropriate dose' of government involvement through regulation backed by clear and long-term strategies is hence required to provide sufficient certainty for business and individual players to invest whilst allowing local authorities to provide appropriate environmental assessment (Sperling, Hvelplund et al. 2011).

To a certain degree, decentralised energy production poses a paradigm shift for land use planning by dispersing the environmental impacts of energy production over a wide and often heavily populated area, as opposed to previous conventional wisdom which required the siting of centralised generation facilities in isolated locations to reduce the potential for land use conflict (Longden, Brammer et. al. 2007). This makes cogeneration difficult to account for in traditional land use planning polices and development controls.

2.4 What are the Environmental, Social and Economic Impacts?

> *Technical feasibility of renewable technologies must be accompanied by public acceptance of the environmental, social and economic benefits* (Möller 2011).

2.4.1 Environmental Impacts

Decentralised energy production can provide a significant environmental benefit by reducing energy-related GHG emissions through utilisation of fuels in a far more efficient manner (through the capture and distribution of waste heat as useful energy) and by reducing the electricity losses associated with long transmission distances (Heagle, Naterer et al. 2011, König 2011). In one example, Woking Borough Council achieved a 77% reduction in CO2 emissions between 1991 and 2004 as a direct result of investment in renewable decentralised energy projects (Allen, Hammond et al. 2008).

Whilst the literature is generally silent on the environmental impacts of small-scale decentralised energy installations within the urban environment, or otherwise concludes these to be small impacts individually, the number of installations required to meet identified energy targets may lead to cumulative environmental impacts in terms of visual impact, reflectivity, noise and building code compliance (Keirstead 2008). This presents a challenge for planners in balancing the perceived cumulative negative impacts with the cumulative positive, but unseen, impacts such as reduced greenhouse gas emissions.

A study on the use of heat distribution networks (Kelly and Pollitt 2010), which are often but not always supplied by cogeneration facilities, listed the environmental benefits of this distribution method as:

- increased energy efficiency;
- reduced pollution;
- provision of local employment;
- opportunities for intelligent systems and supply networks; and
- capacity to use local resources.

With regards to specific technologies, wind turbines have attracted the greatest level of attention in the media and public realm. Whilst there are ambiguities and a range of views held in both the literature and public opinion (Aitken 2010, Bergek 2010, Prados 2010), it is evident from the discourse that there is significant concern regarding the visual and noise impacts resulting from a widespread adoption of this technology. In many instances the push to develop renewable energy facilities as a solution to global environmental issues has taken precedence over local environmental impacts creating community concern (Prados 2010).

2.4.2 Social Impacts, Community involvement and Consultation

A number of academic writers address the need to distinguish between the current energy market which addresses only 'private costs', as opposed to 'social costs' which takes into account GHG emissions and broader environmental impacts (Skoufa and Tamaschke 2011).

In the United Kingdom, developer incentives have resulted in innovative co-ownership models with the local community as a means of addressing the gap between the economic benefits usually only experienced by the land-owner and generator and the environmental impacts experienced by the broader community (Walker 2008). It is also suggested that, in both expectation and reality, community ownership (either in part or full) of generation facilities provides an advantage to developers in obtaining planning permission in a timely and cooperative manner (Sperling, Hvelplund et al. 2011).

The shift to decentralised energy, which will result in the widespread integration of energy generation facilities into the urban fabric, will require the inclusion of local stakeholders and municipal government in energy planning, whilst at the same time continuing the role of executive power exercised by high level government bodies to ensure the 'national' requirements of the energy grid are met (Sperling, Hvelplund et al. 2011).

Rather than being led purely by financial returns, the uptake of decentralised energy production is dependent upon acceptance of these technologies in the socio-political and community discourse prior to gaining market and regulatory acceptance (Heagle, Naterer et al. 2011). As such it is essential that proponents of renewable technologies, irrespective of whether they act for private or public interests, engage the community in a discussion to improve understanding of the various technologies and processes required to achieve a more rapid shift to a clean decentralised energy generation system.

Renewable energy and the public (Walker 1995) is the most comprehensive piece of literature relating to the public's acceptance (and objection to) low-carbon energy generation and specific technologies, and incorporates a review of a number of earlier studies. Walker (1995) contends that the conflict surrounding low-carbon energy development is largely centred around the inevitable land use planning conflicts between 'personal interest' and the 'public interest', which has been the traditional approach taken in land use planning. More recent research utilising a cultural theory approach, however, suggests that responding to and neutralising individual opposition and generating support for low-carbon electricity generation within the community must not be limited to resolving the narrow 'personal interest' and must instead take into account the different 'world-views' within the community (West, Bailey et al. 2010). West et al. suggest that the traditional land use planning approach is likely to struggle to address community conflict regarding low-carbon energy development because the planning system is attuned to resolving conflicting interests, rather than conflicting views of reality (Lovins 1977). It is suggested that a greater understanding of the differing 'world-views' which shape community perceptions of the broader impacts of low-carbon energy development may allow planners to adopt a more pragmatic approach in promoting the use of decentralised energy (West, Bailey et al. 2010).

2.4.3 Economic Impacts

In Spain, Prados notes that the changing economics of food production have combined with government subsidies and facilitative planning policies to encourage widespread land use changes from farming to industrial scale renewable production using solar PV technology without a full planning application or environmental assessment. (Prados 2010). In order to resolve this issue, Prados suggests that the trigger for the environmental assessment of decentralised energy proposals should not be based on a specific type of technology employed but on the amount of surface area covered by the proposal and the existing use of that land. The notion of using measurements of environmental impact to trigger certain assessment requirements challenges the traditional land use planning approach to energy production, which tends to categorise generation facilities by their fuel-source on the basis that these facilities have the same environmental impacts (Prados 2010).

Contrary to the public understanding, traditional electricity generation based on fossil fuel combustion or on nuclear decay are subsidised in various forms throughout the world, particularly by exempting these industries from the environmental costs which are externalised in traditional markets (Dinica 2011). In this case the comparative cost of incentives for the uptake of renewables need to be taken into account in the strategic planning process against the costs of continuing to subsidise traditional centralised generation facilities.

The 'Merton Rule' has been implemented in numerous local planning schemes in the United Kingdom which requires that 10% of energy consumed by a new development is generated by renewables on site. The use of this planning requirement by local authorities has, however, been slowed significantly in a climate where the public discussion on land use planning has revolved increasingly around housing unaffordability and the cost of development (Williams 2010).

2.5 Key Findings

This literature review has identified a wide range of research relating to the implementation of decentralised energy systems and the associated environmental, economic and social consequences. The body of literature establishes a clear rationale for a shift from traditional carbon-intensive centralised energy systems to a renewable and decentralised model with far greater input from local government and non-government participants including developers and communities. A number of sources address specific technology case studies (Bergek 2010, Heagle, Naterer et al. 2011, Mangoyana and Smith 2011) or regulatory environments (Allen, Hammond et al. 2008, Sovacool 2008), whilst other focus on the broader questions of economic (Dinica 2011, König 2011) and social impacts (Walker 1995, Gross 2007, West, Bailey et al. 2010) of decentralised energy.

Much of the literature is international in focus, with Denmark and the United Kingdom featuring heavily due to the relatively strong progress these countries have made in the shift towards decentralised energy (Allen, Hammond et al. 2008, Sperling, Hvelplund et al. 2011), whereas in Australia the concept of decentralised energy is still an emerging field, at least in the academic literature, in which future energy planning is still very much predictive (Pears 2007). At the same time, the preparation of technical policies and strategies by local government in Sydney (Kinesis 2012) simply highlight the gap which the academic literature must fill to provide a more thorough theoretical understanding of the challenges and opportunities associated with decentralised energy before government and industry leap blindly into the void.

3.0 International Case Studies in Cogeneration

Cogeneration has historically had a strong presence in European countries compared to the rest of the world (**Figure 8**), which is a result of significantly higher demand for heating in urban areas to combat colder climates. Governance models in former Eastern Bloc countries such as Russia, Poland, Latvia, the Czech Republic and Hungary also significantly influenced the development of these public utility installations (World Bank 2009). In many instances the installation of these precinct-scale cogeneration systems represented not only the first distributed heating systems, but also the first electricity generation facilities in these areas, and was driven by the economic and social imperatives of providing heat to all areas of the city (Russell 1993). Given that climactic and social factors have shaped the use of cogeneration in most European countries, rather than the more recently identified drivers such as climate change, building energy efficiency and natural resource depletion, it is considered that case studies of these countries are not directly analogous to the City of Sydney context.

Academic literature relating to cogeneration development in urban areas and buildings is entirely based on the international experience, which is to be expected given the emergent-status of this technology in Australia at present. Key studies of the practical experience of implementation of decentralised energy systems have focused particularly on the United Kingdom (Allen, Hammond et al. 2008) and Denmark (Sperling, Hvelplund et al. 2011). These case studies provide a strong theoretical understanding of decentralised energy systems in practice and serve as a good basis for the identification and assessment of many of the environmental, economic and regulatory issues that are comparable to Sydney.

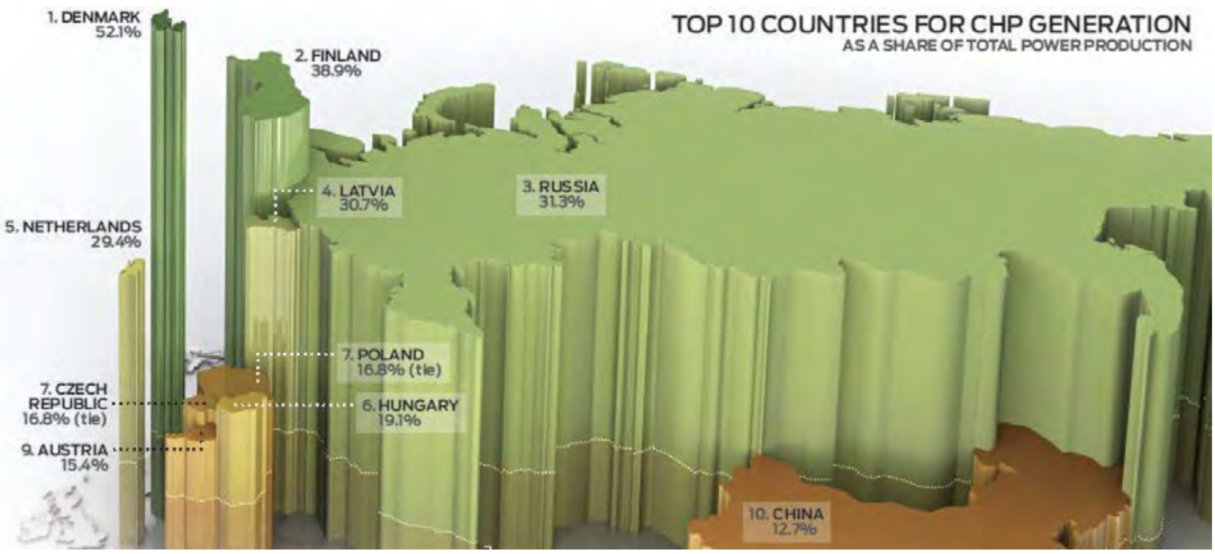


Figure 8 – Combined Heat and Power as a proportion of total national energy production

Source: *IEEE Spectrum 2009*

The case study of the Borough of Woking in the United Kingdom has been selected because this cogeneration development was initiated to displace the existing electricity grid in response to economic and sustainability considerations. It was a pioneering project in the UK context, and involved key personnel who are now involved in the City of Sydney's plans for precinct-scale cogeneration. As noted later in this thesis, the upcoming legislative changes to the NSW Planning system bear similarities with the UK planning system that enabled the Woking development and hence may also bear relevance to future planning settings for cogeneration in Sydney.

New York City has been chosen as the second case study for its status as the 'birthplace' of cogeneration, its existing large-scale local cogeneration facilities operated by Con Edison and the role current strategic planning by 'local' government is playing in promoting further cogeneration development. PlaNYC 2030 identifies the rollout of new on-site and precinct scale cogeneration as a key component in achieving the City's GHG emission reduction target and bears many similarities with the City of Sydney's *Sustainable Sydney 2030* plan and DEMPT.

3.1 Woking, United Kingdom

> *"Over a period between 1990 and 2004 I effectively took Woking off the grid – private wire networks, more than 80 of them, decentralised energy systems, cogeneration, trigeneration, renewable energy, fuel cells, you name it – it all happened in Woking."* (Allan Jones 2012)

Precinct-scale cogeneration has had a presence in the United Kingdom since the first coal-fired district scheme was established in Manchester in 1919 (Kelly and Pollitt 2010). It is only in the past 25 years however that modern technologies and changing attitudes towards sustainability, GHG emissions and climate change in urban development have seen any significant policy or planning action to stimulate the use of cogeneration. The UK experience of cogeneration over the past 5-10 years has been defined largely by locally-led developments and policies such as the roll-out of decentralised energy development within Woking that have provided 'demonstration projects' on which to base further local action (Bunning 2011).

The Borough of Woking is located approximately 40 kilometres south-west of the London CBD and 20 kilometres south of Heathrow Airport. The borough has a population of just over 90,000, of whom 75% live within the urban centre of Woking, a further 15% within smaller villages and the remaining 10% living on rural and semi-rural properties within the London ‘green belt’ which makes up more than half of the borough’s land area (Woking Borough Council 2012). The physical constraints on development of the green belt create clearly defined edges between areas of urban land and non-urban land, and the relatively higher housing densities that occur in these urban centres allow the efficient provision of combined heat and power distribution infrastructure.

3.1.1 Project Description

In 1990 Woking Borough Council began implementing a series of policies and projects that have resulted in the delivery of 81 decentralised energy distribution systems with private wires and heat pipes (i.e. completely grid-independent) to distribute electricity and heating from a number of cogeneration plants to government, commercial and residential buildings throughout the Borough. As of 2010, Woking’s cogeneration plants supply 24GWh of heating per annum to over 1,250 buildings and electricity to a further 5,000 buildings (Thameswey 2012). During the period of 1990 to 2004, Woking Borough Council achieved the following environmental outcomes as a result of the implementation of these borough-wide decentralised energy networks (City of Sydney 2008; Jones 2012; Sustainability Victoria 2011):

- reduction in total energy consumption by 51% as a result of more efficient heating;
- reduction in Council’s own direct GHG emissions by 80%;
- reduction in borough-wide community emissions by 21%;
- reduction in household electricity retail prices by 10%;
- 98% of development within the borough was connected to the local private-wire decentralised energy network; and
- improvement in the energy efficiency of all public and private housing stock by 33%.

Thameswey Ltd, the public utility company formed and owned by Council to implement and operate the Woking decentralised energy network, had an annual turnover of £14.5million in 2011 and an operating profit of just over £1 million, however after the servicing of debts experienced a loss of nearly £3 million. The company has assets valued at over £73 million against total liabilities of £67 million (Thameswey Ltd 2011). Woking Borough Council was required to contribute £4 million in the 2011 financial year to enable Thameswey to cover losses and buy back a share of the energy company subsidiary from Xergi, the public-private partner in the energy network. This cost has been borne by all ratepayers rather than only those who directly benefit from private connections to the decentralised energy network.

3.1.2 Governance and Implementation

The push to develop Woking's decentralised energy networks, which are largely underpinned by cogeneration, was driven at the operational level (i.e. staff) of Woking Borough Council rather than the political level (i.e. elected Councillors). Decisions to investigate and implement the scheme were sold by staff to the Councillors under the primary banner of motivation that the project was an infrastructure investment that would provide economic returns to both residents and the Council, with sustainability only a secondary consideration, allowing the project to gain cross-factional support at the political level (Jones 2012).

Under the provisions of the national electricity regulatory framework in the UK, Woking Council was able to establish a municipal utility company (Thameswey Ltd) to develop the cogeneration plant and distribution networks and supply residents with electricity and heating (Bunning 2011). Woking Council facilitated the establishment of this company and retained ownership over it, but used the company as a vehicle to form public-private and public-community organisation partnerships to fund and deliver the decentralised energy network as shown in **Figure 9**. In the absence of significant domestic expertise in cogeneration development, Thameswey sought a partnership with Xergi Pty Ltd, a European firm based in Denmark where cogeneration accounts for more than half of that country's total energy generation (IEEE Spectrum 2009). This operational structure is commonly used in municipal-scale energy developments where capital risk and regulatory barriers deter private investment and where local authorities lack the technical capacity and financial resources to implement an effective system (Kelly and Pollitt 2010). Whilst several Woking Borough councillors sit on the board of Thameswey Ltd and the various subsidiary companies to represent the Council's interests as a shareholder, this structure is effective in depoliticising the control of and investment in the cogeneration scheme (Jones 2012).

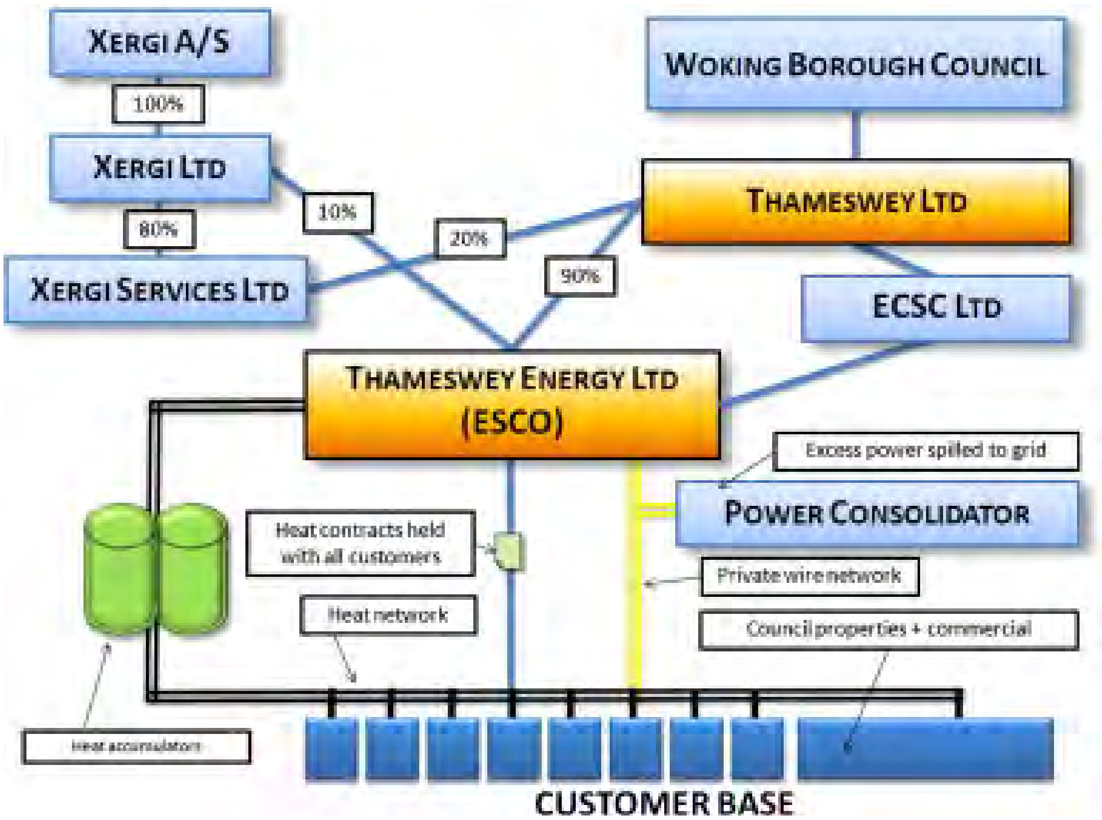


Figure 9 – Governance and operations diagram for the Woking Decentralised energy network

Source: *Kelly and Pollitt 2010*

3.1.3 Planning Policy

> *"[Decentralised energy in Woking] had a significant impact on bringing up the rest of the UK – legislation was brought in, compulsory planning targets, and a lot of that was based around Woking setting the example."* (Jones 2012)

The governance and project financing model implemented by Woking Borough Council was supported by planning regulation introduced under the Woking Local Plan (the Local Plan). The greater delegation of planning powers to local government in the UK under the (now repealed) *Town and Country Planning Act 1947 (United Kingdom)* allowed these planning regulations to be implemented in a relatively rapid manner. Chapter 10:CUS9 of the Local Plan ensures that development for the purpose of cogeneration facilities is permissible across the entire borough in order "to meet both the operational demands of the technology and the environmental policies of the local plan" (Woking Borough Council 1999, p.174), whilst also noting that development of cogeneration facilities should be oriented towards district scale networks which benefit the wider local area.

At the core of Woking's planning regulation was the inclusion of provisions within the Local Plan and supplementary development policies which promoted connection to the precinct cogeneration systems:

> *"Obligatory statutory planning provisions – you could not get development consent without complying with these energy and water requirements. A key measure of that was that any major development had to provide or connect to a decentralised energy network. In addition to that 20% of its energy needs had to come from renewable energy"* (Jones 2012)

Woking's experience in implementing a cogeneration-powered decentralised energy network from the 'ground-up', using direct government action and planning regulation to quickly achieve energy efficiency and GHG emission reductions, catalysed the amendment of the national planning system to empower local government to promote and implement decentralised energy.

The United Kingdom's *National Planning Policy Framework 2012* (NPPF) is a consolidation and review of planning policies which were previously contained within 'Planning Policy Statements' and 'Planning Policy Guidance Notes' within the framework of the *Town and Country Planning Act 1990* (UK) and the *Localism Act 2011* (UK). The NPPF conveys the high-level planning policy controls which apply across the UK and all Local Plans must be consistent with the NPPF. From the finalisation date of the NPFF in March 2012 all local government authorities have been given 12 months to update their local planning policies to ensure that this consistency is achieved. The NSW Planning System Green Paper (August 2012) proposes the introduction of 'State Planning Policies' that are the equivalent of the former UK Planning Policy Statements and which define high-level policy and development controls that must be reflected in local planning instruments.

The NPPF specifically includes provisions which encourage local government to plan for low-carbon and renewable decentralised energy and empower planning authorities to require connection to local decentralised energy supply (**Figure 10**). This framework sends a clear message to both the government and private sector as to the planning policy settings for decentralised energy development in the UK and ensures that all local plans reflect this policy.

96. In determining planning applications, local planning authorities should expect new development to:

- comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable; and
- take account of landform, layout, building orientation, massing and landscaping to minimise energy consumption.

97. To help increase the use and supply of renewable and low carbon energy, local planning authorities should recognise the responsibility on all communities to contribute to energy generation from renewable or low carbon sources. They should:

- have a positive strategy to promote energy from renewable and low carbon sources;
- design their policies to maximise renewable and low carbon energy development while ensuring that adverse impacts are addressed satisfactorily, including cumulative landscape and visual impacts;
- consider identifying suitable areas for renewable and low carbon energy sources, and supporting infrastructure, where this would help secure the development of such sources;[17]
- support community-led initiatives for renewable and low carbon energy, including developments outside such areas being taken forward through neighbourhood planning; and
- identify opportunities where development can draw its energy supply from decentralised, renewable or low carbon energy supply systems and for co-locating potential heat customers and suppliers.

98. When determining planning applications, local planning authorities should:

- not require applicants for energy development to demonstrate the overall need for renewable or low carbon energy and also recognise that even small-scale projects provide a valuable contribution to cutting greenhouse gas emissions; and
- approve the application[18] if its impacts are (or can be made) acceptable. Once suitable areas for renewable and low carbon energy have been identified in plans, local planning authorities should also expect subsequent applications for commercial scale projects outside these areas to demonstrate that the proposed location meets the criteria used in identifying suitable areas.

Figure 10 – Extract from the UK *National Planning Policy Framework 2012*

Source: *UK Department of Communities and Local Government 2012*

The provisions of the NPPF have allowed Woking Borough Council to include additional planning provisions that strengthen the requirement for new development to connect to decentralised energy networks and/or provision of on-site cogeneration as part of the 2012 update to the Local Plan:

> *"All new development in proximity of an existing or proposed cogeneration station or district heating network will be required to be connected to it unless it can be demonstrated that a better alternative for reducing carbon*

> *emissions from the development can be achieved. Details of the zones where connection will be required will be set out in an Supplementary Planning Document and will be determined by factors such as the capacity of the existing cogeneration network, distance from it and physical constraints.*" (Woking Borough Council 2012)

The culture of 'local responsibility' promoted under the *Localism Act 2011* (UK) and the amendment of national planning policies in the NPPF has provided additional powers to Woking Borough Council and all other local authorities within the UK to permit Councils to set up private utility companies or enter into agreements with external operators to develop cogeneration facilities and decentralised energy networks, and then use Local Plans to require new development to connect to these facilities.

3.1.4 Impacts Beyond Woking

Allan Jones, the chief engineer with Woking Borough Council and Director of Thameswey, responsible for the implementation of their decentralised energy scheme between 1990 and 2004, has played a significant role in the promotion and implementation of cogeneration and decentralised energy both within the UK and internationally. The rapid environmental results achieved by Woking Borough Council had a significant role in the inclusion of low-carbon energy provisions within the UK's National Planning Policy Framework (Jones 2012).

In 2004 Jones was recruited from Woking to take up the role of Chief Executive Officer of the (then) newly created London Climate Change Agency with the task of formulating and implementing a new energy framework for London. Whilst the 2007 Mayor's Climate Change and Energy Action Plan identified the development of 170MW of precinct cogeneration as a priority for delivering GHG emission reductions, the only progress in implementing this scheme to date has been the formulation of strategic energy policies and the development of the 10MW trigeneration centre delivered as part of the London Olympics development program (Energy for London 2012).

The functions of the London Climate Change Agency were folded back into the London Development Agency and Jones was made redundant in 2008 after the election of Boris Johnson as Mayor of London, and Jones has now joined the City of Sydney Council as its Chief Development Officer – Energy and Climate Change. Jones is the key person responsible for implementing the City of Sydney's *Decentralised Energy Master Plan – Trigeneration*.

3.2 New York City, United States of America

3.2.1 District Cogeneration in New York City

New York City (NYC) has a long history of district cogeneration and decentralised energy production. The world's first commercial power station, the Pearl Street Station in Manhattan (**Figure 11**), was a form of cogeneration plant designed and constructed by Thomas Edison and became operational in 1882, distributing electricity to street lamps and neighbouring buildings as well as useful heat (WADE 2012). Thomas Edison's original company, through a series of takeovers, mergers and acquisitions of electric, gas and heating companies operating within NYC over the following 140 years, is today continued in the operations of Consolidated Edison Incorporated (Con Edison). Unlike in the UK and Australian context, where power generators have been historically government-owned entities, in NYC energy has been provided by private companies which creates a substantially different context in terms of investment decisions and uptake of new generating technologies. Con Edison is one of the largest private energy companies globally, with over $US39 billion in assets. It continues to operate large-scale cogeneration plants in NYC (**Figure 12**) that power the Manhattan steam pipe network (heating), which services 1,772 residential and commercial buildings and (with additional electrical generation capacity and a separate gas distribution network) more than 3 million customers with electricity and/or gas(Con Edison 2012) as well as (Con Edison 2010).

