LAKE MACQUARIE CITY COUNCIL
ENERGY RESILIENCE PLAN

STRATEGIES FOR AN ENERGY RESILIENT FUTURE

Prepared by Kinesis for Lake Macquarie City Council
July 2012

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NOTE:

This report is provided subject to some important assumptions and qualifications

a) The results presented in this report are modelled estimates using mathematical calculations. The data, information and scenarios presented in this report have not been separately confirmed or verified. Accordingly the results should be considered to be preliminary in nature and subject to such confirmation and verification.

b) Energy and greenhouse consumption estimates are based on local climate and utility data available to the consultant at the time of the report. These consumption demands are, where necessary, quantified in terms of primary energy and water consumptions using manufacturer's data and scientific principles.

c) Cost estimates provided in this report are indicative only based on Kinesis's project experience and available data from published economic assessments.

d) The Kinesis software tool and results generated by it are not intended to be used as the sole or primary basis for making investment or financial decisions (including carbon credit trading decisions). Accordingly, the results set out in this report should not be relied on as the sole or primary source of information applicable to such decisions.

Executive Summary

This Strategic Plan has been developed to analyse and document the actions Lake Macquarie City Council can take to achieve its greenhouse gas emission reduction target and improve the energy resilience of Lake Macquarie's residents. Energy resilience is the ability for the community of Lake Macquarie to draw on resources and technology to adapt to changing political, social, environmental, and economic energy context without loss of quality of life.

Three scenarios were developed using the Lake Macquarie Energy Futures Model to analyse the effects of different energy efficiency and alternative energy actions on Lake Macquarie's emissions (Figure 1) and energy use. Under these scenarios:

1. **No Action** – assumes Lake Macquarie City Council undertakes no additional action to reduce emissions beyond policies (such as the Federal Government's Renewable Energy Target) which are already in place. Without additional action total emissions will increase by 27% on 2007 levels by 2050, with per person emissions reduced by 9%.

2. **Carbon Neutral** – illustrates the scale of action required to meet Lake Macquarie City Council's existing 3% per capita per annum emissions reduction target. It shows that meeting this target will require a considerable investment in infrastructure including the generation of over 600,000 MWh of renewable energy – this is approximately equivalent to the current residential electricity requirements in Lake Macquarie. It will also require the use of renewable gas from 2030 – as shown by the dip in Carbon Neutral scenario (Figure 1).

3. **Local Action** – this scenario attempts to isolate emission reduction actions from the Carbon Neutral scenario that Lake Macquarie City Council has a high ability to influence without the direct involvement of other levels of government. In this scenario total emissions decrease by 17% on 2007 levels by 2050, with per person emissions reduced by 41%.

LAKE MACQUARIE EMISSION REDUCTION SCENARIOS

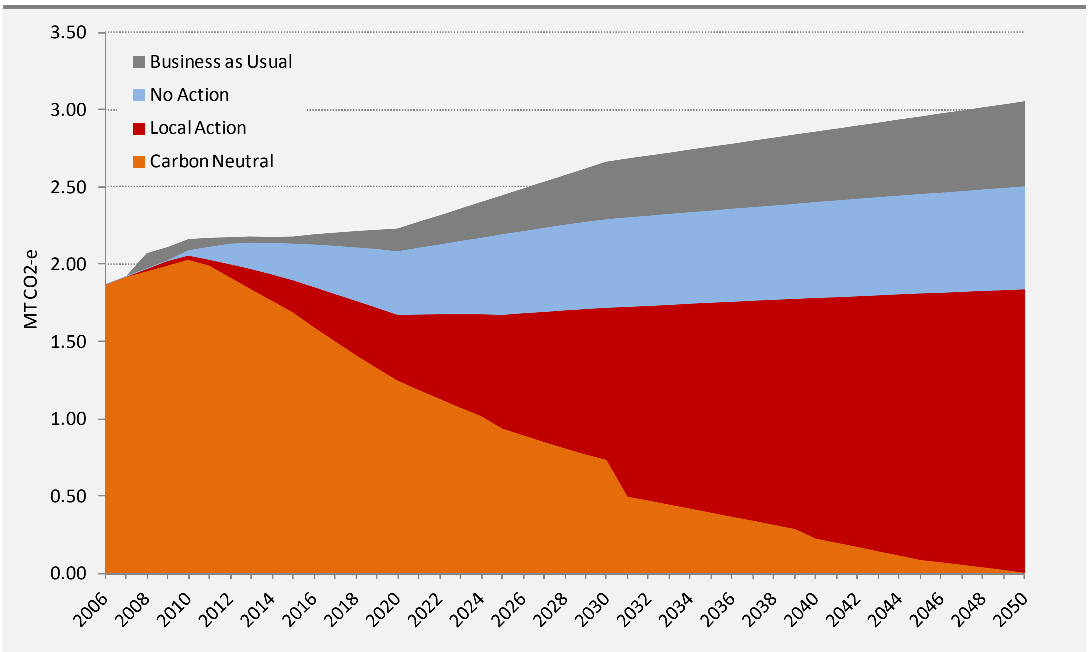

Figure 1: Cumulative Emission reductions by 2050 for each modelled scenario (Note: Business as Usual represents current consumption patterns projected with growth in dwellings and floor space)