Figure 11 – c.1882 Pearl Street Station

Source: *WADE 2012*

Figure 12 – Con Edison 15th Street Cogeneration Plant

Source: *Con Edison 2012*

3.2.2 Pre-2007 Development Patterns

Despite (and in part due to) the long history of large-scale cogeneration in NYC, planning and building codes in the City did not allow the legal installation of on-site cogeneration plants until 2007, and as such no on-site cogeneration capacity had been legally installed (DePalma 2007). This type of prohibition has been perpetuated in the United States by the lobbying efforts of large utility companies which seek to pressure government agencies to implement legislation which limit competition, whilst simultaneously imposing high regulatory and compliance costs on owners of non-cogeneration on-site facilities such as renewables or diesel generation who may wish to export surplus energy to the utility company's grid (Thornton and Monroy 2011).

Traditionally low oil and coal prices and volatile gas prices in the US have made small-scale gas-fired cogeneration less competitive in NYC, and have tended to deter 'clean energy' investment towards other generation technologies such as wind and hydro. Over the past 5-10 years, however, gas prices have stabilised while US oil and coal prices have increased, and the market has become more aware of the potential pricing which may be imposed on GHG emissions. This has created investment conditions which are more facilitative towards cogeneration energy systems to the point that they are now cost competitive in some applications (New York State Energy Planning Board 2009).

3.2.3 PlaNYC 2030

Policy Settings and Strategic Planning

Released in 2007 by Mayor Michael Bloomberg, PlaNYC 2030 is New York City's comprehensive strategic planning vision to guide planning for the City's growing population, sustainability, quality of life and the economy (**Figure 13**). The document was updated in 2011 and is structured around key areas including housing, employment, open space and has a full chapter dedicated towards energy. Whilst also providing a high-level vision for the City, the plan also outlines hundreds of measurable targets which are to guide the actions of the City. As a municipal-level strategic planning document PlaNYC, bears many similarities with the City of Sydney's *Sustainable Sydney 2030* strategy, including a focus on climate change, sustainability and cogeneration.

Figure 13 – PlaNYC – A Greener, Greater New York, 2011 Update Report

Source: *NYC 2012*

One of the key objectives of PlaNYC is to take action to mitigate and adapt to anthropogenic climate change with a reduction in GHG emissions of 30% from 2005 levels by 2030. The New York City urban area already has low per capita GHG emissions that is less than one-third the US average (NYC 2007) due to the high usage of public transport, dwelling density and small dwelling sizes. As shown in **Figure 14** New York City aims to achieve these reductions through a mix of energy efficiency, behavioural change, fuel switching and cogeneration, of which cogeneration will account for approximately 20% of total reductions.

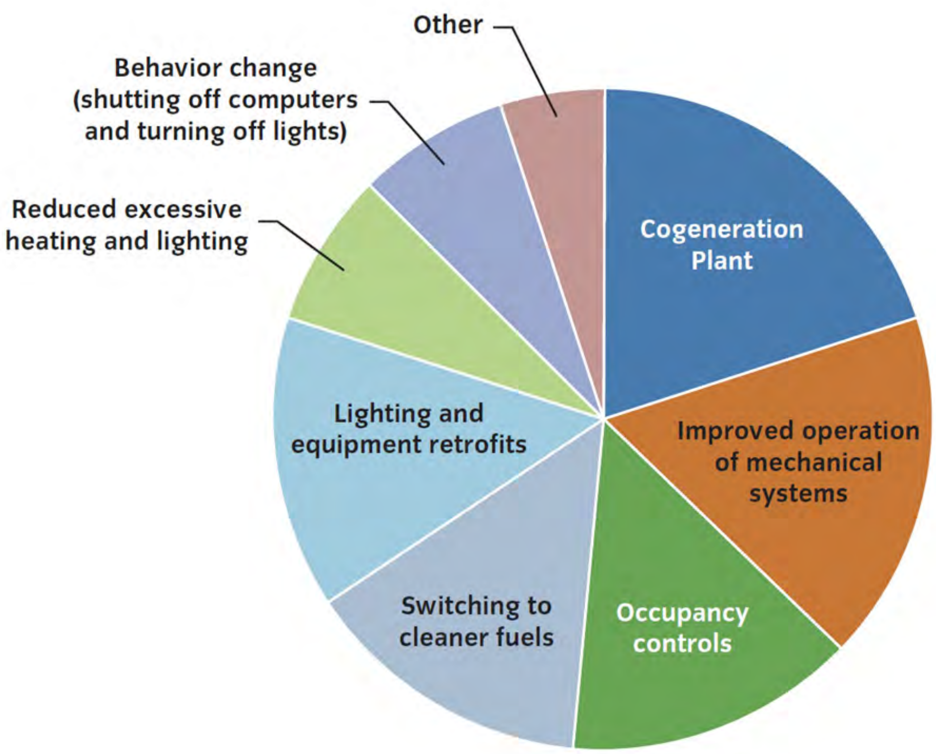


Figure 14 – Key components of the energy reduction strategy under PlaNYC

Source: *NYU via NYC 2011*

Initiative 13 for Energy of PlaNYC targets 800MW of new installed decentralised energy generation, which is to be achieved predominately by new on-site cogeneration installations developed by the City and the private sector and supplemented by other generation technologies such as solar PV and small-scale wind (NYC 2007). Under this initiative the City aims to streamline the approvals process, breakdown known regulatory barriers to cogeneration and provide technical assistance to partner institutions and land owners.

Implementation and Governance

The New York City Council and the Mayor have much broader powers than comparative local governments in either the UK or Australia, in that they have direct control over a much wider range of government activities, including building code regulation, planning law, housing, health, taxation, education and law enforcement. This governance model provides NYC with the ability to directly implement the PlaNYC framework across nearly all of the relevant government legislation and agencies that directly affect the development and operation of the City, ensuring that the PlaNYC is a whole-of-government strategy (Connolly et.al. 2012).

Between the introduction of PlaNYC in 2007 and late-2010 the City had already installed 64MW of on-site and precinct scale cogeneration facilities through directly implemented government projects and technical assistance partnerships with institutions and businesses located within the city (NYC 2010). Two examples of these projects include:

- New York City installed two 7.5MW gas turbine cogeneration plants to provide electricity and heating for the Rikers Island Correctional Facility and surrounding government-owned buildings. This project not only generates electricity for the buildings which are directly connected but also exports excess steam and electricity generated in off-peak periods to the existing steam and electricity grids which service New York (NYC 2009).
- New York University (NYU) installed a 13.4MW gas turbine cogeneration facility within the university's Washington Square campus in Manhattan which connects directly to 37 university buildings with technical assistance from New York City under the PlaNYC program. This installation cost is in the order of $75 million and will save NYU $5-8 million per annum in energy costs (NYU 2012).

In addition to new small-scale generation facilities, New York City collaborated with Con Edison to adjust the existing energy mix supplying the distribution grid to increase the use of Con Edison's cogeneration facilities for steam generation, which is currently supplied to 1,800 existing buildings in Manhattan. Whilst cogeneration plants represent only 30% of Con Edison's installed steam capacity in NYC, changing operating patterns to use these cogeneration plants for baseload steam production rather than during only high-demand periods means that they now account for 50% of steam generation within the City (NYC 2011, p.16).

According to PlaNYC, 85% of all of the buildings which will make up NYC in 2030 are already built, which represents approximately 800,000 buildings (NYC 2012 *GGBP*). Of these 800,000 existing buildings however, only 3% of total buildings (approximately 22,000 buildings) account for 45% of total building energy use across the entire City. Improving the efficiency of these buildings and retrofitting connections to cogeneration forms a key component of the execution of PlaNYC and will be implemented through a package of legislation (NYC 2012 *GGBP*) that:

- establishes minimum energy standards which all new developments and major building renovations must achieve;
- requires annual energy and water auditing and public disclosure or results for all new and refurbished buildings;

- makes auditing, tuning and retro-commissioning of building plant and services mandatory in all buildings at least every ten (10) years; and
- provides for compulsory lighting upgrades and sub-metering of existing large non-residential tenancies.

This legislative base, and particularly the mandatory energy standards, will ensure that the most economic energy supply option for new developments and major refurbishments is for these buildings is to connect to, or provide, new cogeneration facilities. This mixture of regulatory requirements and economic incentives is designed to ensure that the PlaNYC target of 800MW of installed capacity is driven by demand, and will greatly assist in achieving the PlaNYC GHG reduction targets.

The coordination and timely implementation of these statutory requirements and initial projects is largely a testament to the political and statutory powers invested in the governance of New York City which allow significant progress to be made by the organisation without reliance on external agencies authorities or higher levels of government.

3.3 Key Findings

The case studies of Woking and New York City identify some common issues and themes relating to the planning for and development of cogeneration facilities which are transferable to the assessment of other cogenerations schemes that are initiated by local authorities:

- Strategic planning policy which promotes the development of cogeneration must be a whole of government document that will guide the action of all government agencies and authorities who have jurisdiction or control over this type of development.
- Local planning provisions and development controls must reflect and facilitate the strategic planning in order to enable development to occur.
- Local government plays an important role in implementing precinct-scale cogeneration, whether through direct responsibility for construction and operation of the system (such as at the Rikers Island Correctional Facility) or through guarantees to connect government buildings to provide the critical mass required for the commercial development of the system (such as in Woking).

- Partnerships between local government and businesses (such as Con Edison and Thameswey) and institutions (such as New York University) are essential in ensuring that the development of cogeneration occurs in a timely manner that achieves the stated policy objectives.

Figure 15 has been developed to illustrate these key points along two axis which represent the policy integration which is required across all levels of planning (vertical integration) and the cross-institutional collaboration which is best driven by local government (horizontal integration). The presence of horizontal and vertical integration at a local government level is evident as a key factor in the successful implementation of cogeneration development.

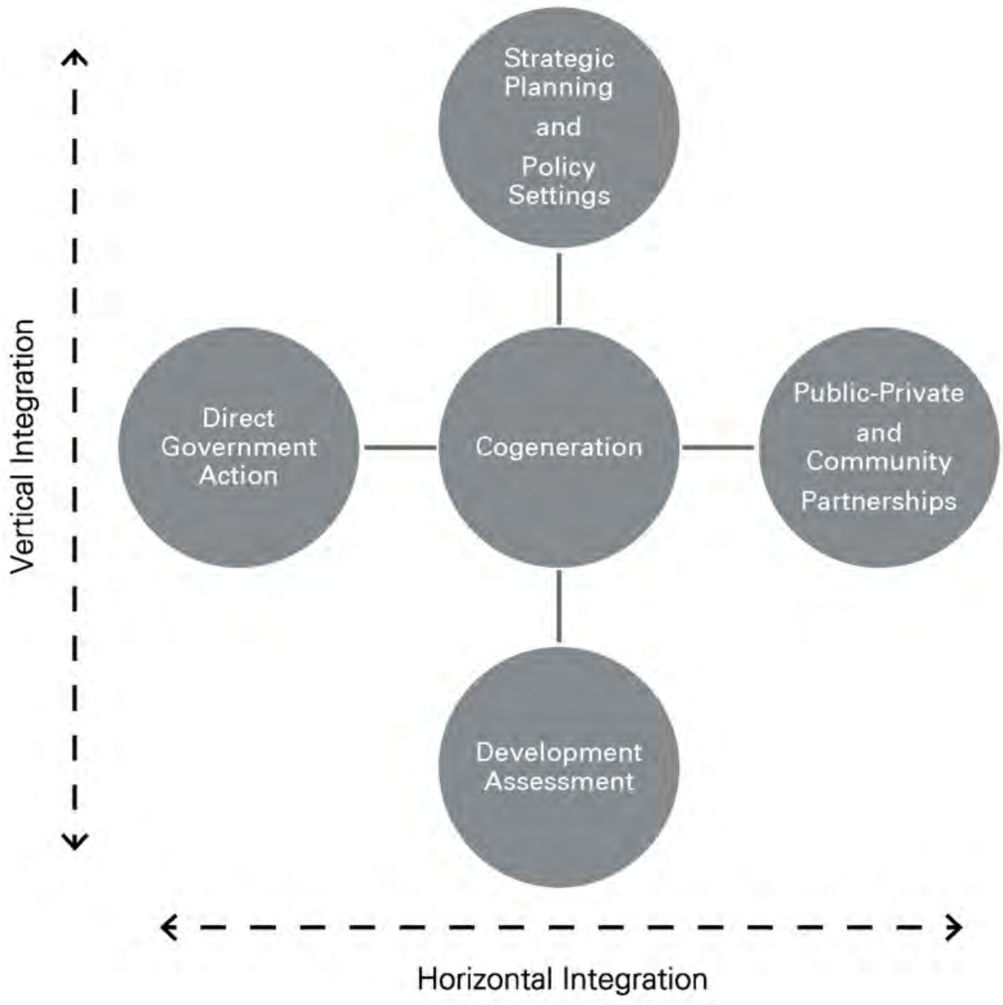


Figure 15 – Integration of planning policy and collaboration

Source: *Author 2012*

4.0 Legislative, Governance and Policy Setting for Cogeneration in Sydney

The development of cogeneration in the City of Sydney is influenced by a complex framework of strategic planning, energy policy, legislation, planning instruments and development controls which are administered by a number of government and independent agencies across the full spectrum of national, state and local government, as shown in **Figure 16**. This framework comprises the governance setting for cogeneration which shapes the ability to undertake development, the patterns of development, and the future for the development of cogeneration in the City of Sydney. This chapter explores and analyses the role of these policies in shaping the development of both on-site and precinct scale cogeneration in the City of Sydney. The chapter is structured according to the traditional hierarchy of governance in the Australian electricity and planning sectors, being Federal, the State, then Local Government.

Australia	NSW	City of Sydney
•National Electricity Market •*Clean Energy Act 2011* •*Renewable Energy (Electricity) Act 2000* •*Building Energy Efficiency Disclosure Act 2010* •Building Sustainability Rating - NABERS and GBCA	•Sydney Metropolitan Plan 2036 •NSW Greenhouse Gas Reduction Scheme •*Environmental Planning and Assessment Act 1979* •State and Regional Development SEPP •Infrastructure SEPP •BASIX •OEH Interim NO_x Policy for Cogeneration in Sydney	•Sustainable Sydney 2030 •*Sydney LEP 2005* •Draft LEP 2011 •Central Sydney DCP 1996 •Draft DCP 2010

Figure 16 – Key government agencies, legislation and planning instruments affecting cogeneration development in City of Sydney

Source: *Author 2012*

4.1 Federal Policy and Planning Setting

The Australian Energy Market Operator (AEMO) is an independent statutory authority formed by the Federal Government which is responsible for the regulation of the National Electricity Market (NEM), or 'the grid'. The NEM serves as the baseline against which the economic and environmental effectiveness of cogeneration must be assessed, but through the AEMO is also a regulator and facilitator of large-scale electricity generators such as precinct-scale cogeneration systems (AEMO 2012).

Under its obligations as part of a wider international response to GHG emissions reduction, the Federal Government has primary responsibility for coordinating a reduction in Australia's GHG emissions. The deep cuts required to effectively mitigate climate change demand significant reductions across all sectors of the economy and are being implemented primarily through the implementation of a policy package branded as the 'Clean Energy Future', which will have direct impacts upon the development environment for all future electricity generation facilities including cogeneration.

In addition to the 'Clean Energy Future' package, the Federal Government and non-government national organisations such as the Green Building Council of Australia (GBCA) have been responsible for the roll-out of several mandatory and voluntary building sustainability ratings tools which promote building energy efficiency in order to reduce both overall energy consumption and peak-demand energy consumption within the Australian market.

These three key aspects of the national governance framework impact directly upon the development of cogeneration facilities in the City of Sydney by influencing the feasibility of this generation technology and its ability to generate carbon emissions, and indirectly as the basis for the development of detailed GHG emissions reductions policies at the levels of State and Local government.

4.1.1 National Electricity Market

The National Electricity Market (NEM) is the interconnected electricity generation and transmission networks of the east coast and southern Australian markets, comprising Queensland, NSW, Victoria, South Australia and Tasmania which allows the sale of energy to a common market which is administered by the Australian Energy Market Operator (AEMO) (Productivity Commission 2011). At present the energy needs of grid-connected buildings within the City of Sydney are generally supplied from the NSW1 generating region within the NEM, however in periods of peak demand and in other occasional circumstances (such as during maintenance shutdowns of generators within the NSW1 region) then electricity is able to be imported from the NEM via the transmission network shown in **Figure 17**.

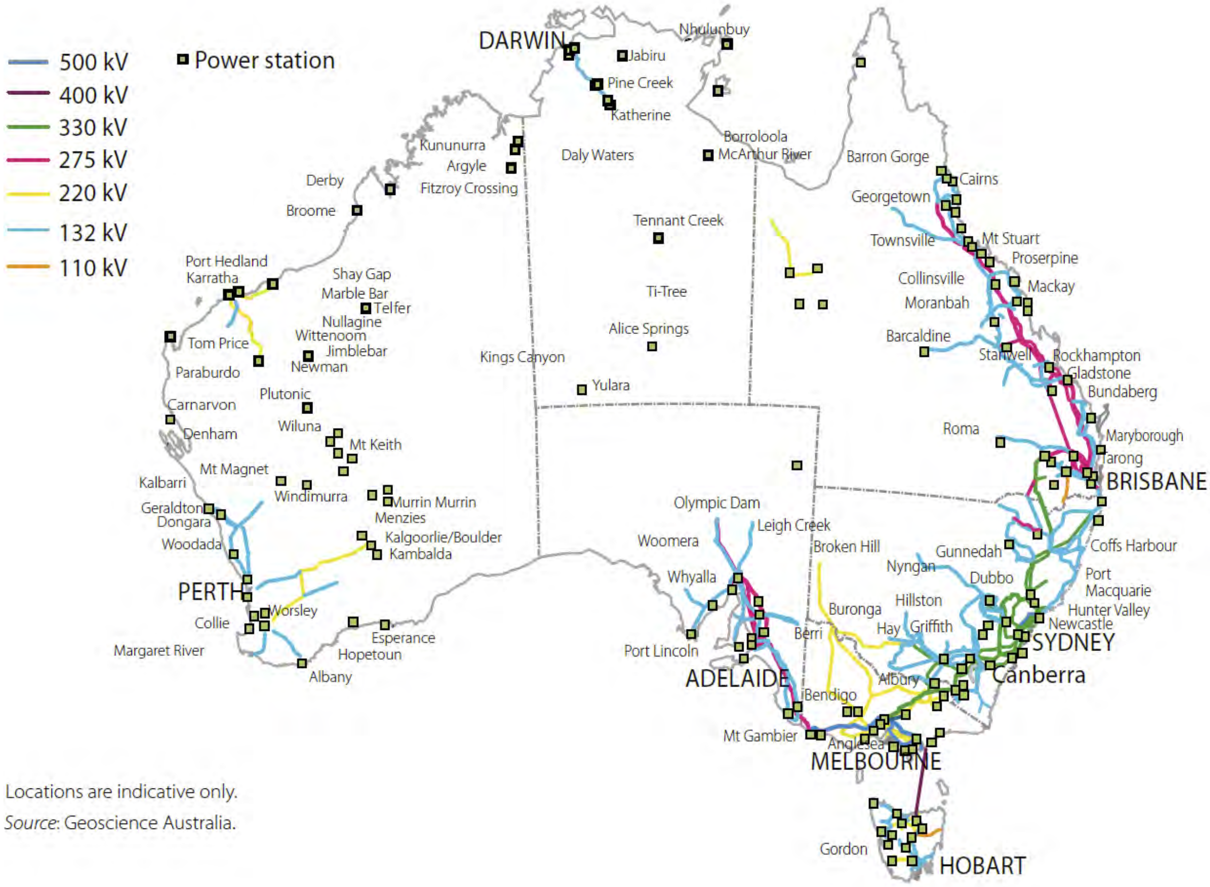


Figure 17 – Australia's electricity transmission network (NEM is eastern states)

Source: *Department of Resources Energy and Tourism 2011*

The NEM reports on the GHG emissions of electricity supplied via the NEM on a regional and market-wide basis, of which the following are directly relevant to the City of Sydney:

- Emissions intensity NSW1 (2011 average) = 0.934 tonnes CO_2-e per MWh[1]
- Emissions intensity NEM (2011 average) = 0.919 tonnes CO_2-e per MWh (AEMO 2012).

The NSW1 region is the 2nd most emissions intensive market within the NEM behind only Victoria (**Figure 18**). The emissions intensity of the NSW1 region is also one of the more consistent throughout the year due to the weather-dependent variability of clean energy in other states such as Victoria and South Australia. This consistency in the NSW market is advantageous to cogeneration development in that the energy produced by cogeneration facilities can deliver a consistent advantage compared to the grid in terms of the GHG emission reductions offered.

[1] CO_2-e is the CO_2 emissions equivalent, which includes CO_2 emissions and other GHG emissions which have an equivalent atmospheric greenhouse impact (AEMO 2011).

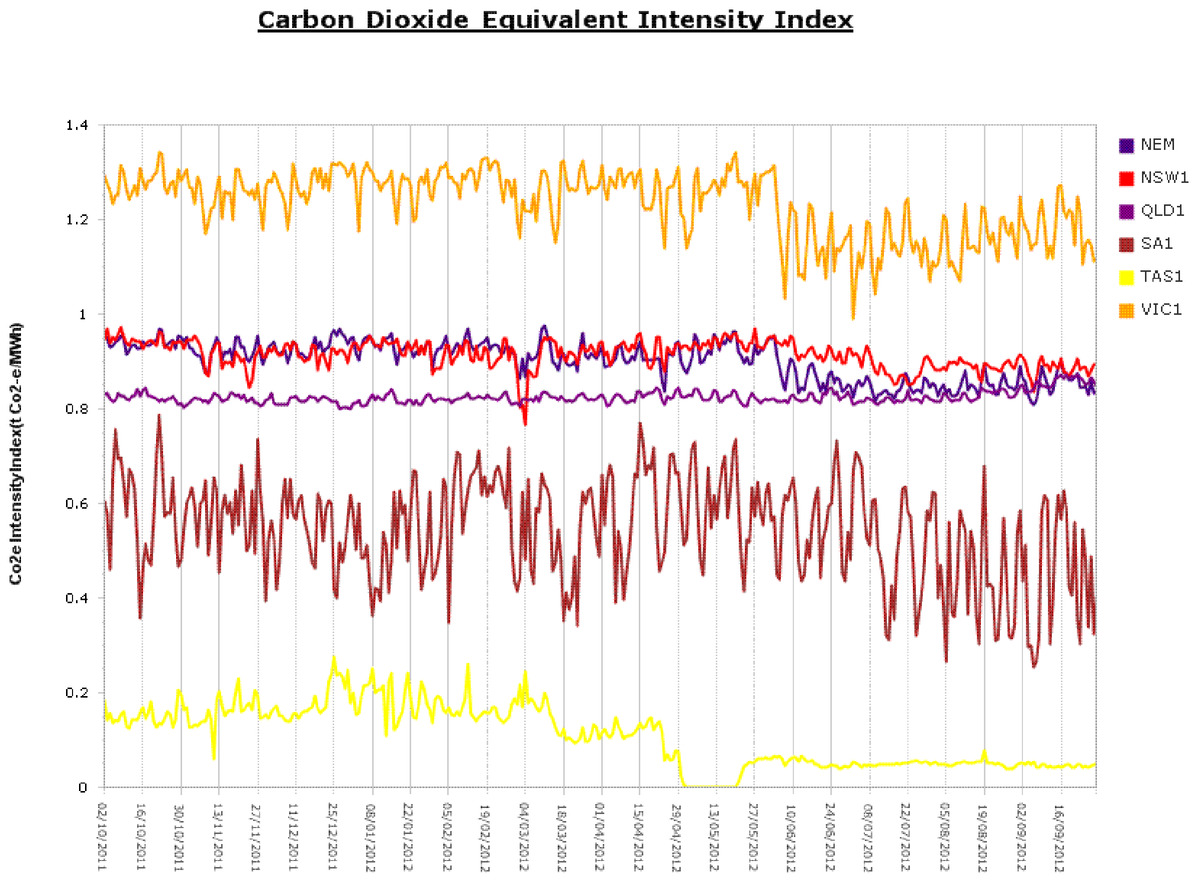


Figure 18 – GHG emission intensity of electricity production within the NEM and subregions 2011-2012

Source: *AEMO 2012*

The *Renewable Energy (Electricity) Act 2000 (Commonwealth)* was introduced by the Federal Government in 2000 to introduce the Mandatory Renewable Energy Target (MRET). The MRET required all electricity generators to buy 'credits' from renewable energy generators in order to demonstrate that a certain proportion of their electricity generation was sourced from renewables, driving a significant investment in new renewable electricity. The MRET effectively doubled the proportion of renewable energy produced in Australia, from a base of about 4% of total electricity generation across the NEM in 2000-01, to 8.22% of total electricity generation in 2009-10 (Climate Change Authority 2012). This period saw electricity generation by non-hydro renewable sources rise from 905GWh (0.4% of total electricity generation) to 7,189GWh (3.0% of total electricity generation) as illustrated in **Figure 19**. This policy led to a substantial 'greening' of the grid that supplies Sydney's electricity, thereby reducing the emissions intensity of indirect emissions associated with the operation of buildings.

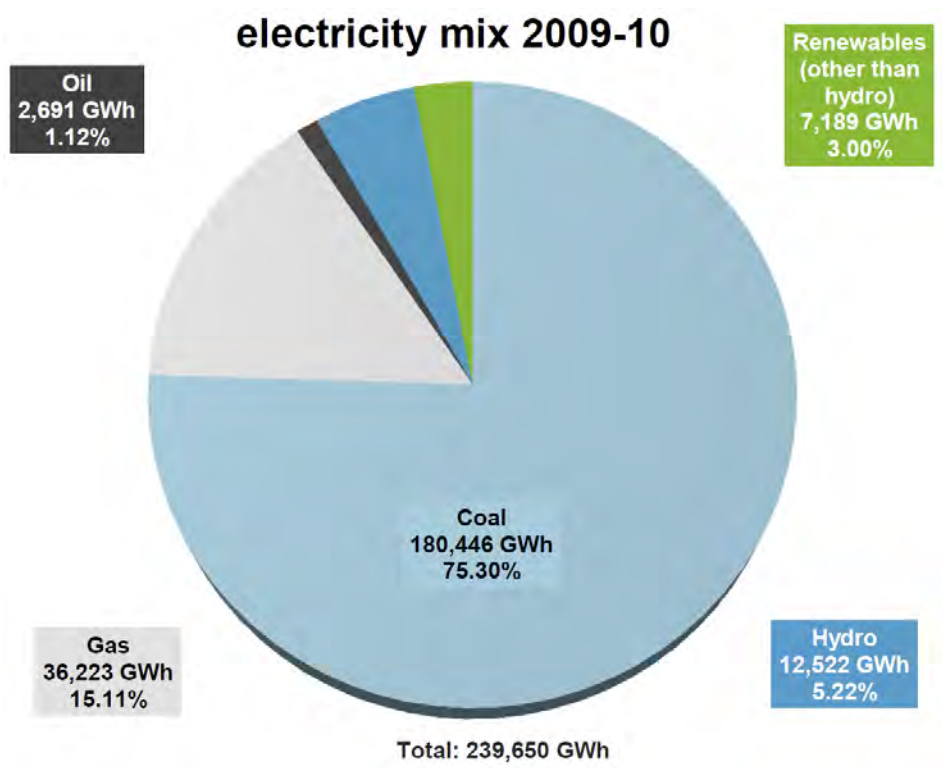


Figure 19 – Australia's national electricity mix 2009-10

Source: *Climate Change Authority 2012*

4.1.2 'Clean Energy Future'

The purpose of the Federal Government's current policy for energy use and development, known as the 'Clean Energy Future' package, is to promote a gradual transition to a low-emissions and renewable energy economy, particularly in the electricity generation, mining and waste disposal sectors. This package seeks to reduce Australia's GHG emissions by at least 5% by 2020 from 2000 levels, in comparison to a projected 24% increase over the same period under a 'business as usual' scenario (DCCEE 2011). Provision is also made within the package for a greater emissions reduction target of between 15% and 25% by 2020 which is conditional on the development of binding international agreements for international emissions reductions.

The 'Clean Energy Future' package seeks to achieve the Government's emissions reductions targets through the enactment of two principle pieces of legislation:

- *Clean Energy Act 2011* – which introduces a GHG emissions pricing mechanism to 'passively' alter market conditions to drive emissions reductions; and
- *Renewable Energy (Electricity) Act 2011* – a mandatory renewable electricity target (RET) to 'actively' require the market to invest in renewable electricity generation.

Carbon Pricing

The *Clean Energy Act 2011 (Commonwealth)* imposes a price (initially fixed at $23/tonne) on the GHG emissions of all major emitters in the Australian economy, including electricity generators, in order to (partially) reflect the environmental costs of the GHG emissions by existing carbon-intensive power generators. The carbon price is levied on all entities that emit more than 25,000 tonnes of GHG emissions per annum, which would include the operator of a precinct-scale cogeneration system. The carbon price, which commenced on 1 July 2012, is designed to be 'technology-neutral' in that it allows the market to decide which GHG emission reduction options are the most cost-effective to implement, and is expected to drive a reduction in the emissions intensity of the stationary energy sector (Interviewee B 2012).

Investment in centralised gas-fuelled electricity generation facilities (i.e. power stations) is expected to benefit significantly from the carbon price as it is:

- an established and proven generation technology in the Australian market, providing confidence in the investment and planning approvals risk profiles;
- often cost-competitive or cheaper than coal-fired electricity production prior to the introduction of the carbon price;
- significantly less emission-intensive than coal-fired electricity generation and the NEM as a whole;
- easier to locate new generation facilities in proximity to the transmission network due to the low energy costs associated with piping gas, thereby reducing upfront capital costs for new generation facilities to connect to the grid; and
- benefits from the economies of scale provided by a centralised facility in terms of operation and maintenance.

The transition to gas is expected to be market-driven under the carbon price (i.e. not requiring additional government intervention or investment) and will provide a greater share of electricity generation within the NEM (**Figure 20**). The rise of gas-fuelled electricity generation will have significant implications for cogeneration. Whilst cogeneration is more efficient and less carbon-intensive than centralised gas electricity generation, the economies of scale and the ability to connect to existing transmission and distribution infrastructure will continue to favour centralised gas over coal under the carbon price (Treasury 2011).

The demand generated by centralised gas electricity generation is likely to further exacerbate the significant projected increases in the price of natural gas as shown in **Figure 21**, thereby reducing over time the economic advantages of using this fuel for cogeneration (Institute for Sustainable Futures 2011).

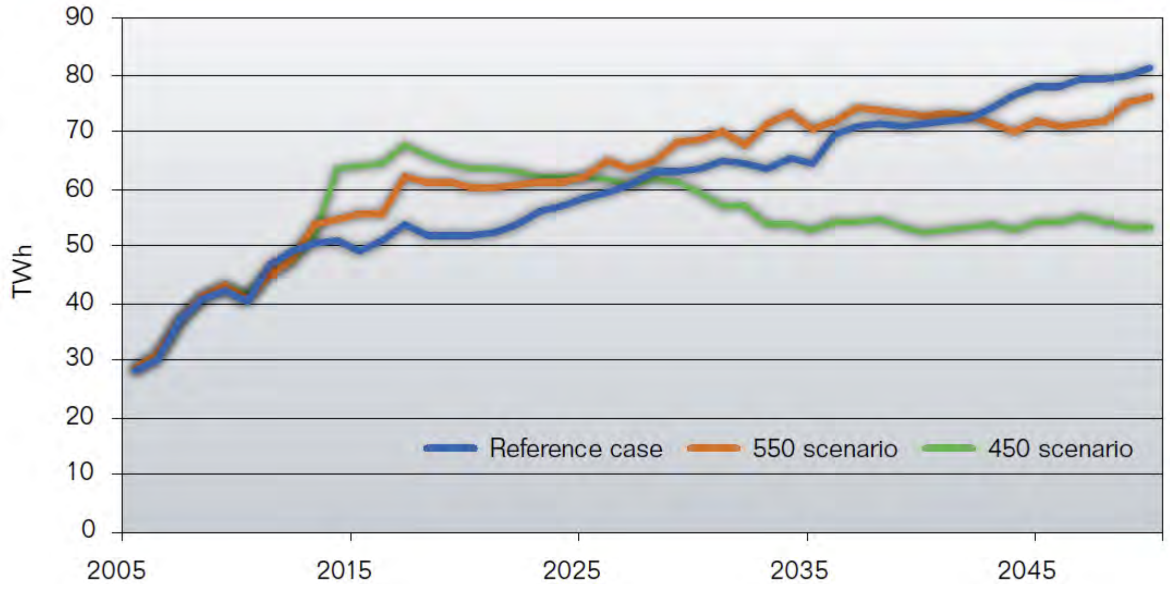


Figure 20 – Projected electricity from gas generation within Australia for high and low GHG emission reductions

Source: *Garnaut 2011, p498*

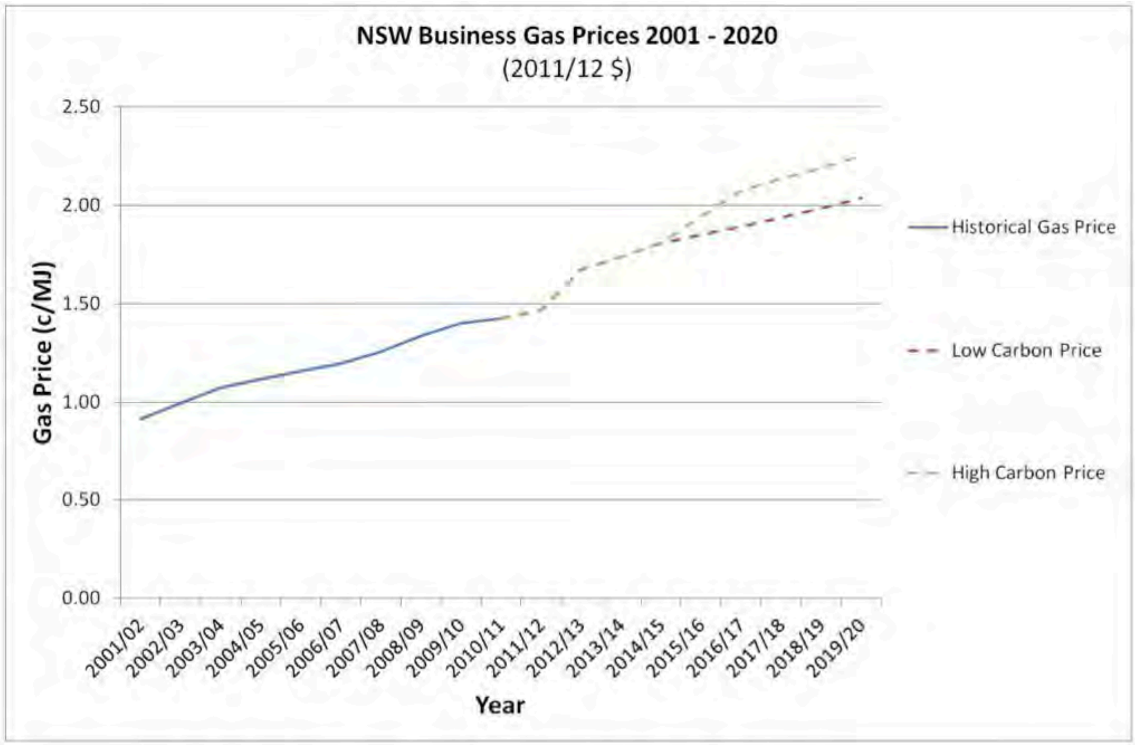


Figure 21 – Projected price of natural gas for business customers in NSW 2001-2020

Source: *Institute for Sustainable Futures 2012*

The administrative and regulatory requirements imposed by the *Clean Energy Act 201* (the carbon price) will place a comparatively greater burden on small-scale generating systems that are fossil-fuel based (such as precinct-scale cogeneration) than on larger electricity generators that benefit from greater economies of scale in meeting the administrative and regulatory requirements of the carbon price (Interviewee B 2012). Small-scale on-site cogeneration facilities would not be impacted by a direct liability under the carbon price, however the carbon price is incorporated in the cost of purchasing natural gas from the supplier (CER 2012).

Whilst the carbon price provides a comparative advantage to all technologies that reduce emissions below the 'business as usual' scenario, such as cogeneration, the advantage provided is far greater for zero-emissions technologies (i.e. renewables) than for 'low-emissions' technologies such as cogeneration and centralised gas electricity generation.

In light of the above, it is evident that the intent and mechanics of the carbon price introduced under the *Clean Energy Act 2011* is to enable a market-driven shift to the most economic energy generation technologies to reduce GHG emissions, and that whilst this shift is likely to marginally benefit cogeneration, the economy-wide shifts are likely to have additional adverse impacts for the feasibility of cogeneration development.

Renewable Energy Targets

The MRET was updated in 2010 under the 'Clean Energy Future' package to become the Renewable Energy Target (RET) (it is also still mandatory), which requires the electricity market to lift the share of <u>renewable</u> generation (inclusive of hydro) from 8.22% of total national electricity production in 2009-10 to at least 20% by 2020-21, which is expected to be borne almost exclusively by non-hydro renewables due to the limited environment capacity for expansion of hydro. This target is expected to require at least 45,000GWh of additional renewable electricity output annually, or more than six times the 2009-10 output of non-hydro renewable generation. The RET requires that at least 41,000GWh out of the 45,000GWh of new renewable energy must be generated by 'large-scale generators' that have a generating capacity of more than 100kw. This requirement is designed to drive investment in larger facilities that generate electricity more efficiently and are more cost effective to install and regulate, but it does not cap the amount of small-scale renewable energy facilities such as domestic-scale solar photovoltaics. Whereas the carbon price seeks to 'passively' direct the market towards emissions reductions, the RET is an 'active' intervention in the market that seeks to begin a long-term transition towards a zero-emissions stationary energy sector by generating an artificial level of demand for renewables not driven by economic markets. This policy is intended to financially support the cost of the additional research and development needed to further commercialise and scale-up the production of these technologies and allow them to become cost-competitive with existing technologies.

Even when fuelled by what City of Sydney Council terms ‘sustainable gas’ (a captured or synthesised gas generated from waste and biomass), cogeneration is not a true renewable energy generator and hence does not contribute towards or benefit from the 20% renewables target under the RET. Whilst not directly affecting the use of cogeneration, the RET will have a number of implications for the comparative economic and environmental benefits of on-site and precinct cogeneration and is likely to reduce the overall competitiveness of this technology in comparison to the grid (Blundell 2012; Interviewee A 2012; Interviewee B 2012; Precious 2012) for the following reasons:

- Grid electricity across the NEM will become significantly less carbon-intensive, reducing the comparative environmental advantage of cogeneration;
- Significant investment in large-scale renewables will drive the installation cost per unit of renewable energy lower through improved economies of scale in commercial production and further research and development; and
- The legislated need to achieve RET targets will divert investment away from fossil-fuel based ‘low-emission’ electricity generation technologies (e.g. cogeneration) in favour of zero emissions technologies (renewables).

The MRET and the RET have been critical in driving the development of wind farms across Australia as seen in **Figure 22** (CER 2012). Since 2000, 2,555MW of new wind power has been installed across Australia and a further 1,483MW of wind power is currently under construction (Clean Energy Council 2012). This includes the 420MW Macarthur Wind Farm located in Victoria– the largest wind power installation ever constructed in Australia at a cost of approximately $1 billion – which is currently two thirds of the way through a 30 month construction program (AGL Energy 2012). Wind farms in Australia operate at a capacity factor of between 30-35% (Miskelly 2012), meaning that installed capacity of any one ‘plant’ cannot be directly compared to a fuelled electricity generator such as cogeneration, which has the ability to operate at full capacity on demand. Despite this, the increased geographical distribution of wind power driven by the RET, as well as the anticipated development of large-scale solar PV and solar thermal electricity generators which maximise output during peak periods (Sandiford

2012) is expected to provide an increasingly reliable baseload and peak generation capacity within the NEM. This is expected to reduce demand for new power generation facilities which provide baseload energy (such as precinct scale cogeneration) and peak demand energy (which on-site generation is better suited to).

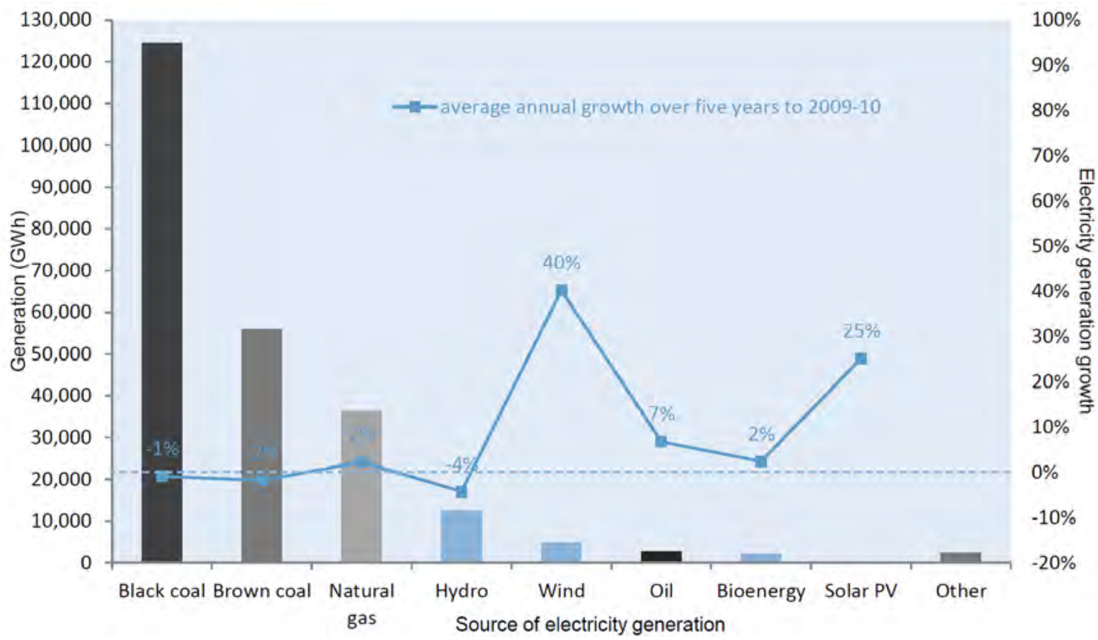


Figure 22 – Electricity production by fuel 2009-10, with growth shown in the five years to 2009-10

Source: *Climate Change Authority 2012*

4.1.3 Commercial and Residential Building Energy Efficiency

The period between 2000 and 2004 saw the commencement of the three key certification tools which today define the sustainable building industry in general and the use of cogeneration in particular, with NABERS (formerly AGBR) in 2000, Green Star in 2003 and BASIX (NSW only) in 2004. The primary purpose of both the NABERS and BASIX energy schemes is to improve building's energy efficiency and, as a result, reduce overall electricity consumption, whilst the Green Star rating seeks to adopt a broader measurement of a building's overall 'sustainability' which goes beyond energy.

Higher rated properties under these schemes can attract a rental return of between 6 and 10% above the market rate for commercial office space in the City of Sydney through their importance to higher-grade tenants such as government departments and national/international businesses (Jones 2012). The 'green premium' on commercial rental yields will in many cases justify additional investment required to upgrade a building's environmental performance, and a number of interview subjects attributed the growth of on-site cogeneration in Sydney directly to the influence and increased market power of these accreditation systems within the property sector (Interviewee A 2012; Midlam 2012; Precious 2012; Wickramasinghe 2012; Wyse 2012).

Whilst building ratings schemes have driven an uptake in on-site cogeneration, energy efficiency measures are favoured by property owners and tenants within the CBD as the primary method of achieving higher rating scores as these measures directly reduce operating costs and provide both a financial and environmental performance return (Blundell 2012; Cameron 2012; Interviewee A; Precious 2012; Property Council of Australia 2012; Sydney Business Chamber 2012). In submissions on the City of Sydney's *Decentralised Energy Master Plan – Trigeneration* and during in-depth interviews with property industry stakeholders as part of this thesis there was a clear and consistent message that building efficiency should be prioritised as a means of achieving emissions reduction ahead of cogeneration and has the potential to significantly reduce and/or remove demand for cogeneration.

Since the commencement of the building sustainability rating schemes a number of commercial building owners have achieved significant energy efficiency improvements across entire property portfolios, for example:

- Between 2004 and 2012 Investa reduced its property portfolio's energy consumption by 47% (Blundell 2012); and
- Between 2005 and 2012 GPT Group reduced its property portfolio's energy consumption by 28% and direct and indirect GHG emissions by 36% (Cameron 2012).

The use of building rating tools in the development assessment process for cogeneration in the City of Sydney is discussed in detail in **Section 4.3** and **Chapter 5.0** of this thesis.

Commercial Building Disclosure and NABERS

The *Building Energy Efficiency Disclosure Act 2010 (Commonwealth)* is a significant intervention by the Federal Government into building sustainability and is the key piece of legislation supporting the Commercial Building Disclosure Program (CBDP). Using the Commonwealth's powers over 'constitutional corporations' within the meaning of section 51(xx) of the Australian Constitution, the *Building Energy Efficient Disclosure Act 2010* requires the owner of a commercial building to disclose the NABERS energy and water efficiency rating in material for the sale or lease of any office building (or part thereof) which has a Net Lettable Area (NLA) of more than 2,000m^2. This is a powerful but 'passive' intervention in the property sector that encourages the market to lead investment in energy and water efficiency upgrades in buildings, particularly as many premium tenants (including government departments) will only occupy commercial spaces which meet a minimum NABERS rating in order to satisfy corporate environmental and social objectives (Wickramasinghe 2012).

The energy efficiencies provided by on-site cogeneration can significantly reduce the overall energy consumption of a building, particularly for heating/cooling requirements, and when implemented effectively cogeneration can directly improve a building's NABERS rating in comparison to the use of grid electricity. The other side of this advantage, however, is the potential for technical issues associated with the installation, operation and maintenance of often complex and sometimes incorrectly designed on-site cogeneration facilities, which can lead to buildings not achieving their designed NABERS rating (Wickramasinghe 2012; Wyse 2012). Particularly in a property market where a building's NABERS rating can directly impact upon the rents charged to tenants, the impacts of a poorly performing cogeneration plant on financial returns can be significant.

A draft ruling in July 2010 by the NABERS Steering Committee allows the energy efficiency and GHG reductions provided by precinct cogeneration schemes to be factored into the NABERS rating of a building which sources its energy from such a scheme (NABERS 2010), which was a departure from what has traditionally been a 'single building' ratings tool. By factoring in the energy savings achieved at the off-site cogeneration facility, the practical implication of this ruling is that a building connected to an on-site or precinct cogeneration or trigeneration system can achieve a 1 to 1.5 Star boost to its NABERS energy rating (Kinesis 2012Kinesis 2012). This ruling provides cogeneration with an advantage over grid-sourced GreenPower which by contrast (as an optional and 'virtual' purchase from the grid) cannot contribute to the base building NABERS rating that is required to be disclosed under the CBDP.

A position paper was issued by NABERS in July 2012 for public consultation which proposes to remove the consideration of GHG and energy savings achieved by buildings connected to precinct-scale cogeneration facilities due to difficulties in measuring the actual savings made by a precinct cogeneration facility as part of the assessment of a single building (NABERS 2012). This draft position would significantly undermine the demand for precinct-scale cogeneration in the City of Sydney as buildings connected to the precinct-scale cogeneration facility would gain no discernible benefit in their NABERS energy rating to reward the (significant) financial investment required to connect to precinct cogeneration (Interviewee A; Jones 2012; Midlam 2012; Property Council 2012; Wickramasinghe 2012).

Green Building Council of Australia – Green Star

The Green Building Council of Australia (GBCA) is a non-government organisation which develops and administers an optional building sustainability ratings tool known as 'Green Star'. Green Star is designed to provide a more broad-based assessment of a building's sustainability beyond only energy and water consumption and includes factors such as transport and accessibility, building materials and embodied energy. Specific rating schemes are tailored to different building categories, such as offices, retail, industrial and residential buildings.

'Green Star - Office v3 Credit Ene-5' is one of the Green Star rating criteria and provides improved ratings for office buildings that reduce their peak electrical demand by a certain percentage from the average building electrical demand. Two interview subjects specifically identified this aspect of the Green Star ratings tool as promoting the inclusion of on-site cogeneration facilities within office buildings for operation during key peak periods in order to achieve higher scores (**Figure 23**). It was further suggested that this scoring system is a potential weakness of the rating tool as it acts as a split incentive which unduly promotes the use of on-site cogeneration in an inefficient manner (i.e. only during peak periods) and may work against other efforts to reduce the overall electricity demand load and of 'flattening' a buildings' electrical demand profile (Interviewee A 2012; Precious 2012).

Green Star - Office Design v3 & Office As Built v3

Credit Summary for:

Energy

Ref No.	Title	Aim of Credit	Credit Criteria Summary	No. of Points Available
Ene - 5	Peak Energy Demand Reduction	To encourage and recognise designs that reduce peak demand on energy supply infrastructure.	Up to two points are awarded where it is demonstrated that the building has reduced its peak electrical demand load on electricity infrastructure as follows: One point where: Peak electrical demand is actively reduced by 15%; OR The difference between the peak and average demand does not exceed 40%. Two points where: Peak electrical demand is actively reduced by 30%; OR The difference between the peak and average demand does not exceed 20%.	2

Figure 23 – Excerpt from Green Star – Office v3 ratings scorecard

Source: *Green Building Council of Australia 2012*

4.1.4 Key Findings

Australian Federal Government policies prioritise a number of measures above cogeneration in seeking to achieve their policy objectives of reducing GHG emissions and overall electricity demand. In particular government policy at the national level prioritises a shift toward renewables and centralised gas-fired electricity generation as a means of 'greening the grid' and consequently reducing the indirect emissions of urban areas which are manifested in the stationary energy sector.

National building rating tools developed by both the government and non-government organisations generally favour energy efficiency over cogeneration. The way in which precinct scale cogeneration is factored into building sustainability under the NABERS rating tool is a particular area where the national policy setting is likely to have a major influence on the commercial feasibility of the development of cogeneration in the City of Sydney.

4.2 State Government Policy and Legislation

The NSW State Government holds primary responsibility for land use planning and development assessment practice under the *Environmental Planning and Assessment Act 1979 (NSW)*. The State Government is also responsible for electricity supply within the NSW region of the NEM as the current owner of the government corporations that operate the NSW electricity generators, transmission network and distribution network. The NSW Government has recently moved to sell the electricity generation assets to the private market (Department of Premier and Cabinet 2012).

The NSW Department of Planning and Infrastructure is the assessment authority for State Significant Development and State Significant Infrastructure, which includes some major electricity generating developments. The determination of such applications is generally delegated by the Minister for Planning to either the Director General of the Department or to the NSW Planning Assessment Commission. Most planning applications for cogeneration in the City of Sydney are, however, still determined at local government level as discussed later in this thesis.

4.2.1 Energy and Emissions Reduction

The *NSW Greenhouse Plan 2005* is currently under review by the NSW Government. As currently published it adopts an emissions reduction target for NSW of 60% by 2050 which was consistent with the target of the Australian Federal Government at the time the policy was released (it has recently risen to 80% by 2050). Prior to the introduction of the carbon price, the NSW Government operated its own emissions trading scheme which sought to reduce the emissions intensity of the state, however, this scheme has now been closed. Whilst the *NSW Greenhouse Plan 2005* is under review there are no specific emissions reduction policies or action items for the specific purpose of greenhouse gas emission reductions beyond those that apply at a national level.

4.2.2 Strategic Planning Policy

A number of NSW State Government strategic planning and environmental policies have direct implications for the development of cogeneration facilities in the City of Sydney, including strategic land use planning and environmental standards.

Metropolitan Plan for Sydney 2036

The *Metropolitan Plan for Sydney 2036* (the Metro Plan) sets out the strategic directions for land use across the entire Greater Sydney region and includes targets for housing, employment, transport and for “tackling climate change”.

Action G1.3 of the Metro Plan identifies the potential to introduce a mandatory minimum NABERS rating for commercial buildings as a key step to improving energy efficiency and reducing overall electricity demand, thereby reducing indirect GHG emissions from stationary energy for commercial centres. The adoption of the NABERS rating scheme for this minimum standard is likely to promote energy efficiency, and may lead to an increased use of on-site cogeneration. If NABERS ratings continue to take into account the energy efficiency and GHG emissions reductions provided by precinct-scale cogeneration systems then a minimum NABERS benchmark could generate substantial demand by buildings within the City of Sydney to connect to a precinct-scale cogeneration system.

Action G1.6 of the Metro Plan states:

> *The NSW Government will also continue providing advice and streamlining the planning system to facilitate adoption of low emission and renewable energy technology across Sydney. For example, the Department of Planning will release best practice guidelines on the application of low–emission technologies in developments to assist the building sector, including information on technologies, costs and benefits, and their application to a variety of developments..... and research will be conducted to encourage uptake of small scale cogeneration and trigeneration plants for multi–unit development. (NSW Department of Planning 2010, p.178).*

Interviewee B noted the commitment in the Metropolitan Plan 2036 to prepare 'best practice guidelines for low-emission technologies in developments', but noted that the Metropolitan Plan had been prepared under the direction of the former (Labor) government and that the plan was currently under review. Interviewee B had no knowledge of any internal action in NSW government departments or agencies to prepare such a plan, or undertake research into the use of cogeneration or trigeneration in multi-unit residential developments.