The three scenarios modelled in this report highlight the downside to inaction as well as the challenge associated with achieving carbon neutrality by 2050 with existing technologies and governance arrangements. However, these scenarios also show that there are a range of suitable and effective actions that Lake Macquarie City Council could pursue to achieve effective and efficient energy resilience outcomes.

These actions have been analysed based on the level of influence Council has over their implementation, the cost of implementation and the amount of abatement potential. This analysis enabled the actions to be broadly categorised and prioritised based on the strategic value of their implementation (Figure 2).

STRATEGIC PRIORITISATION OF EMISSION REDUCTION ACTIONS

PRIORITY	ACTIONS
HIGH	Low Cost + Mid- High Influence: • Facilitate improved lighting efficiency • Increase the uptake of solar hot water • Facilitate lower car use through urban planning • Investigate the establishment of a community solar PV plant • Investigate the potential for establishing a partnership with a gas provider to facilitate higher gas availability and use throughout Lake Macquarie
MEDIUM	Mid-High Cost + Mid-High Influence: • Facilitate the continued uptake of residential solar PV • Investigate the establishment of community wind turbines
LOW	Low-Mid Cost + Low-Mid Influence: • Investigate the role of trigeneration in high thermal demand areas, such as major commercial centres, hospitals and industrial areas • Facilitate the uptake of electric vehicles • Lobby for improved vehicle fuel efficiency standards • Lobby for improved appliance efficiency standards • Investigate the scope for incentive schemes to support residential thermal efficiency

Figure 2: Strategic prioritisation of actions based on relative marginal abatement cost and level of local government influence over implementation

1 Introduction

The *Lake Macquarie Energy Resilience Strategic Plan* has been prepared to define and describe actions and technologies needed to meet Council's emissions reduction target of 3% per annum per capita and improve Lake Macquarie's energy resilience. It is the result of an engaged consultation and analytical process that included Lake Macquarie City Council staff and key industry and community stakeholders.

Energy resilience, in the context of this strategic plan, refers to the capacity for all sectors of the community to absorb increases in retail electricity prices and to generate energy locally to reduce the impacts of any interruptions to energy supply.

The purpose of this plan is to identify areas where energy resilience can be increased by improving the capacity and options for the community react to energy availability and price pressures, so that functions that energy provides can continue without unsurmountable increases in costs or environmental impact.

Reduced energy consumption and alternative energy generation and distribution within the Lake Macquarie local government area has the potential to:

- reduce energy consumption and greenhouse emissions for across the community
- reduce household and business energy costs.

However, the challenge for Lake Macquarie City Council is to determine the actions that will not only achieve the most effective and efficient sustainability and economic outcomes, but also which actions Council can most directly give effect to and which actions will require additional support from the private sector and other levels of government.

Development of the Strategic Plan

Development of *Lake Macquarie Energy Resilience Strategic Plan* has been undertaken in several stages:

1. A Situation Analysis report was produced to identify Lake Macquarie's current energy flows and emissions baseline. The findings from this report have been incorporated in the Energy Resilience Plan.

2. Feedback and consultation was sought from Lake Macquarie City Council staff and key industry and community stakeholders to proof the baseline data, and identify opportunities and constraints to increased energy resilience in the Lake Macquarie local government area.

3. An Energy Futures Model was developed to model different energy scenarios and to compare the sustainability outcomes of different energy efficiency and alternative energy options.

The quantitative analysis included in this report has been produced using the Energy Futures Model which has been developed as a customised tool for Lake Macquarie City Council. The Model utilises Lake Macquarie specific data, where available, and can assess Lake Macquarie's projected greenhouse gas emissions and energy consumption through time, as well as calculating the potential impact of different policy actions on energy consumption, greenhouse gas emissions and household affordability.

Structure of the Strategic Plan

This plan is based on the modelling of three distinct scenarios:

1. **No Action scenario** – in which significant growth in emissions occurs

2. **Carbon Neutral scenario** – meets Council's 3% per capita per annum reduction target

3. **Local Action scenario** – isolates the emission reductions that Lake Macquarie City Council could achieve independently of state and federal government actions.