Guidelines for the use of on-site cogeneration would greatly assist in overcoming the lack of information that is available to the property industry regarding the economic and environmental implications of cogeneration facilities. This was identified as a key barrier to greater uptake of the technology more broadly in the City of Sydney property industry (Interviewee A 2012; Interviewee B 2012; Midlam 2012; Wickramasinghe 2012). The specific emphasis placed on the use of cogeneration and trigeneration in multi-unit residential development was queried by one interview subject (Interviewee B 2012), who along with other interview subjects and technical literature identify a number of other land uses such as industry, manufacturing, aquatic centres and hotels as better economic and environmental applications of cogeneration (Big Switch Projects 2012; Blundell 2012; Interviewee A 2012; Interviewee B 2012; Precious 2012).

Interim Nitrogen Oxide Policy for Cogeneration in Sydney and the Illawarra

Air quality protection is a significant environmental consideration in the planning and environmental assessment of cogeneration facilities. Guidance for this assessment is provided by the NSW Office of Environment and Heritage's (OEH) *Interim Nitrogen Oxide Policy for Cogeneration in Sydney and the Illawarra*, which states:

"*The Sydney CBD only has the capacity to accommodate uncontrolled emissions from around 10 MW of cogeneration before it is possible that health based nitrogen dioxide goals could be exceeded…It is likely that uncontrolled emissions from around 200 MW of cogeneration would result in the health based nitrogen dioxide goal being exceeded across the CBD*." (NSW Department of Environment and Climate Change 2008 p.3)

The cost of installing best practice catalytic reduction technologies to cogeneration systems at a precinct scale has been estimated to be in the order of $6/MWh, which by way of comparison is the equivalent of more than 10% of the average price of 'grid' electricity in NSW (City of Sydney 2010 p.31). Emissions from on-site cogeneration systems are able to be disbursed more easily and as such have reduced environmental impacts compared to precinct-scale generators, and are generally able to avoid the significant cost of these air quality emissions, however this represents a significant cost on precinct-scale systems (Interviewee B 2012). It was also suggested that if on-site cogeneration is expected to significantly increase within the City of Sydney then a more comprehensive strategic air quality assessment will need to be undertaken to understand the potential air quality impacts to avoid adverse public health impacts (Interviewee B 2012).

4.2.3 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979 (NSW)* (the Act) is the principal piece of legislation which enables land use planning and development assessment within the State.

Under the Act, land use controls are generally implemented by environmental planning instruments (EPIs) known as State Environmental Planning Policies (SEPPs), which are generally state-wide planning instruments developed by the NSW Department of Planning and Infrastructure (the Department), and Local Environmental Plans (LEPs) which are generally developed by local government in cooperation with the Department and Parliamentary Counsel.

The following SEPPs are relevant to the development of cogeneration facilities:

- State Environmental Planning Policy (State and Regional Development) 2011;
- State Environmental Planning Policy (Infrastructure) 2007;

The operation of the development assessment systems which apply under the Act within the City of Sydney are considered in detail at **Chapter 5** of this thesis.

State Environmental Planning Policy (State and Regional Development) 2011

Part 2 of *State Environmental Planning Policy (State and Regional Development) 2011* (the State and Regional Development SEPP) provides that certain development described in Schedule 2 is declared to be 'State Significant Development' (SSD) for which the NSW Minister for Planning is the consent authority.

Clause 20 of Schedule 1 of the EP&A Act provides that:

> *Development for the purpose of electricity generating works or heat or their co-generation (using any energy source, including gas, coal, biofuel, distillate, waste, hydro, wave, solar or wind power) that:*
>
> *a) has a capital investment value of more than $30 million, or*
>
> *b) has a capital investment value of more than $10 million and is located in an environmentally sensitive area of State significance.*

It would be extremely rare for an on-site cogeneration development to have a capital investment of more than $30 million (Wickramasinghe 2012), and there are relatively few areas within the City of Sydney which are classified as 'environmentally sensitive areas' and would hence trigger the lower value (generally reserved only for State Heritage Items in the CoS). Dependent upon the staging and rollout process it is possible, however, that a precinct cogeneration system may trigger this value and fall within the SSD approvals stream.

The development assessment requirements for development which qualifies as SSD is more stringent than for development assessed under Part 4 of the Act, and requires the preparation of an Environmental Impact Statement and a higher level of public consultation. Whilst this ensures that the environmental impacts of major development are thoroughly assessed, it also has the potential to increase the time and cost required to gain development approval for a large-scale cogeneration facility.

Clauses 89K of the EP&A Act streamlines the approvals and licensing process for State Significant Development by requiring that many other environmental approvals and licenses that may be required must be issued and that the terms of these approvals must be consistent with the issued development consent. This provision is particularly valuable for larger cogeneration developments which qualify as SSD and where the scale of air pollutants emitted by the facility would trigger the requirements for a license under the *Protection of the Environment Operations Act 1997.* In this respect the SSD process simplifies the environmental approvals process for larger cogeneration developments, and reduces the complexities and uncertainties of follow-on environmental approvals that are inherent in the planning system and cause delays and risk for developers.

State Environmental Planning Policy (Infrastructure) 2007

Division 4 of *State Environmental Planning Policy (Infrastructure) 2007* (the ISEPP) includes provisions which permit the carrying out of certain electricity generating works as either permissible with or without consent under Part 4 of the Act or as Exempt or Complying Development. The provisions of the ISEPP prevail over any inconsistent provisions in local environmental planning instruments and provide a consistent planning assessment process for energy development across NSW.

Clause 34(1) of the ISEPP allows development for the purpose of a cogeneration facility to be installed with development consent as 'electricity generating development' on any land which is zoned industrial, rural or special use. This provision can be useful in permitting stand-alone cogeneration development to occur in a zone where it would otherwise be identified as prohibited development under a LEP.

Subject to certain conditions, the ISEPP permits the development of certain small-scale wind turbines (<10kW in residential zones, <100kW in rural, industrial and special use zones) and solar PV development (<100kW) as Exempt or Complying Development (i.e. privately certified against a fixed set of criteria) by any person on most land. Domestic-scale electricity generation such as roof-mounted solar PV may be carried out as Exempt Development provided it complies with restrictions on location and generating capacity. Larger solar and wind installations may be carried out as Complying Development outside of residential zones, allowing solar PV development for installations up to 500m^2 in area or up to 3 wind turbines up to 35m in height to be carried out. The provisions of the ISEPP effectively override any inconsistent provisions in an LEP.

The ability to use the Exempt or Complying Development codes for the installation of renewable energy installations provides developers of these facilities with a high degree of certainty when making investment decisions, as well as providing a faster approvals pathway in comparison to gaining development consent from a local authority under Part 4 of the EP&A Act.

The ISEPP does not include any provisions for the installation of a cogeneration facility as Exempt or Complying Development, meaning that development for this purpose requires planning consent and must go through the slower and more complex Development Application process. This provides a significant advantage to small-scale solar and wind developments in terms of the timing and risk associated with the planning approvals process for energy generation.

4.2.4 Key Findings

NSW State Government policy generally aligns with Federal Government policy in that it has consistent GHG emission targets, and seeks to facilitate a market-led approach which is focused on renewable energy development and building energy efficiency. Specific provisions for cogeneration development are largely absent from State Government strategic and statutory planning documents, which is a product of the low market-penetration of this energy technology.

The lower priority given to cogeneration development under State and Federal Government strategic policies in favour of renewable energy is reflected in NSW's environmental planning instruments which provide simpler development assessment frameworks for renewable energy. Whilst the *Metropolitan Plan for Sydney 2036* seeks to provide a more 'level' playing field for cogeneration by committing to undertake technical studies for the incorporation of cogeneration in the limited application of residential flat buildings, these action items do not appear to have been progressed.

4.3 City of Sydney Council – Strategic and Statutory Planning

The City of Sydney Council is responsible for local strategic planning, the preparation of local planning instruments and development controls within the City of Sydney Local Government Area (LGA). Council is generally the consent authority for development that requires consent under Part 4 of the *Environmental Planning and Assessment Act 1979* within the LGA, however the Central Sydney Planning Committee is the consent authority for development with an estimated cost of more than $50 million.

4.3.1 Sustainable Sydney 2030

Sustainable Sydney 2030 (SS2030) is the overarching strategic vision prepared by Council that is currently guiding the City of Sydney's policies on urban development, energy and sustainability. Released in 2008 following an extended period of consultation with City of Sydney residents and businesses, the final document sets out a number of key strategies which are intended to assist Sydney to become 'Green, Global, Connected'.

Of the ten strategic directions and ten targets that are identified under the strategy, the following are directly relevant to forming the GHG emission reductions and energy generation policies which influence the development of cogeneration:

- Objectives:
  - A Globally Competitive and Innovative City;
  - A Leading Environmental Performer;
  - Sustainable Development, Renewal and Design; and
  - Implementation through Effective Partnerships.
- Targets:
  - Reduce LGA-wide GHG emissions by 50% from 1990 levels and by 70% from 2006 levels.
  - Have the capacity to meet up to 100% of electricity demand by local electricity generation.

Cogeneration, Electricity and Greenhouse Gas Emission Targets

SS2030 targets GHG emission reductions that are more ambitious, in the short-term, than those adopted by the Federal Government. Council has deliberately sought to position Sydney as a world-leader in environmental performance, a move which has generally been welcomed by the property industry as being consistent with Sydney's status as Australia's pre-eminent world city (Blundell 2012; Cameron 2012; Clean Energy Council 2012; Green Building Council of Australia 2012; Property Council of Australia 2012). It is noted, however, that as shown in **Table 3**, SS2030 adopts emissions reduction targets that are not directly comparable to the Federal and State emissions reduction targets. This is likely to make monitoring and meaningful comparison of the City's strategy against national emissions reductions difficult (Interviewee B 2012).

Table 3 – Comparison of Government Carbon Emissions Reduction Targets

Government Level	'Business as Usual' assumption	2020 emissions	2030 emissions	2050 emissions
Federal Government[1]	+24% from 2000 to 2020	-5% to 25% from 2000 levels	N/A	-80% from 2000 levels
NSW Government[2]	N/A	N/A	N/A	-60% from 2000 levels
City of Sydney Council[3]	+15% from 2006 to 2030	N/A	-50% compared to 1990 levels	-70% from 1990 levels

Sources: 1. *DCCEE (2012)* 2. *NSW Greenhouse Office (2005)* 3. *City of Sydney (2008)*

SS2030 outlines a series of direct emissions reductions programs summarised in **Figure 24** that will be facilitated and/or directly undertaken by the City of Sydney Council in order to achieve the 2030 emissions target. The rollout of natural gas fuelled precinct-scale cogeneration facilities, or 'Green Transformers' as they are branded under SS2030, is expected to provide over a quarter of the City's planned GHG reductions This measure is also expected to account for an overall reduction in the City's GHG emissions of 20%, and represents the single largest emissions reduction measure under the strategy (City of Sydney 2008).

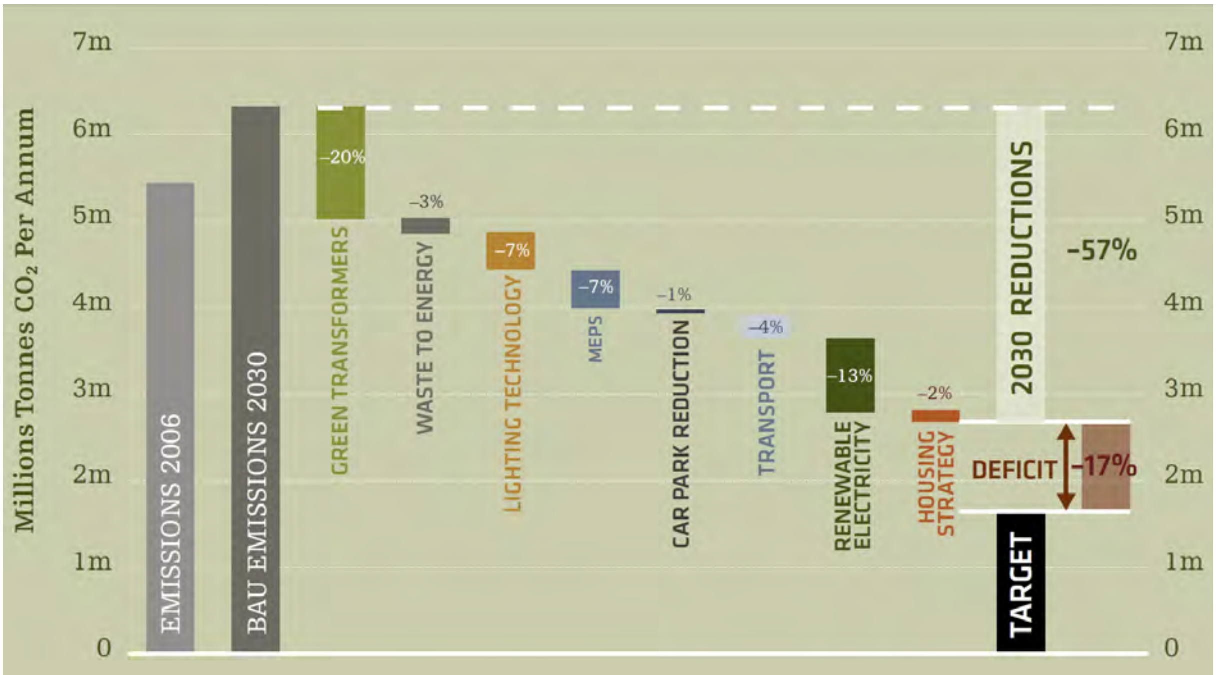


Figure 24 – City of Sydney's LGA-wide GHG emissions reduction 'portfolio'

Source: *City of Sydney 2008*

In justifying the decision to transition towards natural gas-fuelled precinct-scale cogeneration to meet the bulk of the City of Sydney's energy needs by 2030, SS2030 states that:

> *A fully renewable future is a desirable goal – however, this cannot happen overnight. The Vision offers a transition technology and fuel that will significantly reduce emissions and that is available for large-scale use at an acceptable cost. Cogeneration and gas is such a combination.*

Wind power is the only non-hydro renewable energy technology that has been developed on any meaningful scale in Australia to date (Clean Energy Council 2012). At the time of SS23030's release in 2008 only 823.4MW (just over double the nameplate capacity of the proposed Green Transformers) of grid-connected wind power had been installed in the 15 years since the first wind farm was developed in Australia in 1993 (Clean Energy Council 2012). Of this installed capacity, only five wind farms had a generating capacity of more than 50MW with the largest having a generating capacity of 90.75MW. Together these five wind farms located in South Australia, Victoria, Tasmania and Western Australia accounted for nearly half of all installed capacity. The largest wind farm in NSW had a nameplate generating capacity of only 9.9MW.

In this context it was reasonable at the time of SS2030's release in 2008 for the City of Sydney to come to the view that renewables could not realistically be implemented in NSW on a scale large enough to meet the demand generated by the City of Sydney, or soon enough to meet the near-term GHG emissions reduction targets. The view that a ‘stop-gap’ fossil fuel-based technology such as cogeneration was the best way to meet the SS2030 GHG emission reduction target was entirely justifiable. Unfortunately the review period for the SS2030 strategy is only every 5 years from the commencement of the strategy, which is too long to respond to the rapid technological and financial changes in the Australian energy markets. Since the commencement of SS2030 the City of Sydney has already taken significant steps in preparing for the rollout of its precinct-scale cogeneration scheme, as discussed in further detail at **Chapter 5**, but due to the lack of a review of the SS2030 strategy there does not appear to have been any re-examination of the assumptions which underpin this program, such as the capacity of renewables to service the City of Sydney.

In the four years since the release of SS2030 and the present, the total generating capacity of wind power in Australia has more than tripled, with over 1,700MW of new generating capacity being connected to the grid and total installed wind farm capacity now totalling 2,565MW. This has included 265.7MW of new generating capacity located in NSW, including large scale wind farms such as the 140MW Capital Wind Farm located near Lake George. At present, a further 1,483MW of wind farm generation capacity is under construction across the country and due for completion by 2014. This will bring total generating capacity supplied by renewable wind energy to over 4,000MW. **Figure 25** shows the significant increase in the uptake and scale of wind farm development in Australia since the release of SS2030, and it is anticipated that this growth is likely to continue for the foreseeable future (Interviewee B 2012). It is also anticipated that large-scale geothermal, solar thermal and solar PV electricity generation will emerge as significant contributors to baseload renewable energy production under the RET as these technologies are commercialised further and costs decrease (Wright 2012).

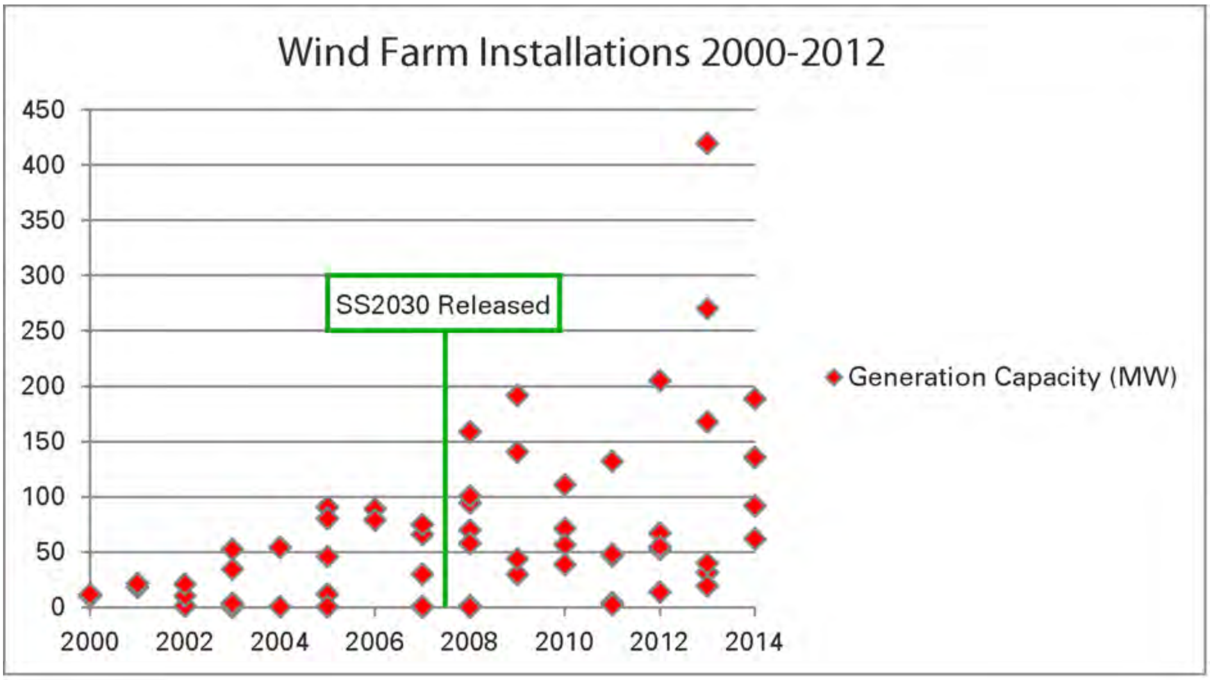


Figure 25 – Installed wind farm generation 2000-12 and wind farms under construction to be connected by 2012

Source: *Author with data from Clean Energy Council 2012*

Cogeneration and 'Energy Security'

The GHG emission reductions provided by the rollout of 'Green Transformers' across the City of Sydney is the primary reason for the inclusion of the program under SS2030, however energy security is also briefly mentioned as a secondary justification (it receives only two mentions in the 111 page document) and has more recently been stated by proponents of the scheme as one of the key benefits (Midlam 2012; Jones 2012). All modern commercial buildings within the CBD incorporate backup electrical generation systems (generally gas or diesel generators) which are in place as a safeguard should the electricity distribution systems fail. These backup systems allow key building services such as lighting, air conditioning, IT systems and computers to continue operating and allow the building to continue functioning during network disruptions, but are expensive in terms of both upfront capital costs and ongoing maintenance.

Proponents of the rollout of precinct-scale cogeneration systems have stated that the provision of precinct-scale cogeneration energy supply by private wire networks will allow the traditional electricity grid to serve as the failsafe and make the provision and/or scale of onsite backup systems redundant and save building owners money (Jones 2012). This claim is disputed by property owners and outside observers, who point out that grid electricity cannot act as a failsafe for building heating and cooling systems that rely on centralised hot water distribution from the 'Green Transformers' such as absorption chillers, as these chillers cannot be operated solely on electricity. In order to back these services up a largely independent system of electricity-driven heating and cooling building plant would be required solely for backup which would simply duplicate on-site equipment (Interviewee A 2012; Interviewee B 2012; Precious 2012). This discrepancy has the potential to negate and potentially outweigh the capital cost savings for building plant equipment.

It is also noted that the operator of the electricity distribution system in Sydney, or 'the grid', has invested heavily since 2007 to improve the reliability and performance of CBD infrastructure to improve energy security of the city. It is anticipated that this investment program will achieve new higher performance levels by 2014 (Ausgrid 2012). The need to achieve further 'energy security beyond these standards was questioned by industry stakeholders (Interviewee B 2012).

Given that there is already significant investment underway to improve 'energy security' in the City of Sydney, and that the property industry is of the view that the 'Green Transformers' do not add any value in this respect anyway, it is unclear why this concept has been linked with the precinct-scale cogeneration proposal.

4.3.2 Sydney Local Environmental Plan 2005

The *Sydney Local Environmental Plan 2005* (the LEP) is the principal local planning instrument which applies to the Sydney CBD and surrounds and outlines the land use zones and planning controls for development within the city. On-site cogeneration for the purpose of supplying a single building or cluster of related buildings would generally be considered to be ancillary to the primary land use of the site (i.e. a commercial premises or a residential use) and would be permissible with development consent provided that it was not considered a separate use in its own right (i.e. if it was purposefully designed and operated to export energy to the grid, rather than only occasionally exporting surplus electricity).

A precinct-scale cogeneration facility developed by, or under the authority of, Council or another government department or agency would be defined as a 'public utility undertaking' under the LEP and is permissible with development consent within all land use zones[2].

[2] Development for the purpose of a 'public utility undertaking' is permissible with consent within the 'Residential-Business' and Public Recreation' zones in the Ultimo-Pyrmont planning area only if it is considered to be consistent with the objectives of the applicable zone.

4.3.3 Draft Sydney Local Environmental Plan 2011

The only material change to local planning controls for cogeneration under the *Draft Sydney Local Environmental Plan 2011* (the Draft LEP) is that the development of a precinct-scale cogeneration facility would be defined as 'electricity generating works'. As a result development for the purpose of a precinct-scale cogeneration facility would become a prohibited use within the 'B3 Commercial Core' zone (this applies only to a few local centres), the 'SP1 Special Activities'[3] zone and the 'SP2 Infrastructure'[4] zone. The prohibition within the SP2 zone has the potential to prevent the future development of precinct-scale cogeneration within the identified cogeneration 'hotspot' of Sydney University without amendment to the LEP.

4.3.4 Central Sydney Development Control Plan 1996

The *Central Sydney Development Control Plan 1996* (the DCP) contains detailed development controls for development carried out within the Sydney CBD and surrounds. The DCP is over 10 years old and as such contains no provisions which are directly relevant to the development of cogeneration facilities. Section 4.3 of the DCP does however promote the development of energy efficient buildings by requiring all DAs for development valued at more than $1 million to provide a report which demonstrates that the building design optimises energy efficiency above base standards.

4.3.5 Draft Sydney Development Control Plan 2010

Section 2.4 'Ecologically Sustainable Development' (ESD) of the Draft DCP notes that the DCP will be updated to reflect the provisions of the *Decentralised Energy Master Plan – Trigeneration*, however, it does not specifically state what type of development controls or requirements the DCP will ultimately impose with respect to this plan. The only mention in the DCP which may be construed as referring to on-site cogeneration is contained in Section 2.4 and states that:

> *Council generally encourages all applicants to implement the principles of Ecologically Sustainable Development (ESD) in the proposed development.*
>
> *Implementing the principles of ESD means that the development will be designed and constructed so that:*
>
> a. *Greenhouse gas emissions will be reduced.*

[3] May be permissible if marked specifically on the map for that land.

[4] As per Footnote 4.

b. *The use of cogeneration and tri-generation systems will be increased.*
c. *Low carbon and renewable energy use will be increased.*
d. *Potable water use will be reduced.*
e. *Development can adapt to climate change.*

Whilst the Draft DCP includes development controls regarding the siting, size, environmental impacts and performance of wind turbines and solar PV panels, there is no guidance within the DCP for on-site cogeneration facilities. This absence of any planning guidance does little to rectify the absence of information regarding the development of cogeneration nor does it do anything to increase the use of cogeneration, which the Draft DCP and SS2030 both identify as a key component of ESD as shown in the excerpt above. By contrast the Draft DCP includes specific requirements designed to promote energy efficiency in non-residential development, but remains notably absent on guidance for cogeneration development.

4.4 Key Findings

Unlike Federal and State policies, which place a significant emphasis on building energy efficiency as a key source of GHG emissions reduction across the economy, the City of Sydney Council's strategic planning under SS2030 seeks to achieve only a small reduction in emissions from building energy efficiency (lighting and Minimum Energy Performance Standards) of 14%. This is despite the fact that building emissions account for 75% of the City's current GHG emissions, and that the commercial buildings which are targeted by Federal Government NABERS program are predominately located in major CBDs such as the City of Sydney. In light of the significant energy use reductions achieved by major commercial property owners in Sydney through energy efficiency measures, such as The GPT Group (28% reduction over 7 years) and Investa (47% reduction over 8 years), and the view held by both these companies and the Property Council of Australia that far greater reductions are both possible and commercially feasible, SS2030 seems to considerably undervalue the potential contribution of energy efficiency to GHG emission reductions over the period to 2030 (Ausgrid 2012;Big Switch Projects 2012; Blundell 2012; Cameron 2012; Interviewee A 2012; Interviewee B 2012; Precious 2012; Property Council of Australia 2012; Sydney Business Chamber 2012).

The strategic decision made in SS2030 to focus GHG reduction action and investment on the development of precinct-scale cogeneration rather than building energy efficiency significantly impedes vertical policy integration for GHG emissions reductions across the Australian economy by creating a disconnect between Federal/State policy and Council policy, and even between Council's own strategic planning policy and statutory planning policy. As seen in the international case studies, GHG emissions reductions are best achieved when the policies at all hierarchies of government are supportive and generally consistent (**Chapter 3**). The Federal and State Government policies clearly demonstrate a policy setting which favours and advantages building energy efficiency and a 'greening of the grid' with renewables over emissions reduction measures such as cogeneration. This misalignment of the policy setting is likely to hinder the GHG emissions strategies sought by both the Australian/NSW governments and by the City of Sydney.

There is also a misalignment in the vertical policy integration between SS2030 and the City's current and draft LEPs and DCPs, as well as between SS2030 and the NSW ISEPP. The statutory planning instruments of both the State Government and City of Sydney Council include clear guidelines and provisions for renewable electricity generation such as solar PV and wind turbines, and require energy efficiency measures to be undertaken and demonstrated at the design/Development Application stage. The Draft Sydney LEP proposes to make 'electricity generating infrastructure' a prohibited use within the 'SP2 Infrastructure zone', including land which is identified under SS2030 as suitable for precinct-scale cogeneration. These controls sit at odds with the City's strategic planning to promote precinct-scale cogeneration and are likely to create confusion in the property industry about the environmental performance systems which should be incorporated in the design of new buildings and major building renovations, thereby hindering the achievement of the overarching environmental objectives.

5.0 Cogeneration Developments in the City of Sydney

At present cogeneration facilities which have been developed, or approved for development, within the City of Sydney Local Government Area (LGA) have been limited to on-site facilities for single buildings due to a reliance on government to implement precinct-scale systems. This chapter analyses the patterns of development, key drivers and development assessment processes for these on-site facilities, whilst also evaluating the rollout of precinct-scale cogeneration under the City of Sydney's *Decentralised Energy Master Plan –Trigeneration*.

5.1 On-Site Generation

5.1.1 Development Patterns in the City of Sydney

Since 2005 there have been a total of 11 development approvals granted for development either involving, or for the purpose of, the installation and use of cogeneration facilities in commercial and residential premises within the City of Sydney LGA. These developments have been located primarily within the Sydney Central Business District as seen in **Figure 26**.

On-site cogeneration has predominately been used in commercial office buildings in the City of Sydney, with seven buildings serviced by cogeneration plants that have generating capacities of between 160kW and 1.54MW. Cogeneration facilities were provided in commercial office buildings as part of both new developments (4) and as part of major retrofits of existing buildings (3), including one within a locally listed heritage item (Legion House).

In the residential sector the 160kW cogeneration facility at The Hyde is used primarily for pool heating and common areas, with some supplementary hot water heating, whilst the 700kW cogeneration facility at The Quay apartments in Pyrmont will provide hot water and space heating for 270 apartments and a 4,000m^2 retail centre over the lower 3 levels.

The redevelopment of the Westfield Sydney shopping centre and the construction of a new commercial office tower on the site supported the installation of the second largest cogeneration facility (configured for trigeneration) operating within the City of Sydney (behind the Global Switch building).

The largest facility, located in the Global Switch building in Pyrmont, is a trigeneration system using nine separate gas engines with a total generating capacity of 38.7MW. This facility has a generating capacity larger than all of the other approved cogeneration plants in the city combined. This Global Switch data centre has high and relatively constant electrical and cooling requirements 24 hours a day by the nature of its operations, which is well-suited to the efficient operation of trigeneration system. The Global Switch facility was one of the four projects involving cogeneration that were approved by the Minister for Planning rather than the City of Sydney Council.

A full summary of the details of the 11 approved cogeneration facilities for commercial and residential buildings in the City of Sydney LGA is provided at **Table 4** below and mapped in **Figure 26** below.

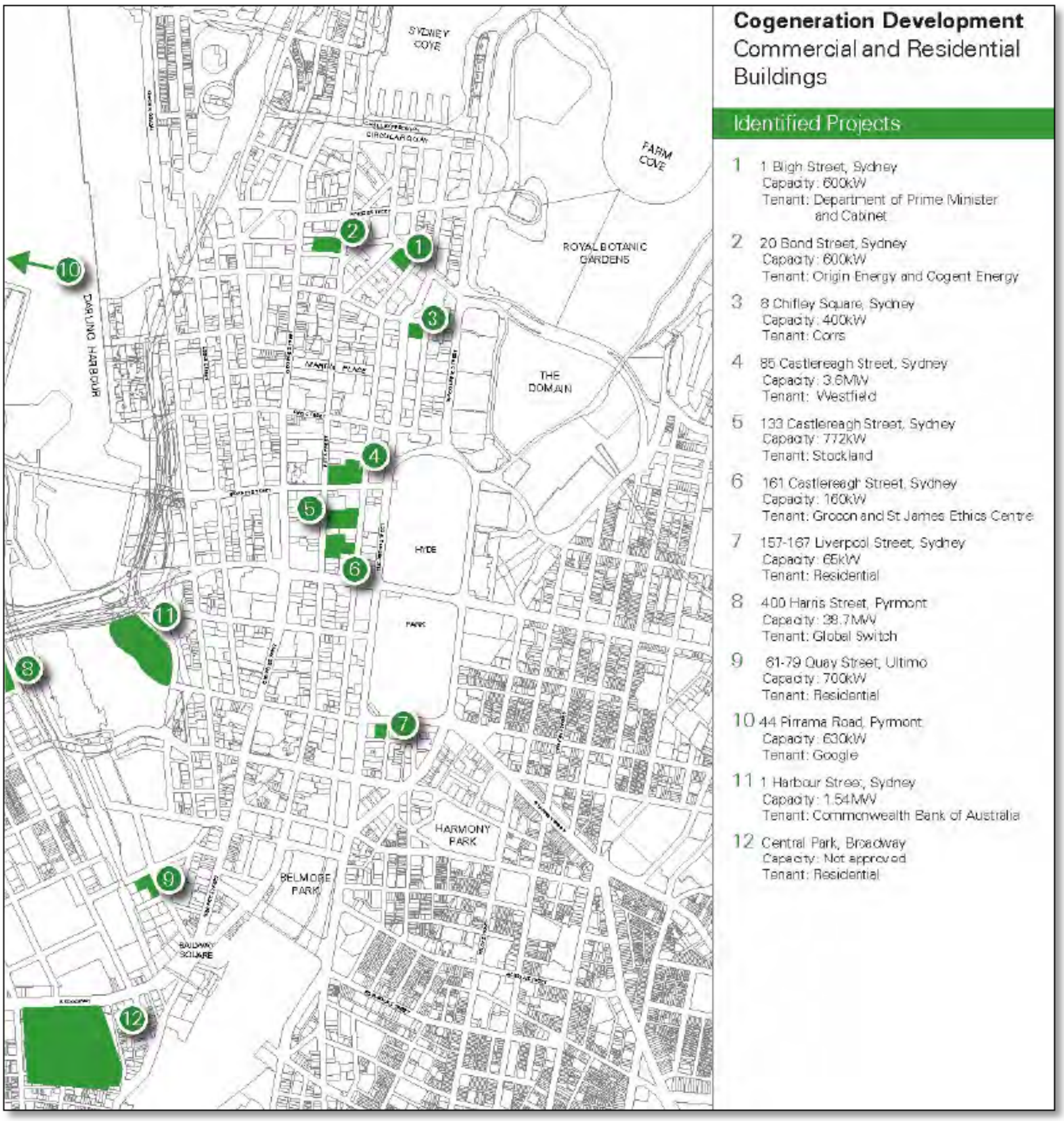


Figure 26 – Location of approved cogeneration facilities in City of Sydney
Source: *Author 2012*

Table 4 – Summary of planning approvals for cogeneration facilities within the City of Sydney LGA

Site Address	Building Name	Proponent	Building Type	Cogen/ Trigen	Project Description	Major Building Tenant	Application Reference #	Approval	Generator Capacity (electrical)	Assessment Report	Relevant Conditions of Consent	GBCA/ NABERS Energy	NLA (GFA)	Notes
1 Bligh Street	N/A	DEXUS	Commercial Office	T	New Commercial Office Tower	Clayton Utz/ Dpt. Prime Minister and Cabinet	D/2007/1270 (CoS)	July 2008	600kW	Mentioned only in context of achieving ESD ratings.	None	6-Star Design/ 5 star NABERS	42,282	
20 Bond Street	N/A	Mirvac (with Investa)	Commercial Office	C	Retrofit and fitout of entire 31 storey office building	Origin Energy/ Cogent Energy	D/2009/1384 (CoS)	October 2009	600kW	Mentioned in assessment of ESD performance.	None	4-Star Green Star As Built/ 5 Star NABERS	33,000	
8 Chifley Square	Chifley Square	Mirvac	Commercial Office	C	New Commercial Office Tower	Corrs Chambers Westgarth	D/2008/368 (CoS)	March 2009	400kW	Mentioned in assessment of ESD performance.	5-Star NABERS	6-Star Design/5-Star NABERS	19,120	
85 Castlereagh Street	Westfield Centrepoint	Westfield	Retail and Commercial Office	T	New retail and commercial office tower	Westfield/ JP Morgan	D/2007/1228 (CoS)	December 2007	3.6MW	Mentioned in context of ESD performance and ratings.	5-Star As Built and 5-Star NABERS, minimum 30% reduction in energy use on existing buildings	6-Star Design/ 5-Star As Built/ 5-Star NABERS	(145,000)	1
133 Castlereagh Street	Picadilly Complex	Stockland	Commercial Office	C	Retrofit of 7 storeys of existing building.	Stockland	D/2006/959/B (CoS)	May 2007	772kW	Mentioned in context of ESD performance and ratings.	Min. 4.5 Star NABERS Energy	4.5 NABERS	39,436	
161 Castlereagh Street	Legion House	Grocon (The GPT Group, La Salle, ISPT)	Commercial Office and Retail	C	Retrofit of existing heritage building and two storey addition	Grocon NSW/ St James Ethics Centre	D/2007/1792/ H (CoS)	December 2011	160kW	Noted OEH referral	Quarterly emissions monitoring, limit on engine size, NOx engines, fuel type, management plan, noise, 6 pages of conditions relating solely to cogen plant.	6 Star Design/ 6 Star NABERS		
157-167 Liverpool Street	The Hyde	Stockland	Mixed-use Residential and 3 levels of Retail	C	Residential Flat Building	N/A	D/2006/1400 (CoS)	November 2006	65kW	Not mentioned.	None.	BASIX certified	18,856	

Site Address	Building Name	Proponent	Building Type	Cogen/ Trigen	Project Description	Major Building Tenant	Application Reference #	Approval	Generator Capacity (electrical)	Assessment Report	Relevant Conditions of Consent	GBCA/ NABERS Energy	NLA (GFA)	Notes
400 Harris Street, Pyrmont	Global Switch	Global Switch Property (Australia) Pty Ltd with Sydney Harbour Foreshore Authority	Data Centre	T	Retrofit of former NSW Government Printer building	Global Switch	MP 08_0222 (Department of Planning and Infrastructure)	November 2010	38.7MW (total)	Notes reduction in CO2 emissions associated with natural gas fuel, refers to DECCW (now OEH) requirements on emissions	Statement of Commitments on emissions, acoustics, ESD, requirement for POEO license	N/A	22,285	
61-79 Quay Street, Haymarket	The Quay	The Quay Haymarket Pty Ltd	Residential and Retail	C	New residential flat building	N/A	D/2010/950 (CoS)	December 2010	700kW (total	Noted in ESD, as positive environmental consideration, further air quality analysis required.	Air quality assessment to be undertaken prior to CC	BASIX/ 5-Star Design for Retail	30,263	
44 Pirrama Road, Pyrmont	Workplace6	Citta Property Group (The GPT Group)	Commercial Office	C	New commercial office building	Google	Unknown (Department of Planning and Infrastructure)	January 2005	630kW	Unknown.	Unknown.	6-Star As Built	18,000	2
1 Harbour Street	Darling Quarter	LendLease	Commercial Office	C	New commercial office building with retail	Commonwealth Bank of Australia	MP08_0057 and MP08_0092 (Department of Planning and Infrastructure)	December 2008	1.54 MW	Mentioned in reference to achieving ESD ratings.	5-Star Design/ 5 Star NABERS	6-Star As Built/ 5 Star NABERS	58,000	

Notes

1. Westfield received a $2 million grant from the NSW Office of Environment and Heritage to assist in funding this project (DCCEE 2012).
2. Consent was granted by the (then) Minister for Planning on 31 January 2005 as the consent authority under *Sydney Regional Environment Plan No.26 – City West*. Documents relating to the base building and cogeneration plant DA were not able to be obtained.

5.1.2 Key Influences on On-Site Cogeneration Development in Sydney

The review of the development consents identified three primary factors which have influenced the decision to use cogeneration in commercial premises and residential buildings in the City of Sydney:

- Managing thermal and electrical demand;
- Achieving higher building energy efficiency and sustainability ratings; and
- Building services and infrastructure investment cycles.

Managing thermal and electrical demand in buildings

Cogeneration developments over the past four years have predominately been driven by the development of buildings which have high thermal and electrical demands for space heating and cooling. In these buildings cogeneration can often serve as a cheaper alternative than operating less efficient electrical buildings systems that draw from the grid. The data centre at Global Switch, as well as the large retail components within Westfield Sydney and The Quay Apartments, have significantly greater thermal management requirements throughout the day in order to maintain temperatures within large retail and circulation spaces that are not as thermally efficient as the smaller thermal zones (i.e. enclosed spaces) of commercial and residential uses (Interviewee A 2012; Interviewee B 2012). These high heating demands allow on-site cogeneration to overcome one of the largest technical hurdles in successfully implementing these systems – balancing heat and electrical loads (Wickramasinghe 2012).

The gas engines used in modern cogeneration facilities achieve maximum energy efficiency when the cogeneration facilities are operated at or near maximum capacity, however, if there is reduced demand and the engines are required to operate below their optimal output the performance efficiency drops away very quickly (Midlam 2012; Wickramasinghe 2012). Operating a cogeneration facility below its optimum output to meet a reduced load profile will generally negate the GHG and financial benefits of the technology compared to grid power. As such when the demand for either thermal or electrical energy is reduced, the cogeneration facility will be shut down as the building becomes cheaper and greener to operate using electricity from the grid. In most buildings the thermal demand load, which is less constant and more affected by external factors such as weather, is the key determinant of whether the output of the cogeneration facility can be consumed, however, improved electrical efficiencies in buildings can also constrain the electrical demand. Informed industry stakeholders confirmed that some of the buildings that are shown in **Table 4** do not operate their installed cogeneration facilities at all, or operate them for only a few days or weeks per year, due to overestimation of a building's thermal demand at the design stage (Interviewee A 2012; Interviewee B 2012; Midlam 2012; Wickramasinghe 2012).

In one documented example at 40 Mount Street, North Sydney (The Ark) (outside of the City of Sydney LGA) a new commercial office building was designed with a trigeneration facility that was oversized to meet the normal electrical demand of the building by a factor of approximately two. As the excess electricity could not be exported to the grid, and operating the plant at a reduced output to meet only the The Ark's electrical demand would have significantly reduced the environmental and financial performance of the plant, the trigeneration plant was not operated at all. The building owner sought assistance from Cogent Energy (who was not involved in the original design or installation of the plant) who, as a subsidiary of Origin Energy, have access to a retail network license, allowing the plant to operate at maximum output and export excess electricity from the site. Rather than selling the excess electricity back the grid (which is not permissible under the energy regulations) Cogent Energy established a 'virtual private wire' which allocates electricity produced at The Ark to another Investa building located in the Sydney CBD as shown in **Figure 27**, sharing the environmental and financial benefits across both buildings (Wickramasinghe 2012).

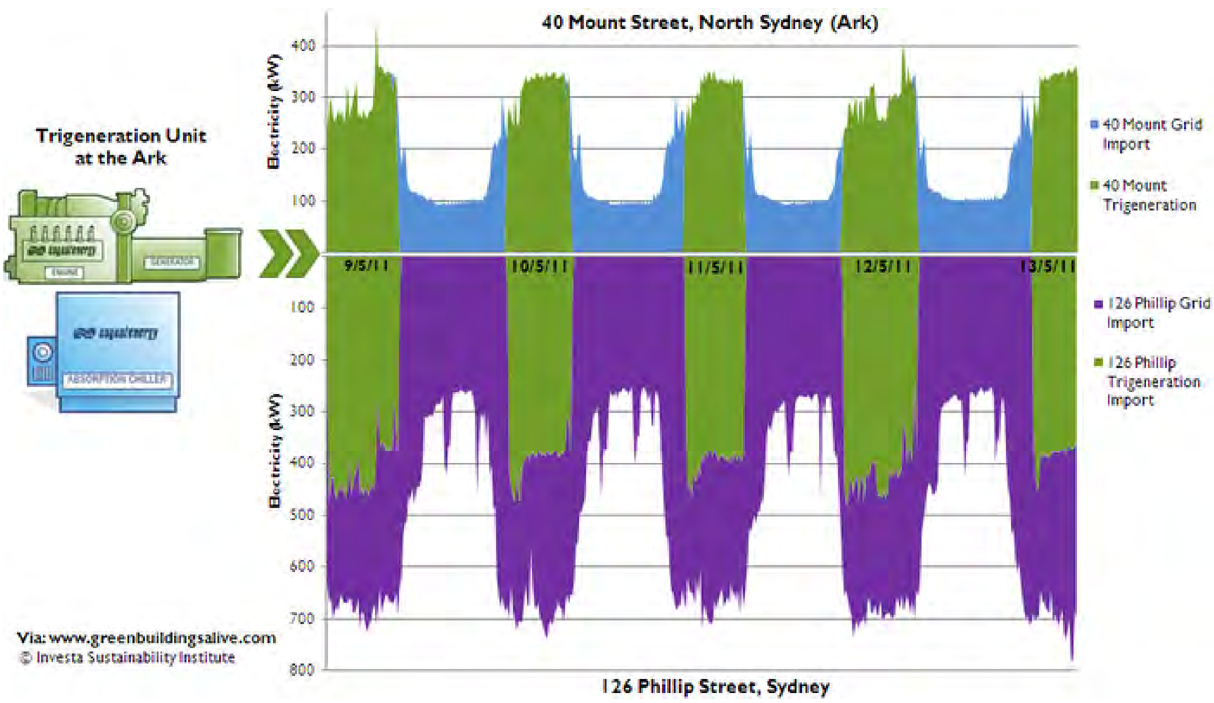


Figure 27 – Trigeneration and grid electricity profile for 40 Mount St, North Sydney and 126 Phillip St Sydney

Source: *Green Buildings Alive 2011*

Achieving higher building energy efficiency and sustainability ratings.

The primary driver for using cogeneration in the buildings identified in **Table 4** was the attainment of improved performance in environmental ratings systems. Out of the 11 buildings with cogeneration, only the Global Switch data centre did not have an environmental rating – there is no relevant sustainability rating tool for this type of building use. The residential components of The Hyde and The Quay attained BASIX certification, which is not ranked and is compulsory for all residential dwellings in NSW under *State Environmental Planning Instrument (Building Sustainability Index: BASIX) 2004*. A breakdown of the environmental scores that were achieved for the buildings which were reviewed is provided in **Table 5** below (does not total 11 due to the fact that residential buildings are not NABERS rated and not all buildings were Green Star rated).

Table 5 – Breakdown of sustainability ratings achieved by buildings with cogeneration facilities in City of Sydney

	4 Stars	5 Stars	6 Stars
NABERS	1	5	1
Green Star	1	2	4

As discussed earlier at **Section 4.1.3**, commercial buildings that are highly rated under NABERS and the voluntary Green Star programs can achieve rental yields which are significantly above the standard market rate (Jones 2012). Premium tenants in the Sydney office market (including government departments) increasingly require a minimum rating to be achieved for any buildings that they occupy, and this trend was clearly evident in the buildings studied. Of the 11 buildings, occupants included premium tenants across the full spectrum of the economy, including:

- Finance and Accounting
  - Commonwealth Bank of Australia
  - JP Morgan
- Legal Services
  - Clayton Utz
  - Corrs Chambers Westgarth
- Property Development
  - Grocon NSW
  - Stockland
  - Westfield
- Energy
  - Origin Energy
  - Cogent Energy
- IT and Technology
  - Google
  - Global Switch
- Government and Not-for-Profits
  - Department of Prime Minister and Cabinet
  - St James Ethics Centre

These tenants would all be categorised as 'premium grade' tenants within the national office market and would provide a rental return to building owners substantially higher than the Sydney average. It is also noted that The Hyde apartments are at the upper end of the luxury market in Sydney and apartments attracted initial sales prices ranging from $715,000 (1 bedroom) to $3.1 million (3 bedroom) and the 4-bedroom penthouse attracting a price in the vicinity of $12 million (Chancellor 2009).

On-site cogeneration has not achieved any market penetration beyond the 'premium grade' development sector to date (bar niche applications such as in the Global Switch building), and it is clear from both the cogeneration audit and anecdotal evidence that the commercial feasibility of this energy source is largely dependent on achieving the top-tier sustainability ratings which attract these 'premium grade' rental yields (Interviewee A 2012; Wickramasinghe 2012).

Building Services and Infrastructure Investment Cycles

The investment lifecycle for plant equipment and services in major commercial buildings is typically between 10-20 years depending on the size and quality of the equipment used. Four (4) of the cogeneration developments reviewed incorporated cogeneration as part of a major building systems overhaul where the existing plant equipment had reached the end of its economic lifecycle and required replacement. Cogeneration technology was incorporated in these buildings because it was the most economic and practical solution to the environmental, financial <u>and</u> servicing objectives for the building retrofit, rather than simply a choice made solely to attain environmental benefits (Interviewee A 2012).

5.1.3 Development Assessment Practice for Cogeneration in Sydney

There are six general approvals streams for undertaking development for which an approval is required under the Environmental Planning and Assessment Act 1979 the Act):

- Part 4 Development Requiring Consent;
- Part 4.1 State Significant Development (formerly Part 3A);
- Part 5 Activity Approvals;
- Part 5.1 State Significant Infrastructure;
- Complying Development; and
- Exempt Development.

The cogeneration facilities for commercial and residential buildings in the City of Sydney have generally received planning approval under Part 4 of the Act (9 cogeneration facilities) and the remainder received approval under what was formerly Part 3A of the Act (now State Significant Development). As discussed in Chapter 4, whilst there are pathways to develop electricity generating technologies such as solar photovoltaics and wind turbines which make gaining planning approval either simpler (Complying Development) or not necessary (Exempt Development) there are no such provisions for cogeneration. Part 5 Activity Approvals are required where development consent is not required under an environmental planning instrument and generally only where the works are carried out by, or on behalf of, a state government authority or agency, which has the effect of excluding nearly all on-site and precinct-scale cogeneration facilities.

In order to gain development consent under Part 4 or Part 3A of the Act the proponent of a development is required to provide to the consent authority a range of documentation which describes the proposal and its consistency with the relevant planning instrument and development controls. As outlined in the methodology of this thesis, this material was reviewed along with the assessment report and development consent issued by the determining authority for all but one of the cogeneration facilities identified in **Table 4**. The findings of this research, as well as anecdotal evidence provided during the in-depth interviews, has identified a number of trends and issues in the way in which the planning approvals process is applied to cogeneration developments in the City of Sydney LGA.

Use of Energy Efficiency and Sustainability Rating Tools In Development Assessment

In assessing the overall sustainability of the Development Applications (DAs) submitted to Council involving cogeneration, a number of Council's development assessment reports made use of or referenced the targeted NABERS and Green Star ratings. NABERS and Green Star 'Design' ratings were also taken into account when assessing a project's 'design excellence' in accordance with clause 26 of the LEP and the project's contribution to the 'public interest' under section 79C of the Act. The reliance on these ratings tools was equally evident in the review of documentation for projects assessed under the Part 3A/State Significant Development stream by the NSW Department of Planning and Infrastructure.

The owners and regulators of the NABERS and Green Star rating systems have both previously made submissions to the City of Sydney Council objecting to draft requirements to incorporate the mandatory use of these tools in Council's local development controls. Whilst the tools can be useful in providing a general high-level overview of the building's likely efficiency or sustainability, both NABERS and Green Star are performance measures and as such targeting or designing to a certain rating at the DA stage does not guarantee that this rating will actually be achieved. A number of simple changes can be made to a development proposal between the DA and the actual operation of the building – such as discovering that the cogeneration plant was not sized for optimal performance or simply choosing not to operate the cogeneration plant at all – which can dramatically alter the building's actual efficiency or 'sustainability' and as a result the performance ratings that are ultimately achieved. The anecdotal evidence of the number of installed cogeneration plants both within the City of Sydney that are not operated to achieve optimal performance or sit idle supports the view that this a real issue rather than a speculative one (Interviewee A 2012; Interviewee B 2012; Wickramasinghe 2012).

Given that a well-designed and effectively operated cogeneration plant can be the difference between 1 or 2 NABERS stars (Jones 2012), the value of using these tools in assessing the sustainability of a building with cogeneration at the DA stage is questionable at best and arises largely due to the void in existing development controls and policies.

Three of the development approvals issued by the City of Sydney Council and one issued by the NSW Department of Planning and Infrastructure included conditions of consent which require the attainment of a minimum NABERS of Green Star rating and the attainment of certification to this effect. The potential impacts of imposing a minimum are double-edged. On one hand, the consent authority is requiring the proponent to achieve the environmental performance standards which define the merits of the project, which is undoubtedly a positive outcome. On the other hand, however, such conditions are difficult to administer, and in the case of Green Star ratings essentially forces compliance with a voluntary, non-government ratings scheme. This is an issue which clearly has implications beyond only those projects which include cogeneration facilities and indeed for development outside of the City of Sydney, and as such clear guidance for the use of these ratings tools in planning assessment should be developed at a state or national level. At present the use of these rating tools in the planning assessment and approvals process is inconsistent, unclear and ad-hoc.

Conditions on the Design and Operations of Cogeneration Facilities

In one of the development consents reviewed (Legion House, D/2007/1792/H), the City of Sydney Council imposed a condition of consent on the cogeneration facility limiting the size of the cogeneration plant to be no more than 2x80kW gas engines. In light of the identified issues in correctly sizing a cogeneration plant for optimal performance at the design stage and the environmental and economic implications of not sizing the plant correctly, it is considered that a more flexible approach may be appropriate. The implication of having a condition that specifies the exact size of the cogeneration facility is that a modification to the development consent is required to be approved by Council if the size is varied even slightly at the detailed design stage. This would seem to represent a regulatory burden which is not proportionate to the minimal environmental impact which would result from the resizing of the cogeneration equipment.

Assessment of Air Quality Impacts

The *Interim Nitrogen Oxide Policy for Cogeneration in Sydney and the Illawarra* which is administered by the NSW Office of Environment and Heritage (OEH) is the key air quality policy for cogeneration development in Sydney. Despite this, out of the 10 facilities for which development consents were reviewed, the policy was mentioned in only two development assessment reports prepared by the City of Sydney Council and one development assessment report prepared by the NSW Department of Planning and Infrastructure. Of these development assessments, one was for the largest cogeneration facility in the City Sydney (Global Switch at 38.7MW) and one was for the second-smallest (Legion House at 160kW). All three of these proposals were referred to OEH (formerly NSW Department of Environment and Climate Change) for comment, however, it was not apparent from the assessment report as to whether the remaining DAs were referred to OEH.

There was no consistent approach in the way in which conditions of consent were applied to the use of cogeneration facilities in the three consents where relevant conditions were included. The development consent issued by Council for Legion House contained 5½ pages of conditions relating solely to the operation of the 160kW cogeneration plan, including requirements for:

- emissions standards for solid particles, NOx, sulphur dioxide and volatile organic compounds;
- emissions monitoring upon cogeneration plant commissioning;
- quarterly emissions monitoring and reporting to Council for a period of at least 10 years;

- installation of a continuous emissions monitoring system;
- design and dimensions of the emissions discharge stack;
- criteria for emissions temperatures and velocities;
- permissible fuel types; and
- submission of an Operational Environmental Management Plan to Council for the cogeneration facility.

These conditions are substantially more detailed than the OEH policy and impose a substantial regulatory cost on the building owner, who will be required to have a specialist air quality report prepared quarterly for at least ten years in addition to the commissioning and ongoing air quality monitoring requirements. Without dismissing the potential health and air quality impacts of large-scale or widespread cogeneration within the Sydney basin, these conditions seem excessively burdensome for a 160kw gas engine that has NOx emissions equivalent to one light-rigid truck (Umow Lai 2011), particularly when equivalent conditions were not imposed on cogeneration facilities which were approved by Council and up to five times larger.

Documentation Required by Consent Authority

A review of the documentation required by the relevant consent authorities identified some clear inconsistencies in the level of documentation required as part of the application for approval. In most instances an ESD Report accompanied each application however these did not always address the environmental impacts (air quality, noise) of the cogeneration facility. Air quality reports were provided for the two planning applications which were approved by the NSW Department of Planning and Infrastructure, whilst the conditions of consent for The Quay required further detailed air quality and emissions studies to be carried out and provided to Council prior to the issuing of a Construction Certificate. Neither the Department nor Council provide guidelines or development controls that specify the level of documentation which can be expected to be provided for an application involving cogeneration.

5.1.4 Key Findings

On-site cogeneration development within the City of Sydney has been implemented in a relatively broad mix of retail, commercial office, residential and technology services buildings within a geographical area concentrated around the central business district, however the number of cogeneration developments has been small. Cogeneration plants typically have capacities in the vicinity of 600kW to 1MW, although substantially smaller and larger facilities are also present.

There are a number of inconsistencies in the way in which the development of cogeneration facilities are assessed at the planning application stage, and the reasons for this are not limited to (but also not helped by) the differences in how these proposals are assessed by the City of Sydney Council for development under Part 4 of the Act and the NSW Department of Planning and Infrastructure for major development under the (now repealed) Part 3A and SSD. The inconsistent and disproportionate assessment processes which are imposed on on-site cogeneration installations throughout the City of Sydney is likely to deter the widespread use of this technology. This is particularly the case in light of the much simpler planning processes involved in installing on-site renewable generation facilities or in simply connecting to the distribution network.

5.2 Precinct-Scale Cogeneration: City of Sydney Decentralised Energy Master Plan – Trigeneration

5.2.1 Proposed Development

The *Decentralised Energy Master Plan – Trigeneration* (DEMPT) is the City of Sydney Council's plan for 'Green Transformer' precinct-scale cogeneration throughout the city in line with the strategic actions identified in *Sustainable Sydney 2030* (**Figure 28**). The DEMPT has been prepared by the climate change and energy use consulting firm Kinesis on behalf of the Council and was publicly exhibited as a preliminary-draft between December 2010 and January 2011, with the final version publicly exhibited between 9 August 2012 and 8 October 2012. A total of 14 public submissions were made on the most recent exhibition of the DEMPT including by key stakeholders including the AEMO, NSW Department of Planning and Infrastructure, Property Council of Australia, GBCA, Ausgrid and the Clean Energy Council of Australia.

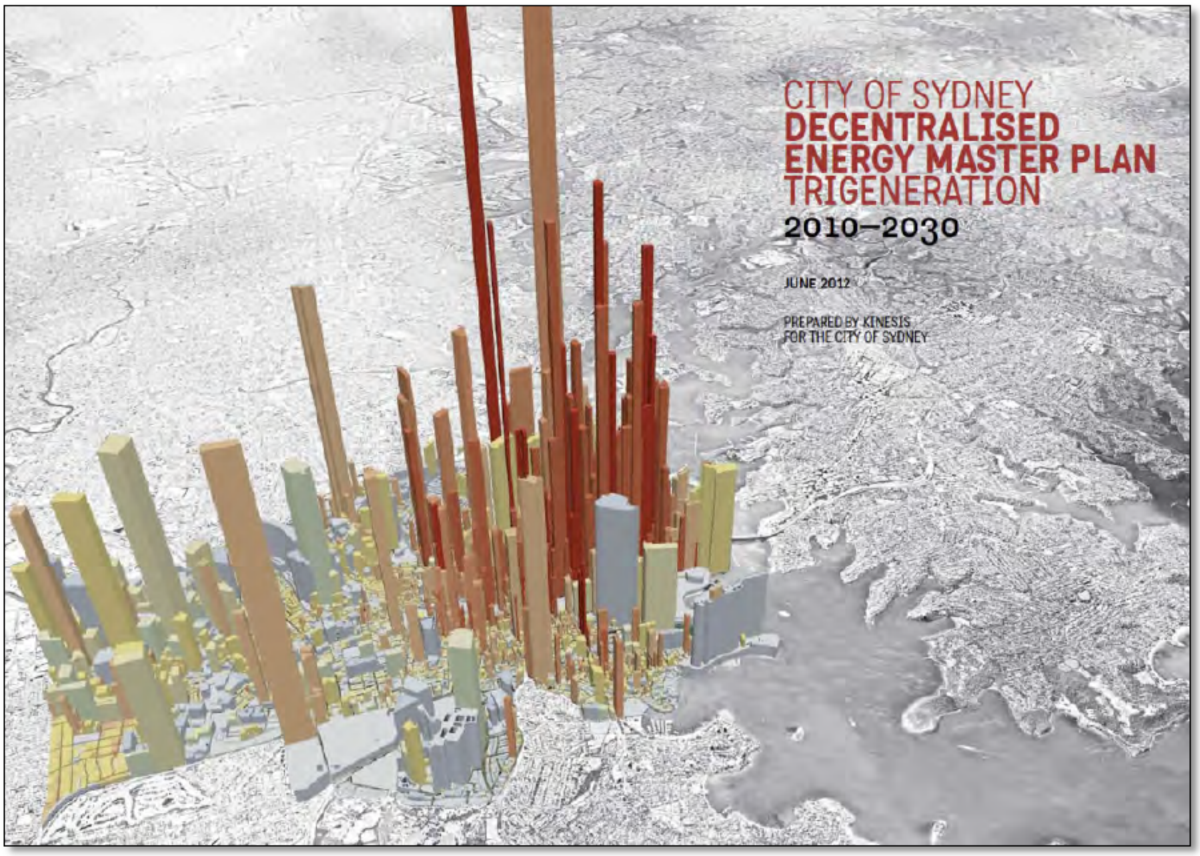


Figure 28 – City of Sydney's *Decentralised Energy Master Plan – Trigeneration*

Source: *Kinesis 2012*

Low Carbon Infrastructure Zones

The DEMPT proposes the staged development of a series of precinct-scale cogeneration facilities and private distribution networks with a total generation capacity of 372MW to service four 'Low Carbon Infrastructure Zones' across the City of Sydney LGA by 2030. These precincts are shown in **Figure 29** and identified as being:

- CBD North – 130MW (bound generally by Sydney Harbour, Macquarie Street and King Street);
- CBD South – 130MW (bound generally by King Street, Harbour Street, Wentworth Avenue and College Street with a 1km long 'finger' along William Street to Kings Cross);
- Pyrmont, Ultimo and Broadway – 80MW; and
- Green Square – 20MW.

These four zones are designed to service the highest density commercial and residential precincts within the City of Sydney LGA, which at present account for approximately 65% of the LGA's annual electricity consumption. Despite being called a trigeneration master plan, the DEMPT proposes that the 'Green Transformers' will be cogeneration facilities that distribute only electricity and hot water to buildings via a private decentralised energy network. Privately owned buildings that choose to connect to the decentralised energy network will be required to install their own absorption chillers on-site to convert hot water to chilled water if cooling is required.

A Heads of Agreement in respect of the delivery of precinct-scale cogeneration facilities and distribution network was agreed to by the City of Sydney Council and Cogent Energy Limited in March 2012. The finalisation of the DEMPT will inform a final agreement between the Council and Cogent Energy for the delivery and operation of the Low Carbon Infrastructure Zones (City of Sydney 2012b).

The cost of delivering and operating the Low Carbon Infrastructure Zones over the period of 2010 to 2030 is estimated to be $4.8 billion, the costs of which will be shared between the City of Sydney and Cogent Energy (Kinesis 2012). Operating costs account for the bulk of expenditure and total $3.92 billion between 2010 and 2030, however it is noted that ongoing expenditure is not included in this figure post-2030. Should the City of Sydney propose to source landfill or biomass gas to operate the 'Green Transformers' beyond 2030 under the (yet to be publicly released) *Advanced Waste Treatment Master Plan*, it is possible the fuel-costs may in fact rise beyond 2030. 79% of the total modelled operating costs between 2010 and 2030 relate to the purchase of natural gas to fuel the cogeneration facilities (Kinesis 2012).

Approximately 70% of buildings that will exist in the City in the year 2030 have already been built (City of Sydney 2008). As a result, a significant number of buildings located within the Low Carbon Infrastructure Zones will need to be retrofitted to allow connection to the City's precinct-scale cogeneration system. The estimated connection rate for buildings within the Low Carbon Infrastructure Zones to the decentralised energy network is shown in **Table 6** below and underpins the preliminary feasibility analysis undertaken by Kinesis as part of the DEMPT.

Table 6 – Assumed adoption rates for new and existing development within DEMPT precincts

Building Use	Connection Rate (% of total buildings)
Commercial Office	65
Retail	50
Residential	30

Source: *Kinesis 2012*

Cogeneration 'Hotspots'

The DEMPT also identifies potential for a further 38MW of cogeneration capacity located in four additional 'hotspots' shown at **Figure 29** and located outside of the 'Low Carbon Infrastructure Zones' at:

- Sydney University;
- Australian Technology Park, Redfern;
- Alexandria/Beaconsfield/Rosebery Industrial Precinct; and
- Moore Park Entertainment Quarter.

These cogeneration hotspots represent the largest consolidated sites under single ownership within the City of Sydney LGA and together account for approximately 8.5% of the LGA's annual electricity consumption (Kinesis 2012). The identification of these 'hotspots' is intended to recognise the potential to implement precinct-scale cogeneration relatively simply and quickly for single-customer sites, such as has occurred overseas under the partnerships established by New York City Council with New York University and the Department of Correctional Services under the PlaNYC rollout of precinct-cogeneration as discussed in Chapter 3. The ability to contain services and energy distribution infrastructure within a precinct held under single ownership avoids the need to extend services onto neighbouring public or private land, and avoids the significantly higher cost of the design and construction of services under public roads that does not disrupt existing infrastructure.

The Heads of Agreement between the City of Sydney and Cogent Energy flags the potential for Cogent Energy to further investigate these precincts in cooperation with the Council and the relevant land owners (City of Sydney 2012b) however there are no immediate plans to undertake further investigations of these precincts in the near-term. No costings have been undertaken for this component of the DEMPT.

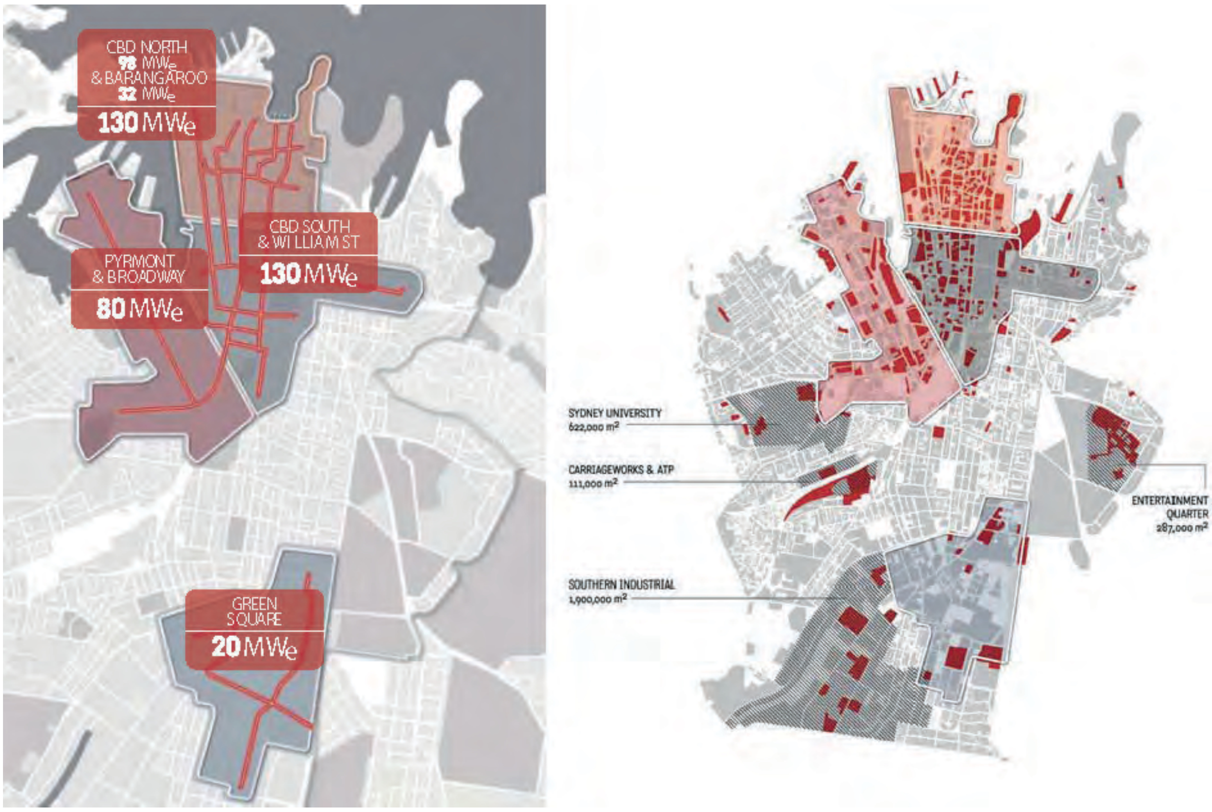


Figure 29 – Proposed 'Low Carbon Infrastructure Zones' and 'Hotspots'

Source: *City of Sydney 2012*

5.2.2 Key Benefits of Precinct-Scale Cogeneration for Sydney

The benefits delivered by precinct cogeneration are well documented by Council in both SS2030 and the DEMPT, and have been widely promoted by Council using forums such as the traditional media, community updates and forums such as the 'City Talks' public lectures held over the past 4½ years. The key benefits of the DEMPT are summarised as follows (Kinesis 2012; Jones 2012):

- reduces GHG emissions within Low Carbon Infrastructure Zones by between 39% and 56%;
- reduces LGA-wide GHG emissions by 18%;
- precinct-scale cogeneration with larger generators and a broader 'customer' base provides a steadier demand load and can be up to 25% more efficient than on-site cogeneration facilities;
- provides new generating capacity which would negate the need for the equivalent of a new 500MW coal-fired power station; and
- avoids the need for $1.5 billion of investment in upgrades to transmission grid and new electrical generating capacity.

These outcomes, if realised, would place the City of Sydney at the forefront of leading rapid emissions reductions amongst other world cities and would provide economic benefits to residents and businesses across the entire Sydney metropolitan region through averted infrastructure costs (Interviewee B 2012; Jones 2012).

5.2.3 Economic Implications of Precinct-Scale Cogeneration

There has been significant discussion within the property industry regarding some of the assumptions that underpin the calculation of the key benefits that are claimed to be achieved under the DEMPT by its proponents (Perinotto 2012). These discussions have mainly centred on the ability to economically connect premises to the network and the comparative efficiency of the absorption chillers required to convert the heat distributed by the City's proposed 'Green Transformers' (Blundell 2012; Interviewee A 2012; Midlam 2012; Precious 2012; Roussac 2012; Wickramasinghe 2012; Wright 2012).

System Efficiency

The crux of the debate regarding efficiency of cogeneration systems in Sydney arises from the fact that unlike the northern hemisphere case studies of Woking and New York City discussed in Chapter 3, which have much cooler climates and mostly require heating rather than cooling, in Sydney cooling accounts for approximately 80% of thermal energy consumption by buildings. As such the thermal efficiency of the precinct-scale cogeneration network distributing high-grade heat is determined largely by the comparative efficiency co-efficient (how efficiently hot water or electricity is converted to cooling) of the absorption chillers that are required to convert the hot water to cooling. Critics of the assumptions in the DEMPT claim that Kinesis has overstated the comparative efficiency of absorption coolers when compared to electrical chillers connected to the grid (Precious 2012; Wright 2012), whilst proponents of the scheme claim that these criticisms are misinformed (Midlam 2012; Wickramasinghe 2012). **Figure 30** shows the DEMPT calculated system efficiency which finds a 67% efficiency, whilst **Figure 31** shows calculations by renewable-energy lobby group Beyond Zero Emissions which find a system efficiency of only 58% whilst comparing this with claimed efficiencies for centralised gas-fired electricity generators and renewable electricity. Resolving these disputes is outside of the scope of this thesis, however it is sufficient to say that the actual energy efficiencies achieved by the City of Sydney's 'Green Transformers' will have a significant bearing on the real environmental benefits delivered.

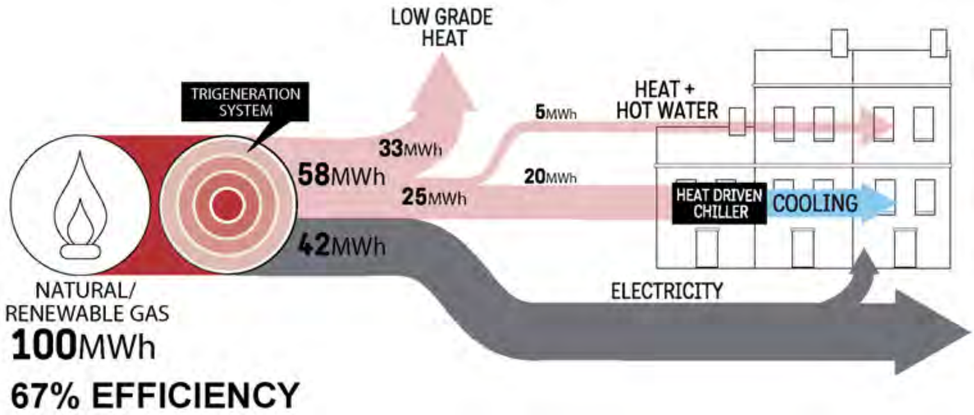


Figure 30 –DEMPT energy efficiency assumptions

Source: *Kinesis 2012*

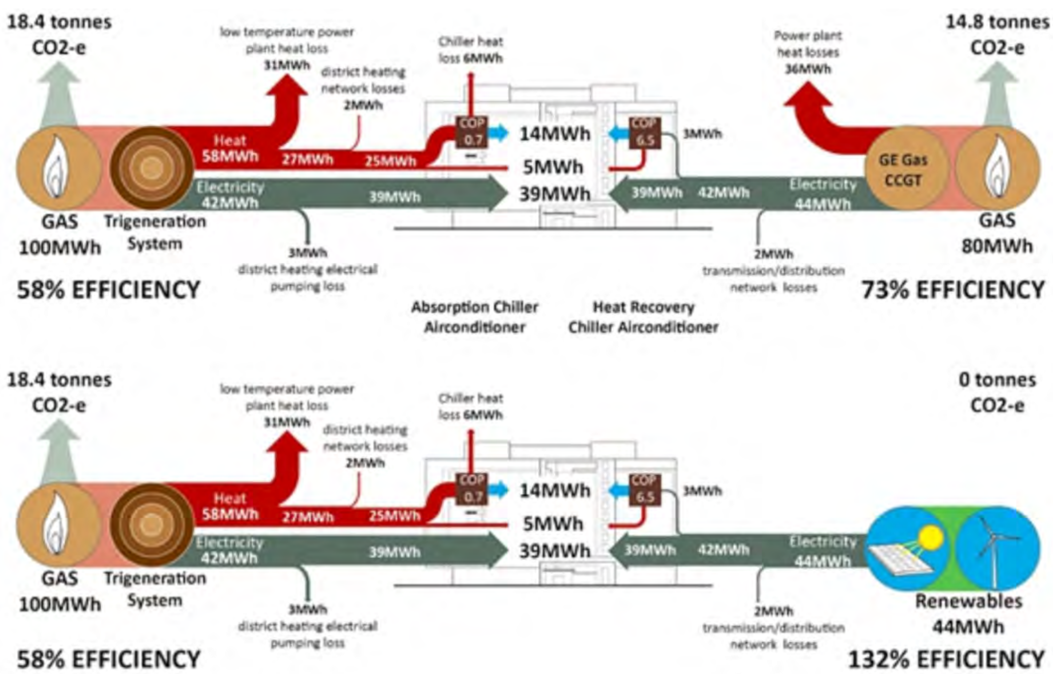


Figure 31 – Comparison of distributed hot water and electricity efficiency with centralised gas-fired and renewable electricity

Source: *Wright 2012*

Distribution Methods and Premise Connection Costs

The absorption chillers that are required to convert the hot water distributed by the 'Green Transformers' for cooling are conspicuously larger and heavier than the electric chillers which are currently used in buildings in Sydney to provide cooling. In many existing buildings the plant rooms will simply not be able to accommodate absorption chillers without substantial modification to the base building, whilst internal services risers may also limit the ability to transport heated water and refuse to mid-rise or rooftop plant equipment (Interviewee A 2012; Precious 2012; Wickramasinghe 2012). This challenge could largely be overcome if chilled water was distributed, as it would remove the need for some of the most expensive and intrusive of the building plant and servicing upgrades required to connect to the network, and would incidentally make the DEMPT a true master plan for trigeneration rather than cogeneration.

The modifications required to accommodate new plant equipment in the more constrained buildings are likely to be a significant hurdle for building owners seeking to connect to the decentralised energy network, and will in many cases make connection to the network commercially unviable. Whilst several key stakeholders in the property sector have called for the distribution of both hot and chilled water through the decentralised energy network (Precious 2012; Property Council of Australia 2012) both Cogent Energy and the City of Sydney maintain that the distribution of both hot and chilled water through the decentralised energy is too costly (Midlam 2012; Wickramasinghe 2012).

The DEMPT does not take into account the cost of private building plant upgrades required to connect to the decentralised energy network when calculating the societal cost (or 'real' cost) of the proposal, on the basis that these upgrades will occur as part of the normal building plant reinvestment cycle. It is evident however that there is a genuine belief and concern within the property industry that the cost of connecting a significant proportion of existing buildings to the decentralised energy network will be higher than the normal building plant reinvestment costs, particularly if only hot water is distributed. These additional costs should be reflected in the overall cost of the DEMPT particularly as, by comparison, other measures which 'green the grid' do not require new connections to premises.

Marginal Cost of GHG Abatement

Whilst the City of Sydney has been widely commended for its proactive approach to tackling the challenge of GHG emissions reductions at a local scale, there is significant concern from both the property industry and the environmental movement regarding the proposal to achieve the bulk of these reductions through a transition to precinct-scale cogeneration

The DEMPT includes modelling which compares the marginal social cost, or 'true cost', of GHG emission reductions achieved through a variety of different measures including existing and enhanced fossil fuel based electricity generators, renewables and demand reduction. This modelling is graphically represented in **Figure 32** and shows the cost of the precinct-scale cogeneration network proposed under the DEMPT as being marginally cheaper to society than investment in renewables such as high capacity wind (which has a large unexploited potential resource base within NSW) and small-scale hydro (which has only a limited unexploited resource base in NSW) and is used to justify the City's decision to proceed with precinct-scale cogeneration. This appears to be inconsistent with the market conditions and the nature of the technologies compared:

1. The cost of renewable energy production, and particularly wind power, has fallen dramatically over the past 5 years and is expected to fall further (Wright 2012), making a static price comparison disingenuous as a guide for future investments over a long timeframe.
2. The modelling only estimates the abatement cost of the DEMPT on the basis of costings between 2010 and 2030 and does not take into account fuel costs (which are \$3.09 billion between 2010 and 2030) beyond this point, which unfairly disadvantages renewable energy technologies which do not require fuel and hence provide greater comparable economic returns over a longer timeframe.

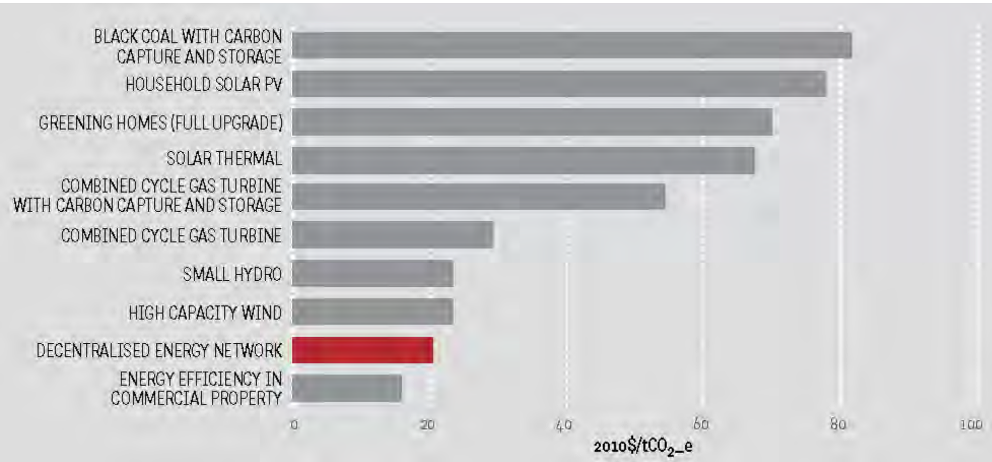


Figure 32 – Marginal social cost of abatement for GHG emission reductions
Source: *Allen Consulting Group 2012 in Kinesis 2012*

5.2.4 Environmental Implications of Precinct-Scale Cogeneration

Natural Gas and Greenhouse Gas Emission Reductions

The DEMPT is being driven primarily by the SS2030 target of reducing LGA-wide GHG emissions by 50% from 1990 levels by 2030. The DEMPT is the detailed plan for the rollout of the 'Green Transformers' program which is the single largest planned GHG emissions reduction under the SS2030 strategy that was released in 2008.

Whilst Council points out that its *Decentralised Energy Master Plan – Renewables* will soon be released for public consultation, and that the DEMPT forms part of the full suite of GHG emissions reductions offered under SS2030 (Midlam 2012), a number of interview subjects expressed their bemusement that the DEMPT continues to be Council's largest and highest priority emissions reduction project. A common theme amongst interview subjects (except those employed by the City of Sydney and Cogent Energy) was a sense of bemusement that one of the most sustainability-oriented and forward-looking Council's in the country has opted to prioritise a fossil-fuel powered technology over renewables, or 'light-brown over green' (Interviewee A 2012; Interviewee B 2012; Precious 2012).

A number of key stakeholders acknowledged the potential for the DEMPT 'locking in' a fossil-fuelled energy system (Interviewee A 2012; Interviewee B 2012; Precious 2012; Wickramasinghe 2012). The significant entrenched infrastructure required to distribute the hot water produced by the precinct-scale cogeneration facilities is likely to create undue barriers to future emerging technologies which may provide better environmental outcomes, such as renewables. This risk of system 'lock-in is supported in the academic literature:

> *"'Lock-in' of existing energy infrastructure and policy frameworks … difficilitate* [prevents] *energy producers from competing on an even playing field. Under the arrangements for wholesale electricity markets, small, variable and unpredictable power generators appear to incur higher costs"* (Kelly and Pollitt 2010)

Environmental and Economic Assumptions and Modelling

The Technical Appendix to the DEMPT (Kinesis 2012b) contains the assumptions and calculations that underpin the performance claims made regarding the environmental and economic performance of precinct-scale cogeneration in the City of Sydney context. At page 27 of the Technical Appendix, the DEMPT makes the following assumptions:

- the GHG intensity of natural gas production in NSW will be constant for the period from 2010 to 2030;
- the GHG intensity of the NSW electricity grid will fall from 1.009 tonnes CO_2-e per MWh to 0.936 tonnes CO_2-e per MWh in 2020 as shown in **Figure 33**, which aligns with the scheduled end of the current Renewable Energy Target (RET); and
- after 2020, the GHG intensity of the NSW electricity grid will rise gradually back to 0.971 tonnes CO_2-e per MWh as shown at **Figure 33** on the assumption that after 2020 "renewables stall and fossil fuels take up the growth in demand" (Kinesis 2012b, p27)

There are critical weaknesses in these three assumptions which are discussed below.

There is evidence that the emissions intensity of natural gas is currently underestimated as a result of accounting gaps relating to fugitive emissions released in the extraction process (Parkinson 2011). Further to this the emissions intensity of natural gas is likely to increase further as 'coal seam gas', which is more emissions-intensive, continues to account for a larger proportion of NSW natural gas consumption (Parkinson 2011).

The GHG intensity of electricity is monitored and reported publicly by the Australian Energy Market Operator (AEMO) on a daily basis. The actual emissions intensity of the NSW grid was not only lower on average than the annual projections given in the Technical Appendix for the starting years for the DEMPT of 2010, 2011 and 2012 (to date), on a daily basis the actual emissions intensity of the NSW grid did not once exceed the annual average emissions intensity projected by Kinesis for these years (AEMO 2012). In light of this, it is probable that the GHG emission savings which the DEMPT claims will be achieved by the use of precinct-scale cogeneration have been overstated.

The Technical Appendix assumes that in 2020, when the RET requires 20% of all electricity consumed within Australia to be supplied by renewable energy, there will be no further incentive to invest in additional renewable energy generating capacity and as such fossil-fuel based generating facilities will be developed. This is unlikely to occur for three reasons:

1. Just as the RET replaced the MRET when it expired in 2010 and increased the renewable energy target by a factor of six (6), it is quite likely that when the RET target is achieved in 2020 (8 years from now) the renewable energy target will be increased further if this has not already occurred.
2. The carbon price is likely to promote investment in electricity generation technologies with lower GHG emissions than the existing grid. Assuming that demand for electricity is still growing in 2020 – Ausgrid's submission on the DEMPT notes that the City's demand forecasting is greater than Ausgrid's own modelling by a factor of 10 – it is not reasonable to automatically assume that fossil-fuel electricity generation will be the most economic investment choice.
3. Even replacing ageing coal-fired power stations with new coal-fired stations under the 'business as usual' investment cycle (without RET and carbon price) is likely to result in reductions in the GHG intensity of the grid, as old inefficient generators are replaced with new modern generators that comply with current environmental standards and are more energy-efficient.

These weaknesses are also likely to affect the modelling and outcomes of the *Decentralised Energy Master Plan – Renewables*, although this plan has not been publicly released to date to allow its review.

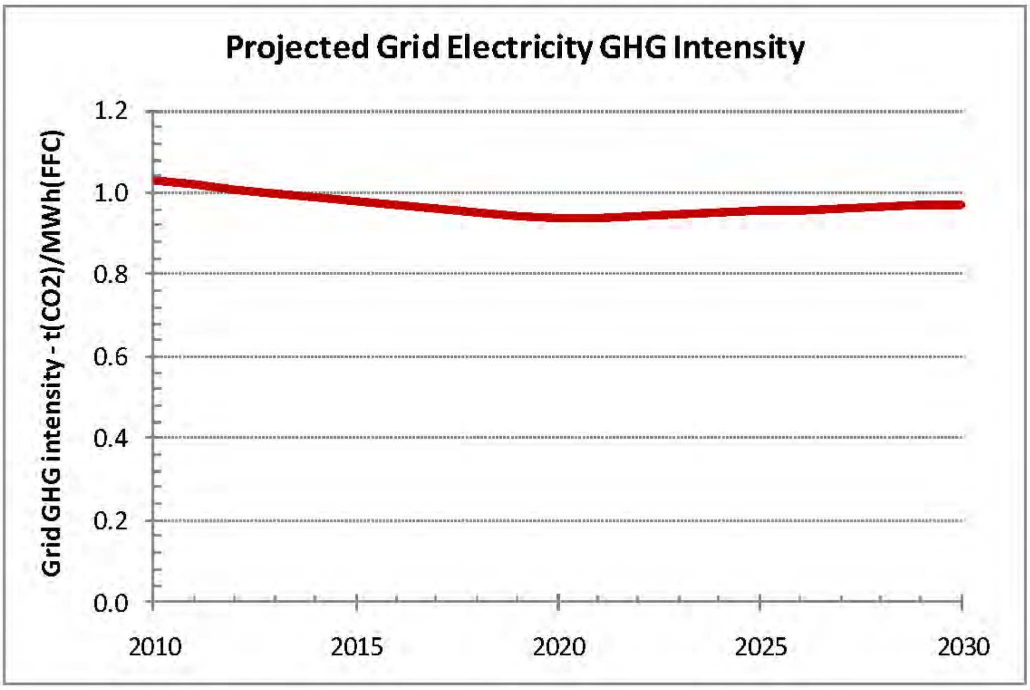


Figure 33 – Projected grid electricity GHG intensity for NSW market

Source: *Kinesis 2012b*

5.2.5 Planning Framework for Precinct-Scale Cogeneration

Green Transformers

As with on-site cogeneration, the City of Sydney's precinct-scale cogeneration facilities will require development consent under Part 4 of the *Environmental Planning and Assessment Act 1979*. A Development Application (D/2012/835) for the host building for the first 'Green Transformer' located in Green Square (**Figure 34**) has been prepared and submitted, with the DA to be independently assessed by an external consultant (as it is Council's DA) and determined by the Central Sydney Planning Committee. This DA does not however include the installation of the cogeneration plant itself, which will be the subject of a later application to Council following the finalisation of the DEMPT.

As discussed in Chapter 4 there is currently an absence of any local planning provisions or development controls in place to indicate or control how cogeneration should be implemented in the City of Sydney or within NSW more generally. Future DAs for the cogeneration facilities at the Green Square and other 'Green Transformer' locations will represent some of the largest cogeneration facilities installed in the City of Sydney LGA and will require detailed assessment of the environmental impacts of these facilities with regards to air quality, noise and vibration in particular. In the absence of any clear development controls for cogeneration, and in the absence of any clear guidelines on the requisite level of technical documentation required to be provided as part of the cogeneration DA, it will be left to the independent consultant responsible for assessing the application to make planning policy and process decisions which should have been made by the City of Sydney Council. This is likely to further exacerbate the existing level of uncertainty surrounding the environmental assessment requirements for cogeneration development.

Figure 34 – Proposed 'Green Transformer' conversion of the former South Sydney Hospital site at Green Square

Source: *City of Sydney 2012c*

Cogeneration 'Hotpsots'

The planning approvals framework for precinct-scale cogeneration systems within the four identified cogeneration 'hotspots' are the same as for the Low Carbon Infrastructure Zones irrespective of whether these facilities are developed by Council or by the relevant landowners.

Should the Draft Sydney LEP be gazetted in its current form however, it would have the effect of prohibiting 'electricity generating works' within the University of Sydney precinct and thereby require an amendment to the LEP to allow the development of precinct-scale cogeneration facilities. In order to remove the prohibition on the development of precinct-scale cogeneration, the LEP would be required to be amended either to add 'electricity generating works' as a permissible use within the SP2 Infrastructure zone, or as an additional permitted use only within the Sydney University grounds under Schedule 1 of the LEP. At present the LEP amendment process is cumbersome and time consuming, with even simple amendments such as the one which would be required to allow precinct- scale cogeneration likely to take several months or longer. Whilst the Minister for Planning has recently announced proposed changes to the *Environmental Planning and Assessment Act 1979* that would provide greater power to Councils to implement minor LEP amendments more rapidly (Hazzard 2012), such a process would still take considerable time and expense that could be avoided by amending the Draft LEP prior to its gazettal. Notwithstanding these changes, this issue could be simply remedied if Council brought its statutory planning into line with its strategic planning.

Connecting Buildings to the Decentralised Energy Network

> *"So we are delivering this not through statutory planning policy like we would have done in London, because we just don't have those powers here, we're doing that through a Voluntary Planning Agreements so things that could be given up in each stage for developers committing to connect back to the green infrastructure." (Jones 2012)*

The DEMPT recommends the amendment of the *Draft Sydney Development Control Plan 2012* to incorporate basic plant room and service connection design requirements for all new development within the proposed Low Carbon Infrastructure Zones so that new development is capable of connecting to the decentralised energy network. These changes to the Draft DCP have not, however, occurred to date. The uncertainty regarding these requirements is adversely affecting the ability of land owners of buildings within the Low Carbon Infrastructure

Zones to make decisions regarding the design and investment profile of new buildings, major building retrofits and overhauls and smaller-scale building plant upgrades (Interviewee A 2012; Precious 2012).

The City of Sydney may not amend its environmental planning instruments to make connection to the decentralised energy networks by buildings compulsory, as this would be anti-competitive and an unjustifiable blurring of Council's roles as planning consent authority and a private utility supplier (in cooperation with Cogent Energy). Instead, the City of Sydney is proposing to use Voluntary Planning Agreements (VPA) to encourage new development to connect to the decentralised energy network or host essential network infrastructure in return for development bonuses or concessions on development contribution requirements (Jones 2012). The VPA process is significantly more complex than the normal method of levying development contributions for 'standard' types of development under S94A of the *Environmental Planning and Assessment Act 1979*, and is likely to deter land owners undertaking small and simple developments such as retrofits of existing buildings from going down this route. It is also questionable whether using the VPA process to 'incentivise' connection to the decentralised energy network in exchange for development bonuses, such as additional floor space, is any less coercive than a compulsory requirement under the LEP.

In order to provide sufficient 'encouragement' for land owners to connect to the decentralised energy network, and ensure that the take-up rates required to provide the environmental and economic returns to the City are achieved, the proposed amendments to the DCP must be implemented. These development controls would prevent land owners to gain a cost saving by only developing a building to connect to the electricity distribution grid, and would allow the supply of decentralised hot water and electricity to compete directly with the supply of grid-electricity at the meter point. Without this incentive Cogent Energy would be required to price discount hot water and electricity to offset the higher capital costs of retrofitting a building for connection, and this is likely to affect the commercial feasibility of developing the Low Carbon Infrastructure Zones.

5.2.6 Key Findings

The *City of Sydney Decentralised Energy Master Plan – Trigeneration* proposes the large scale rollout of precinct-scale cogeneration facilities throughout the most densely occupied areas of the LGA in accordance with the strategic policy set out in Sustainable Sydney 2030. The rollout of precinct-scale cogeneration offers significant GHG emission reductions in comparison to the existing emissions associated with the NSW electricity grid, but will involve significant capital investment at a cost of almost $5 billion by 2030 and significant additional investment by land owners within the proposed Low Carbon Infrastructure Zones. It is probable, however, that the assumptions and modelling used in the study have caused the environmental benefits of the DEMPT to be overstated and the economic costs to be understated. As a result, it is likely that there are a number of other GHG emissions options, such as building energy efficiency and renewables, that would meet Council's strategic targets more effectively and economically.

The rollout of precinct-scale cogeneration is likely to encounter many of the same policy gaps and uncertainties faced by on-site cogeneration in the City of Sydney. The absence of planning provisions for land within the Low Carbon Infrastructure Zones is already affecting certainty and risk profiles for land owners and developers within these areas who are seeking to undertake development that may be able to or required to connect to the decentralised energy network.

5.3 Relationship Between On-Site and Precinct Scale Cogeneration

On-site cogeneration has generally been implemented on a sporadic basis in Sydney to achieve specific technical outcomes in order to boost the NABERS and/or Green Star ratings of individual buildings. Achieving these higher sustainability ratings is primarily a financial motivation – building improvements such as cogeneration facilities deliver premium tenants and rental yields that payback the initial expense over a relatively short investment lifecycle of between five and 20 years. These cogeneration facilities deliver a targeted and measurable environmental outcome that is achieved in response to environmental policies coordinated at the State and Federal level to achieve greenhouse gas emission reductions by lowering the energy consumption of buildings. Well designed on-site cogeneration facilities offer be the best available technological solution for reducing energy use and greenhouse gas emissions in some buildings, and should be facilitated. The short investment lifecycle for the use of on-site cogeneration means that when another technology becomes better suited to achieving the economic and environmental objectives of the day, then these technologies can easily replace cogeneration as part of the building's natural upgrade cycle.

The City of Sydney's *Decentralised Energy Master Plan – Trigeneration* is the coordinated response of the City of Sydney Council to the environmental objective of reducing greenhouse gas emissions within the local government area. If delivered, the plan promises to achieve a substantial and immediate reduction in greenhouse gas emissions for all buildings which connect to the network between its initial implementation and the completion of the plan's rollout in 2030. In many instances however the plan diverges from State and Federal Government policies to reduce greenhouse gas emissions, to the extent that the City of Sydney's precinct-scale cogeneration network has the potential to undermine the longer-term outcomes sought at the national level – a transition to a zero-carbon economy and the more efficient use of energy. Unlike on-site cogeneration, the embedded physical infrastructure and significant capital investment required to develop precinct-scale cogeneration facilities is likely to 'lock-in' the City of Sydney to cogeneration energy generators for a system lifecycle of over 40 years. On this timescale it is unlikely that a natural-gas fuelled, or even biogas-fuelled, precinct-scale cogeneration will be the most economically or environmentally effective means of delivering energy to Sydney's buildings. As a result, whilst the City of Sydney's proposed precinct-scale cogeneration network is likely to achieve significant environmental benefits in the near-term, this is likely to be at significant environmental and economic cost to future generations.

6.0 Recommendations

This thesis has identified a number of areas where existing planning practice and policies for the development of on-site and precinct-scale cogeneration require improvement or clarification so as to ensure that the best environmental, economic and social outcomes are achieved. These recommendations are structured according to the governance authorities with primary responsibility for the issue, however many of the recommendations will have implications beyond one authority.

6.1 City of Sydney Council

The City of Sydney's key strategic and statutory planning instruments are inconsistent and unclear for on-site cogeneration development, whilst creating barriers to private sector implementation of this technology where it is suitable. The emphasis placed on precinct-scale cogeneration in reducing greenhouse gas emissions is based on assumptions and data that are outdated and potentially counter-productive to achieving the City's core environmental objectives. To address this, this thesis makes the following recommendations:

6.1.1 Sustainable Sydney 2030 and the Decentralised Energy Masterplan – Trigeneration

1. **The forthcoming review of *Sustainable Sydney 2030* should review the role and priority of all GHG emission reduction programs, including the share and priority of precinct-scale cogeneration in Council's GHG emission reductions strategy.**
   The technical, economic and environmental effectiveness of several GHG emission reduction options, such as renewable energy and building energy efficiency, have changed significantly since the release of *Sustainable Sydney 2030*. Before investing significant capital in the infrastructure networks required to rollout precinct-scale cogeneration, the City of Sydney should ensure that it remains the most effective means of achieving the City's GHG emissions reductions targets. The City of Sydney should not constrain this assessment to opportunities located within the City of Sydney LGA.

2. **Council should not proceed with *Decentralised Energy Master Plan – Trigeneration* unless a clear pathway is established for the supply of 'sustainable gas'**
   The significant infrastructure and capital investments required to support precinct-scale cogeneration creates a risk of system 'lock-in' which may frustrate the growth of cleaner and more economic energy supplies such as renewable electricity. Unless there is a clear pathway to transition from natural gas to biomass or landfill gas for fuelling precinct-scale

cogeneration then this 'lock-in' is likely to have significant environmental and economic impacts on development in Sydney. In the absence of any existing evidence that biomass or landfill gas can be provided in an economically feasible and timely manner at the quantities required, it is recommended that the *Decentralised Energy Master Plan – Trigeneration* should not proceed until such a time as this evidence is available.

3. **Assumptions made in the Technical Appendix to the Decentralised Energy Master Plan – Trigeneration should be reviewed.**

   The accuracy of several of the assumptions made in the Technical Appendix that underpins the *Decentralised Energy Master Plan – Trigeneration* have been questioned by key stakeholders and identified in this research. This includes assumptions in respect of system efficiency, electrical demand forecast and GHG emissions intensity projections for the NSW electricity grid and natural gas supply. These assumptions are likely to influence the actual economic and environmental outcomes achieved by the proposed precinct-scale cogeneration network.

4. **A detailed lifecycle cost-benefit analysis of the *Decentralised Energy Master Plan – Trigeneration* should be undertaken prior to Council entering into any binding agreements to deliver the plan.**

   To date only high-level cost estimates have been undertaken of the proposal for precinct-scale cogeneration. Detailed lifecycle analysis should be conducted to assess the relative environmental and economic returns of the proposed precinct-scale cogeneration network, including the costs to land owners and in comparison to the lifecycle costs and benefits of alternative low-carbon energy projects such as renewable energy.

5. **The *Decentralised Energy Master Plan – Trigeneration* should be renamed.**

   As Council is only proposing to generate and distribute hot water and electricity from the proposed 'Green Transformers', the 'Decentralised Energy Master Plan – Trigeneration' should be renamed the 'Decentralised Energy Master Plan – Cogeneration'.

6.1.2 Planning Instruments and Development Controls

6. ***Draft Sydney Local Environmental Plan* should be amended to ensure 'electricity generating works' are a permissible use within the SP2 Infrastructure**

   The proposed prohibition on development for the purpose of 'electricity generating infrastructure' within the SP2 Infrastructure zone under the Draft Sydney LEP will prohibit the development of precinct-scale cogeneration within one of the key 'cogeneration hotspots' identified in the *Decentralised Energy Master Plan – Trigeneration*. This should be amended to allow precinct-scale cogeneration to be implemented by the University of Sydney or Council if it is deemed appropriate.

7. ***Draft Sydney Development Control Plan*** **should be amended to include basic requirements for plant room and building services to allow connection to distributed hot water and electricity**

Should Council elect to proceed with the development of the proposed Low Carbon Infrastructure Zones then the Draft Sydney DCP should be amended to identify land affected by these zones. In order to ensure that new development has the ability to connect to the proposed decentralised hot water and electricity networks then the Draft Sydney DCP should include minimum requirements for plant rooms and service connections to ensure that the necessary building plant can be accommodated on-site.

6.1.3 Development Assessment Practices

8. Develop and adopt a clear and consistent approach for how building sustainability rating tools are used in the development assessment process

The review of consents for developments involving cogeneration facilities demonstrated that the weighting given to highly-rated buildings was not always consistent or clear. Council should provide development officers with clear direction regarding the degree to which targeted sustainability ratings such as NABERS and Green Star, rather than certified efficiency design ratings like BASIX, will inform the development assessment.

9. Develop clear documentation requirements for development involving cogeneration facilities

Council should liaise with the NSW Office of Environment and Heritage to determine whether it will require Air Quality, Noise and Vibration Assessments to accompany Development Applications for cogeneration facilities. Consideration should be given to a tiered system such that the level of documentation is proportional to the generating capacity (and hence the actual environmental impact) of the cogeneration facility. These requirements should be noted in the DA Checklist, or alternatively could be included in the Draft DCP.

10. Develop standard conditions of development consent for cogeneration facilities

Council should liaise with the NSW Office of Environment and Heritage to establish standard conditions of consent for development involving cogeneration facilities for matters such as emissions standards and air quality monitoring requirements. The level of air quality monitoring required should be proportional to the generating capacity (and hence the actual environmental impact) of the cogeneration facility.

6.2 NSW State Government

Whilst NSW State Government policies are well integrated with the Federal Government's policy package for reducing Australia's greenhouse gas emissions, it must take a more proactive approach in assisting local government to interpret these policies at a local scale.

11. State Government should provide guidance regarding the role and responsibilities of Local Government in facilitating GHG emission reductions

The NSW Government, through the Division of Local Government, should provide Councils with clear guidance regarding their role and responsibilities in achieving GHG emission reductions. Local government plays a key role in local utility development (such as energy networks) and in developing and implementing local planning controls, both of which have significant potential to influence economy-wide GHG emissions intensity. Clear guidance would assist local government in implementing strategies and policies which ensure that GHG emissions reductions strategies are vertically integrated across the governance hierarchy.

12. Consider amending State Environmental Planning Policies to allow on-site cogeneration facilities to be installed as Complying Development.

The NSW Department of Planning and Infrastructure should consider amending *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* or *State Environmental Planning Policy (Infrastructure) 2007* to permit the installation of on-site cogeneration facilities that comply with prescribed development standards relating to generating capacity, plant location, emissions, noise and vibration, fire safety and compliance with the Building Code of Australia as Complying Development.

13. Finalise *Interim Nitrogen Oxide Policy for Cogeneration in Sydney and the Illawarra*

The NSW Office of Environment and Heritage should finalise the *Interim Nitrogen Oxide Policy for Cogeneration in Sydney and the Illawarra* and incorporate clear guidance within this policy for how it should be used in development assessment of both on-site and precinct-scale cogeneration facilities and set appropriate emission limits to inform Complying Development standards.

6.3 Australian Federal Government

The policy settings of the Federal Government are primarily intended to facilitate market-led emissions reductions across the economy, under the *Clean Energy Act 2011* (the carbon price), and building energy efficiency under the *Building Energy Efficiency Disclosure Act 2010* (the Commercial Building Disclosure program). This market-led approach, as supplemented by the Renewable Energy Target, appears to be largely effective in achieving the desired objectives of the Federal Government in respect of achieving GHG emission reductions across the country. This setting is consistent with the established division of powers under which land use planning powers remain with State and Local Government. As such, there is only one recommendation for Federal Government:

14. Facilitate improved communication of GHG emission reductions data and market activities to State and Local Government

In order to ensure that State and Local Government policy settings provide 'vertical' integration with Federal Government policy settings, the Federal Government should collate and distribute information regarding trends and patterns in energy development and GHG emission reductions nationally. This will allow State and Local Governments to understand what is required in terms of land use, planning, development control and direct government action programs.

6.4 Sustainable Building Rating Organisations

As discussed in this thesis, building sustainability rating tools play a significant role in influencing the use of both on-site and precinct-scale cogeneration, however further action is required to ensure that these tools are used correctly in development assessment and provide sufficient certainty to inform investment decisions.

6.4.1 NABERS

15. NABERS should clarify whether connecting to precinct-scale cogeneration will improve the base energy rating for individual buildings.

Clarification on whether connecting to precinct-scale cogeneration networks will improve the base NABERS rating of a building is an important consideration for individual land owners and proponents of precinct-scale networks such the City of Sydney Council and Cogent Energy. The uncertainty regarding the draft NABERS ruling, 'Proportioning of Energy used by Cogeneration or Trigeneration Systems, is actively deterring investment in precinct-scale cogeneration.

16. **NABERS should develop guidelines for planning authorities on the appropriate use of the NABERS rating tool at the development assessment stage, and the implications of the use of this tool.**

    The way in which NABERS ratings were taken into account in the planning assessment and approvals process varied greatly from application to application amongst the development consents reviewed. Particular guidance should be provided on the efficacy of using the targeted NABERS energy rating for assessment purposes when a development proposal is at the Development Application stage and detailed building design has not yet occurred.

6.4.2 Green Building Council of Australia

17. **GBCA should develop guidelines for planning authorities on the appropriate use of the Green Star rating tool at the development assessment stage, and the implications of the use of this tool.**

    The way in which Green Star ratings were taken into account in the planning assessment and approvals process varied greatly from application to application amongst the development consents reviewed. Particular guidance should be provided on the efficacy of using the Green Star rating for assessment purposes when a development proposal is at the Development Application stage and detailed building design has not yet occurred.

7.0 Conclusion

Addressing the Research Objectives

This thesis set out to address a series of research objectives that were identified to inform an analysis of the use of cogeneration within the City of Sydney Local Government Area.

Whilst there is a range of academic literature which relates to the role of decentralised energy and the urban planning implications of its emergence in an international context, there is a distinct absence of Australian research of the issue. Whilst many of the economic and environmental themes in the literature on decentralised energy have direct relevance to and are interlinked with cogeneration, there is almost no academic literature relating to the role which urban planning plays in the development of cogeneration facilities at either an international or Australian level.

The absence of an established international body of knowledge regarding the environmental, economic and urban planning implications of the use of cogeneration development to reduce greenhouse gas emissions has meant that proponents of this technology have often been required to learn on the ground. In New York City and the Borough of Woking, proposals for precinct-scale cogeneration have delivered substantial reductions in greenhouse gas emissions through short term programs. These developments have occurred in isolation, however, and often without regard to the broader long-term economic and environmental implications of this technology.

In Australia and NSW, the policy setting for greenhouse gas emissions reductions generally favours a market-led approach to achieve the most economic form of GHG emission reductions. This market-led approach has been guided by specific policies which promote the development of renewable energy to 'green the grid' and building energy efficiency to reduce overall demand for energy.

The City of Sydney has diverged from the Federal and State policies by targeting more ambitious greenhouse emission reductions in the short-term through the implementation of a series of direct government action plans. Of these, the proposed development of precinct-scale cogeneration under the *Decentralised Energy Master Plan – Trigeneration* is the highest priority action being pursued by Council. This proposal will require significant infrastructure and capital investments that will 'lock-in' the Sydney CBD to a fossil fuel-based energy model, which is an approach that is not consistent with Federal and State policy. In the absence of any guidance on the broader long-term environmental and economic implications, Council has been forced to develop its own long-term analysis and assumptions which underpin modelling of the environmental and economic costs of precinct-scale cogeneration in Sydney. These assumptions conflict with Federal and State policies, have not been received well by the Sydney property industry, and are not likely to achieve the environmental or economic outcomes that have been claimed.

At the same time, policy settings for on-site cogeneration (which does not have the same adverse 'lock-in' potential of precinct systems) have both helped and hindered the uptake of this technology in Sydney. Building sustainability and energy rating tools such as NABERS and Green Star have created a niche for the use of cogeneration facilities within premium-grade commercial and residential buildings in the City of Sydney. The top-tier ratings achieved by buildings which incorporate cogeneration facilities allow the attraction and retention of premium-grade tenants who justify the expense of the higher installation and operating costs of cogeneration. The absence of relevant State of local policies for cogeneration development has meant that response of the City of Sydney planning assessment system to the emergence of on-site cogeneration has been inconsistent, unclear and ad-hoc. Clear, relevant and practical planning guidance is required to support the emergence of this development type in Sydney.

Further Research

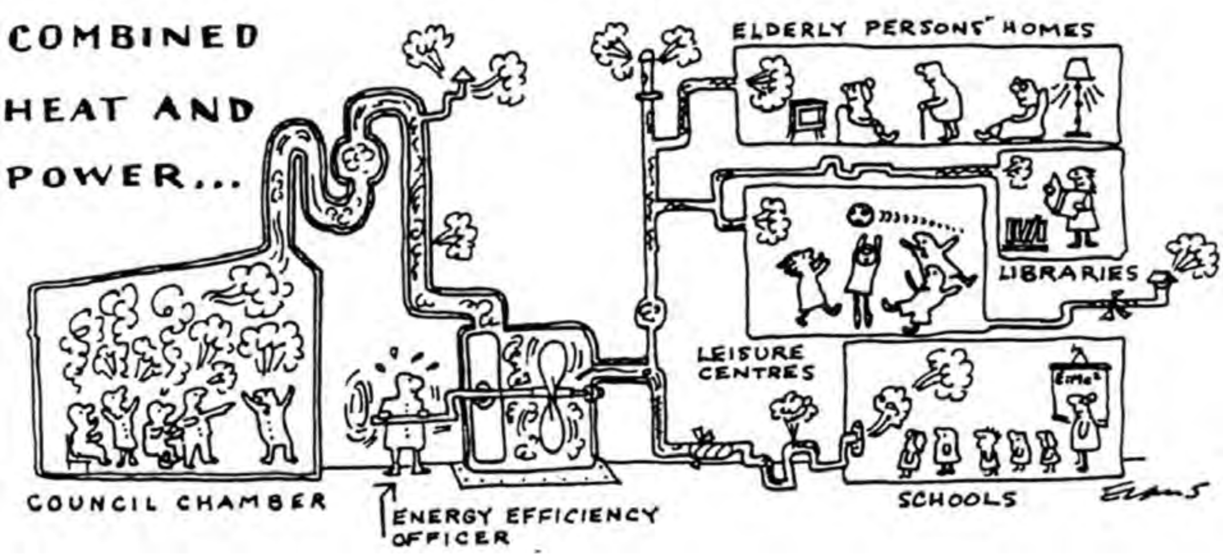
This thesis has primarily investigated and analysed the role of planning in the development of cogeneration, including the environmental and economic implications of this development type. The formulation of good strategic planning and development policy requires a strong and reliable evidence base drawing on a range of interdisciplinary expertise. A key theme throughout this thesis has been the absence of clear and relevant information relating to the applications of cogeneration in meeting Australia's environmental and economic objectives. In order to address this knowledge gap, further research is required across a range of research fields including economics and finance, energy policy, climate policy, engineering and environmental science. This research must not only analyse the 'costs' and 'benefits' of cogeneration in its own right, but must also place this analysis in the context of other available and emerging low-carbon energy technologies.

Concluding Remarks

The City of Sydney should be commended on its proactive role in seeking to achieve the significant greenhouse gas emission reductions that are required to be achieved around the world if catastrophic human-induced climate change is to be averted. The emphasis on precinct-scale cogeneration as part of the strategy is, however, less commendable. The City of Sydney is essentially proposing to generate electricity and heat for Sydney's main energy users using a fossil fuel (natural gas) at the same time as the benefits provided by this technology diminish rapidly. Demand for both electricity and thermal energy is falling as a result of improved building energy and thermal efficiency regulations. At the same time, large scale renewable energy production is growing exponentially prompted by diminishing installation costs and the rekindling of the Renewable Energy Target, whilst the greenhouse gas emissions-intensity and cost of natural gas supplies in NSW is increasing. The significant physical infrastructure and capital investment required to develop precinct-scale cogeneration facilities within the Low Carbon Infrastructure Zones, which span the entire Sydney CBD, is likely to 'lock-in' a system that will ultimately hinder the development of greenhouse gas emission measures that are environmentally, economically and technologically superior to precinct-scale cogeneration, and will impose a significant cost on future generations of Sydney residents and businesses.

Despite this, there is clearly a role for cogeneration in the City of Sydney Local Government Area to provide rapid and short-term greenhouse emissions reductions in certain instances where it <u>is</u> the most appropriate economical, technological and environmental response to meeting defined energy demands. There are clear instances of building types within the City of Sydney, such as hotels and aquatic centres, or small clusters of buildings under single ownership, such as Sydney University, where on-site cogeneration is the best available low-carbon energy technology. Whilst on-site cogeneration can be less efficient overall than precinct-scale cogeneration, the lower capital and infrastructure requirements for these systems will allow them to be implemented rapidly to achieve quick greenhouse gas emission reductions, and then be easily replaced by cleaner and cheaper low-carbon energy systems as Australia shifts towards a zero-carbon economy.

Governments at all levels need to do more to provide information and governance systems that support the development of low-carbon energy systems, particularly in urban areas such as the City of Sydney. The current absence of clear planning and development policies for both local government and the property industry creates uncertainty and confusion as to what action is required to reduce greenhouse gas emissions. This leads to conflicting actions at different levels which ultimately work against the overall goal of a reducing Australia's national greenhouse gas emissions. Major cities such as Sydney have great potential to contribute to the reduction of greenhouse gas emissions, but need greater guidance in understanding how this potential should be converted to action within the broader context of state and national energy policy.



Source: *London Climate Change Authority 2006*

8.0 Bibliography

Interviews

Interviewee A 2012, Qualitative interview with author for thesis project, Sydney, 24 September 2012

Interviewee B 2012, Qualitative interview with author for thesis project, Sydney, 12 September 2012

Midlam, N 2012, Qualitative interview with author for thesis project, Sydney, 19 September 2012

Precious, B 2012, Qualitative interview with author for thesis project, Sydney, 21 September 2012

Wyse, K 2012, Qualitative interview and site inspection of UNSW Lowy Cancer Research Centre, 3 October 2012

Public Forums

Jones, A 2012, Public lecture at Macquarie University on Decentralised Energy and Trigeneration, Sydney, 21 August 2012

Existing Literature

Ackermann, Thomas, Andersson, Göran, and Söder, Lennart (2001), 'Distributed generation: a definition', Electric Power Systems Research, 57 (3), 195-204.

Aitken, Mhairi (2010), 'Wind power and community benefits: Challenges and opportunities', Energy Policy, 38 (10), 6066-75.

Allen, S. R., Hammond, G. P., and McManus, M. C. (2008), 'Prospects for and barriers to domestic micro-generation: A United Kingdom perspective', Applied Energy, 85 (6), 528-44.

Australian Bureau of Agricultural and Resources Economics and Statistics 2011, *Energy in Australia 2011*, Department of Resources Energy and Tourism, Canberra

Australian Energy Market Operation (AEMO) 2012, Carbon Dioxide Equivalent Intensity Index, website, Australian Energy Market Operator, accessed 12 August 2012, http://www.aemo.com.au/Electricity/Settlements/Carbon-Dioxide-Equivalent-Intensity-Index

Bazilian, Morgan, et al. (2011), 'Interactions between energy security and climate change: A focus on developing countries', Energy Policy, 39 (6), 3750-56.

Bergek, Anna (2010), 'Levelling the playing field? The influence of national wind power planning instruments on conflicts of interests in a Swedish county', Energy Policy, 38 (5), 2357-69.

Blackhurst, Michael, et al. (2011), 'Designing building energy efficiency programs for greenhouse gas reductions', Energy Policy, 39 (9), 5269-79.

Bunning J 2011, Governance supporting distributed energy systems for low carbon urban development, conference paper presented at *19th International Congress on Modelling and Simulation,* 12–16 December 2011, Perth, Australia

Chancellor 2009, The Hyde of it: penthouse sale seeks to top $20m, 31 October 2009, Sydney Morning Herald, news website, accessed 10 September 2012, http://www.smh.com.au/executive-style/luxury/the-hyde-of-it-penthouse-sale-seeks-to-top-20m-20091030-hprf.html#ixzz299idLIEI

Chicco, Gianfranco and Mancarella, Pierluigi (2007), 'Trigeneration primary energy saving evaluation for energy planning and policy development', Energy Policy, 35 (12), 6132-44.

Chomitz K 2009, Climate Change and the World Bank Group, Phase 1: an evaluation of win-win energy policy reforms, World Bank, Washington DC, p.74-75

City of Sydney 2008, Sustainable Sydney 2030 Strategy, City of Sydney Council, Sydney

City of Sydney 2010, Approach to Retail Exemptions Issues Paper Submission to the Australian Energy Regulator, City of Sydney Council, Sydney

City of Sydney 2012, NCOS Carbon Neutral Program Public Disclosure Summary, City of Sydney, Sydney

City of Sydney 2012b, Edited non-confidential Heads of Agreement between the Council for the City of Sydney and Cogent Energy in respect of the delivery of trigeneration services for the City of Sydney buildings and operations and City of Sydney Local Government Area, council report, 26 March 2012, Sydney

City of Sydney 2012c, Statement of Environmental Effects for former South Sydney Hospital, June 2012, Sydney

Clean Energy Regulator 2012, Guide to carbon price liability under the *Clean Energy Act 2011*, Clean Energy Regulator, Canberra

Climate Change Authority 2012, Renewable Energy Target Review Issues Paper, August 2012, Climate Change Authority, Canberra

ClimateWorks 2010, Low Carbon Growth Plan for Australia, ClimateWorks, Canberra

Con Edison 2010, *Long Range Plan for Steam 2010-2030*, Consolidated Edison Ltd, New York City

Con Edison 2011, Air Emissions Performance, *2011 Sustainability Report*, Consolidated Edison, New York City

Da Silva M 2012, The Real Threat to Natural Gas Prices, The Global Mail, website, accessed 13 August 2012, http://www.theglobalmail.org/feature/the-real-threat-to-natural-gas-prices/259/

De Palma, Anthony 2007, Building Code Lags Behind Mayor's Vision: City's Red Tape Slows An Effort to Go Green, *New York Times*, newspaper, 15 September 2007, New York City

Department of Climate Change and Energy Efficiency (DCCEE) 2010, National Greenhouse Accounting Factors, Commonwealth Government of Australia, Canberra, p.11-13

Department of Climate Change and Energy Efficiency (DCCEE) 2011, Securing a Clean Energy Future: The Australian Government's Climate Change Plan, Commonwealth of Australia, Canberra

Department of Premier and Cabinet 2012, Historic day for NSW electricity sale, media release, 30 May 2012, NSW Department of Premier and Cabinet, Sydney

Dicorato, M., Forte, G., and Trovato, M. (2008), 'Environmental-constrained energy planning using energy-efficiency and distributed-generation facilities', Renewable Energy, 33 (6), 1297-313.

Dinica, Valentina (2011), 'Renewable electricity production costs—A framework to assist policy-makers' decisions on price support', Energy Policy, 39 (7), 4153-67.

Dunstan, C. & Langham, E. 2010, *Close to Home: Potential Benefits of Decentralised Energy for NSW Electricity Consumers*, prepared by the Institute for Sustainable Futures, University of Technology, Sydney for the City of Sydney, November 2010.

Energetics 2012, *Inclusion of Energy Generation in Building Energy Efficiency* Standards, Australian Department of Climate Change and Energy Efficiency, Canberra, http://www.climatechange.gov.au/~/media/publications/nbf/inclusion-of-energy-generation-in-building-energy-efficiency-standards-pdf.pdf

Energy for London 2012, Latest CHP data for London paints confusing picture, *Energy for* London, weblog post, 27 September 2012, accessed 2 September 2012, http://www.energyforlondon.org/latest-chp-data-for-london-paints-confusing-picture/

Freed A 2010, Best Practice: PlaNYC: NYC's Long-Term Sustainability Plan, New York City Mayor's Office of Operations 2010, New York City

Gillard 2012, Electricity prices: the facts, Speech to the Energy Policy Institute of Australia, transcript of speech, 7 August 2012, accessed 9 August 2012, http://www.pm.gov.au/press-office/electricity-prices-facts-speech-energy-policy-institute-australia

Goodman, D 2011, 'Responding to Climate Crisis: Modernisation, Limits and Socialism', *Journal of Australian Political Economy: Special Issue – Challenging Climate Change*, 66:144-165

Green Building Council of Australia 2012, Green Star – Office v3 Technical Manual, 27 July 2012, Green Building Council of Australasia, Sydney

Gross, Catherine (2007), 'Community perspectives of wind energy in Australia: The application of a justice and community fairness framework to increase social acceptance', Energy Policy, 35 (5), 2727-36.

Hargreaves, Tom, Nye, Michael, and Burgess, Jacquelin (2010), 'Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors', Energy Policy, 38 (10), 6111-19.

Hazzard, Brad 2012, Feedback sought on rezoning changes, media release, 27 March 2012, Sydney

Heagle, A. L. B., Naterer, G. F., and Pope, K. (2011), 'Small wind turbine energy policies for residential and small business usage in Ontario, Canada', Energy Policy, 39 (4), 1988-99.

Hobson, Kersty and Niemeyer, Simon 2011, Public responses to climate change: The role of deliberation in building capacity for adaptive action, Global Environmental Change, Volume 21, Issue 3, August 2011, Pages 957-971

IEA, International Energy Agency (2008), World Energy Outlook 2008 (Paris: OECD/IEA).

Institute for Sustainable Futures 2011, *NSW Business Energy Prices to 2020*, University of Technology Sydney, Sydney

Ison N, Rutovitz J, Harris S, 2011, NSW Business Energy Prices to 2020, Kaundinya, Deepak Paramashivan, Balachandra, P., and Ravindranath, N. H. (2009), 'Grid-connected versus stand-alone energy systems for decentralized power—A review of literature', Renewable and Sustainable Energy Reviews, 13 (8), 2041-50.

Keirstead, James (2008), 'What changes, if any, would increased levels of low-carbon decentralised energy have on the built environment?', Energy Policy, 36 (12), 4518-21.

Kelly, S. & Pollitt, M. & Crawford-Brown, D., 2012. "Building performance evaluation and certification in the UK: a critical review of SAP?," Cambridge Working Papers in Economics 1238, Faculty of Economics, University of Cambridge.

Kinesis 2012, Decentralised Energy Masterplan: Trigeneration, City of Sydney Council, Sydney

Kinesis 2012b, Technical Appendix to the Decentralised Energy Masterplan: Trigeneration, City of Sydney Council, Sydney

Kinrade, Peter (2007), 'Toward a sustainable energy future in Australia', Futures, 39 (2–3), 230-52.

König, Andreas (2011), 'Cost efficient utilisation of biomass in the German energy system in the context of energy and environmental policies', Energy Policy, 39 (2), 628-36.

La Gennusa, Maria, et al. (2011), 'A model for predicting the potential diffusion of solar energy systems in complex urban environments', Energy Policy, 39 (9), 5335-43.

London Climate Change Agency 2007, Submission on OFGEM Distributed Energy Review – Review of Arrangements for Distributed (Decentralised) Energy, London Climate Change Authority, London

Longden, David, et al. (2007), 'Distributed or centralised energy-from-waste policy? Implications of technology and scale at municipal level', Energy Policy, 35 (4), 2622-34.

Low Carbon Australia 2011, City of Sydney Goes Carbon Neutral, media release, website, accessed 10 September 2012, http://www.lowcarbonaustralia.com.au/business/going-carbon-neutral/carbon-neutral-network/city-of-sydney.aspx

Lovins, A.B. (1977), Soft energy paths: toward a durable peace, Medium: X; Size: Pages: 251.

Mangoyana, Robert B. and Smith, Timothy F. (2011), 'Decentralised bioenergy systems: A review of opportunities and threats', Energy Policy, 39 (3), 1286-95.

Miskelly 2012, Wind Farm Performance Data, website, accessed 2 September 2012, http://windfarmperformance.info/?date=2012-09-18

Möller, Bernd (2011), 'Continuous spatial modelling to analyse planning and economic consequences of offshore wind energy', Energy Policy, 39 (2), 511-17.

New York City Department of Correction 2009, *Rikers Island Energy Upgrade (Cogeneration Facility) Project*, New York City Department of Corrections, New York City

New York City Mayor's Office of Long-Term Planning and Sustainability 2012, *Overview of the Greener, Greater Buildings Plan*, New York City

New York State Energy Planning Board 2009, Energy Infrastructure Issue Brief, *New York State Energy Plan 2009*, New York State Energy Planning Board, New York City

New York University 2011, *NYU Switches on Green CoGen Plant and Powers Up for the Sustainable Future*, media release, New York University, New York City

NSW Department of Planning and Infrastructure 2012, A New Planning System for NSW, July 2012, NSW Department of Planning and Infrastructure, Sydney

NSW Department of Trade and Investment, Major Existing NSW Power Stations, Electricity Generation, NSW Government, Sydney, Website, http://www.trade.nsw.gov.au/energy/electricity/generation [Accessed 12 September 2012]

Oresome Resources, Fossil Fuel Power Stations in Australia interactive Google map, website, accessed 14 August 2012, http://www.oresomeresources.com/interactives_view/resource/interactive_fossil_fuel_power_stations_in_australia_map

Parkinson 2012, Is CSG cleaner than coal?, *Climate Spectator*, news website, 19 August 2011, accessed 28 September 2012, http://www.climatespectator.com.au/commentary/csg-cleaner-coal

Patel-Predd 2009, *Generation Cogeneration*, IEEE Spectrum, weblog, March 2009, accessed 12 August 2012, http://spectrum.ieee.org/green-tech/clean-coal/generation-cogeneration/0

Pears, Alan K. (2007), 'Imagining Australia's energy services futures', Futures, 39 (2–3), 253-71.

Perinotto, Tina 2012 Sydney's chiller trigen plan hits a road block, *The Fifth Estate*, news website, 22 August 2012, accessed 24 August 2012, http://www.thefifthestate.com.au/archives/37751

Portman, Michelle (2009), 'Involving the public in the impact assessment of offshore renewable energy facilities', Marine Policy, 33 (2), 332-38.

Prados, María-José (2010), 'Renewable energy policy and landscape management in Andalusia, Spain: The facts', Energy Policy, 38 (11), 6900-09.

ClimateWorks 2011, Unlocking Barriers to Cogeneration: Project Outcomes Report, September 2011,Property Council of Australia, Melbourne

Rockstrom et.al. 2009, *A Safe Operating Space for Humanity*, Nature 461, 472-475 (24 September 2009); doi:10.1038/461472a

Russell S 1993, Writing energy history: explaining the neglect of CHP/DH in Britain. The British Journal for the History of Science, 26, pp 33-54

Salleh, A 2011, 'Making the Choice Between Ecological Modernisation or Living Well', *Journal of Australian Political Economy: Special Issue – Challenging Climate Change*, 66:118-143

Sandiford 2012, Who's afraid of solar PV?, *Climate Spectator*, news website, 22 August 2012, accessed 22 August 2012, http://www.climatespectator.com.au/commentary/whos-afraid-solar-pv

Sinclair Knight Mertz 2011, Projections of Greenhouse Gas Emissions for the Stationary Energy Sector, Department of Climate Change and Energy Efficiency, Canberra

Skoufa, Lucas and Tamaschke, Rick (2011), 'Carbon prices, institutions, technology and electricity generation firms in two Australian states', Energy Policy, 39 (5), 2606-14.

Sovacool, Benjamin K. (2008), 'Distributed Generation (DG) and the American Electric Utility System: What is Stopping It?', Journal of Energy Resources Technology, 130 (1), 012001-8.

Sustainability Fund 2012, *Smart Energy Zones Case Study: Woking UK*, Sustainability Victoria, Melbourne

Sperling, Karl, Hvelplund, Frede, and Mathiesen, Brian Vad (2011), 'Centralisation and decentralisation in strategic municipal energy planning in Denmark', Energy Policy, 39 (3), 1338-51.

Tebbut, M 2008, $10.7 million for local climate change projects, media release, 26 September 2008, NSW Deputy Premier's Office, Sydney, accessed 30 August 2012

Thameswey Limited 2012, Report of the Directors and Consolidated Financial Statements for the year ending 31 December 2011, Thameswey Limited, Woking

Treasury 2011, Strong Growth, Low Pollution – Modelling a Carbon Price, Commonwealth of Australia, Canberra,

Umow Lai 2011, Carbon Neutral and Green Star Concept Design Report, Legion House, 161 Castlereagh Street, technical report. 28 April 2011, Melbourne

Steinfield 2011, Data shows trigeneration is saving tonnes, *Green Buildings Alive*, weblog, 26 May 2011, accessed 28 September 2012,
http://www.greenbuildingsalive.com/discussions/2011/05/26/trigeneration-saving-tonnes/

Walker, Gordon (1995), 'Renewable energy and the public', Land Use Policy, 12 (1), 49-59.
— (2008), 'What are the barriers and incentives for community-owned means of energy production and use?', Energy Policy, 36 (12), 4401-05.

West, J., Bailey, I., and Winter, M. (2010), 'Renewable energy policy and public perceptions of renewable energy: A cultural theory approach', Energy Policy, 38 (10), 5739-48.

Williams, Jo (2010), 'The deployment of decentralised energy systems as part of the housing growth programme in the UK', Energy Policy, 38 (12), 7604-13.

Woking Borough Council 2012, Population Statistics, website, Woking Borough Council, Woking, accessed 14 August 2012, http://www.woking.gov.uk/woking/people/population

Woodman, Bridget and Baker, Philip (2008), 'Regulatory frameworks for decentralised energy', Energy Policy, 36 (12), 4527-31.

World Alliance for Decentralised Energy 2003, Guide to Decentralized Energy Technologies, World Alliance for Decentralised Energy, Edinburgh

Wright 2012, Trigeneration: Sydney's White Elephant, *Climate Spectator*, news website, 4 September 2012, accessed 5 September 2012,
http://www.climatespectator.com.au/commentary/trigeneration-sydneys-white-elephant

9.0 Appendices

PROJECT INFORMATION STATEMENT

Date: September 2012
Project Title: *Planning for Cogeneration and Trigeneration in Sydney*

Approval No.: 125025

UNSW
THE UNIVERSITY OF NEW SOUTH WALES
BUILT ENVIRONMENT

Participant selection and purpose of study
You are invited to participate in a study of the implementation of on-site and precinct-level cogeneration and trigeneration facilities within the Sydney CBD, particularly with regard to the implications for urban planning in terms of this type of development's economic, environmental and social impacts. You were selected as a possible participant in this study because of your role, knowledge and experience in building and urban sustainability and particularly in cogeneration and trigeneration.

Description of study
If you decide to participate, we will undertake an in-depth interview in person or by telephone. The interview will be guided by a set of questions designed to provide a range of opinions regarding the topic. This interview is expected to take no longer than one hour. We cannot and do not guarantee or promise that you will receive any benefits from this study.

Confidentiality and disclosure of information
Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission, or except as required by law. If you give us your permission, we plan to discuss the results of the interview in the final thesis project undertaken as the final core requirement of the Bachelor of Planning program under the Faculty of Built Environment, University of New South Wales.

Your consent
Your decision whether or not to participate will not prejudice your future relations with The University of New South Wales or other participating organisations. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without prejudice by completing the statement below and returning this entire form to [redacted] or:

[redacted]
c/- Faculty of Built Environment
University of New South Wales
Sydney, NSW 2052

If you have any questions, please feel free to ask [redacted] or on [redacted] If you have any additional questions later, [redacted] Program Director – Planning UNSW [redacted] will be happy to answer them.

[redacted]

REVOCATION OF CONSENT. Project Title: *Planning for Cogeneration and Trigeneration in Sydney*
(Please send this entire form to the above address.)
I hereby wish to withdraw my consent to participate in this research project. I understand that such withdrawal will not jeopardise my relationship with The University of New South Wales, other participating organisations or other professionals.

....	....	....
Signature	Please PRINT name	Date

Framework Questions for In-Depth Interviews

These questions were used as a generic framework for all qualitative interviews. These were supplemented by specific written questions tailored to the interview subject and further unprepared 'follow-up' questions to clarify issues during the course of the interview.

1. Interviewee position description, organisation description, background

2. How significant do you believe cogeneration can be in addressing the environmental and economic objectives of your organisation and for cities more generally?

3. Do you believe cogeneration is an appropriate solution to addressing greenhouse gas emission targets?

4. To what extent has awareness of sustainability issues driven consumer and political demand for cogeneration development? What role have green building rating tools played?

5. What impacts do you believe on-site and precinct scale cogeneration systems have on the urban environment and the development industry? Should cogeneration be more widely adopted in the Sydney CBD?

6. Do you believe that exiting policies, legislation and development assessment systems are well suited to addressing cogeneration development and decentralised energy more generally?

7. What do you see are the key benefits, costs and barriers to the City of Sydney's proposed precinct-scale trigeneration scheme?

8. How confident are you that 'sustainable gas' can be sourced and supplied to meet the future needs of cogeneration facilities?

9. How well placed do you feel your organisation is to address the issues of climate change and energy policy in terms of skills and resources?

10. Additional specific questions

11. Any further comments to add?

Cogeneration is a well-established technology used in cooler climates as a solution to the social and economic imperatives of delivering heat and electricity to cities. In the warm climate of Sydney, the use of the technology is still in its infancy but is being promoted as a means to address a primarily environmental objective – the reduction of greenhouse gas emissions. In the absence of an established framework for reducing emissions at the 'street-level' of our major cities, cogeneration has been developed in an opportunistic and sporadic way by individual actors seeking to achieve one-off economic or environmental objectives rather than as part of a coordinated response. The challenge for urban planners is to facilitate the development of cogeneration in a way that achieves the overarching environmental objective without producing adverse economic, environmental and social impacts. Addressing this challenge requires further understanding of the current planning policy settings for cogeneration and the implications of existing and future cogeneration development patterns.