These scenarios should not be seen as finite recommendations of particular emission reduction targets or policy responses. Rather, they represent an opportunity to explore the process of achieving a target of carbon neutrality by 2050 (in line with Council's 3% reduction per capita annually) and identify the proportion of these reductions which Lake Macquarie City Council could feasibly take responsibility for.

An overview of each of the three scenarios is provided in section three – **Energy Resilient Future Scenarios**. The comparative greenhouse gas reductions achieved in each scenario on an action-by-action basis are summarised, and the impact of each scenario on household energy costs is also shown.

The actions modelled in the scenarios were quantitatively and qualitatively assessed on the following basis:

1. Technical Constraints
2. Environmental Impact
3. Emissions Reduction Impact
4. Social Impact
5. Economic Impact
6. Governance Implications

The outcomes of this analysis are outlined in the **Detailed Action Profiles** section.

The strategic effectiveness of each action is analysed in the **Chapter 5: Implementation** section, where emission reductions are graphically represented against the cost and level of influence Lake Macquarie City Council would have in their implementation. The visual representation of this matrix analysis identifies those actions, which Lake Macquarie City Council should pursue as a high priority.

2 Current Energy + Emission Profile

Council has an existing greenhouse gas emission reporting procedure for the city. Council's reporting has a scope greater than the sectors covered in the analysis presented in this report and includes sources such as embodied emissions related to food and material consumption, emissions from waste to landfill and fugitive emissions from mining. The current reported 2007/08 baseline for council is 4.8 Million tonnes (see Appendix 2)

In 2007/08, greenhouse gas emissions within the Lake Macquarie LGA from energy electricity, gas and transport fuel that is captured by the data sources used in this analysis totalled approximately **1.9 million tonnes per annum**. This figure is based on:

- Ausgrid data for 2007/08 which included High Voltage (HV) data. It should be noted that Ausgrid no longer provides High Voltage (HV) data creating a future data gap in the industrial sector;
- Gas data provided by Jemena based on the tariff market and excluding the large contract market (Industrial sector); and
- Transport data based on the household travel survey which does not cover commercial travel from businesses, e.g. heavy freight.

The official council footprint has used state and national data scaled to Lake Macquarie as a means of filling the data gaps in the areas where data gaps have been identified above to give as full a picture of greenhouse emissions as possible. It is acknowledged that the industrial sector is not covered in full and is therefore a source of difference with the data in the official footprint in the sectors that they both cover.

The profile in the analysis presented in this report has focused on directly available local data and its applicability to building a model for to allowing future changes to be predicted primarily in the residential and commercial sectors.

In the analysis presented residential energy use and transport is responsible for approximately 60% of Lake Macquarie's emissions (Figure 3 – note that the percentage is lower than seen in Figure 4 due to rounding). Industry also contributes 26% of total emissions whilst commerce is responsible for 8%. This emission profile reflects the low-density urban form in Lake Macquarie and the associated energy consumption from residential buildings and resident transport (see Figure 4).

LAKE MACQUARIE EMISSIONS PROFILE

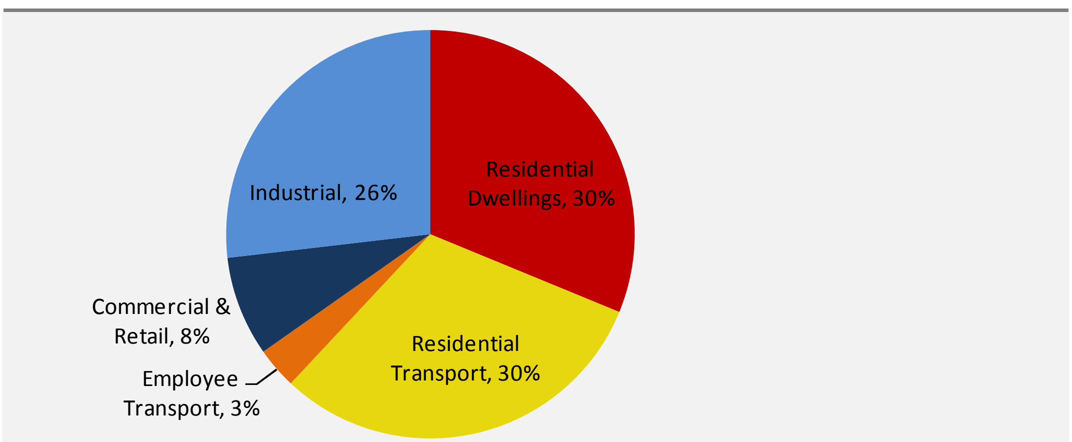

Figure 3: Greenhouse gas emission profile of Lake Macquarie (2007/08)

LAKE MACQUARIE ENERGY FLOWS

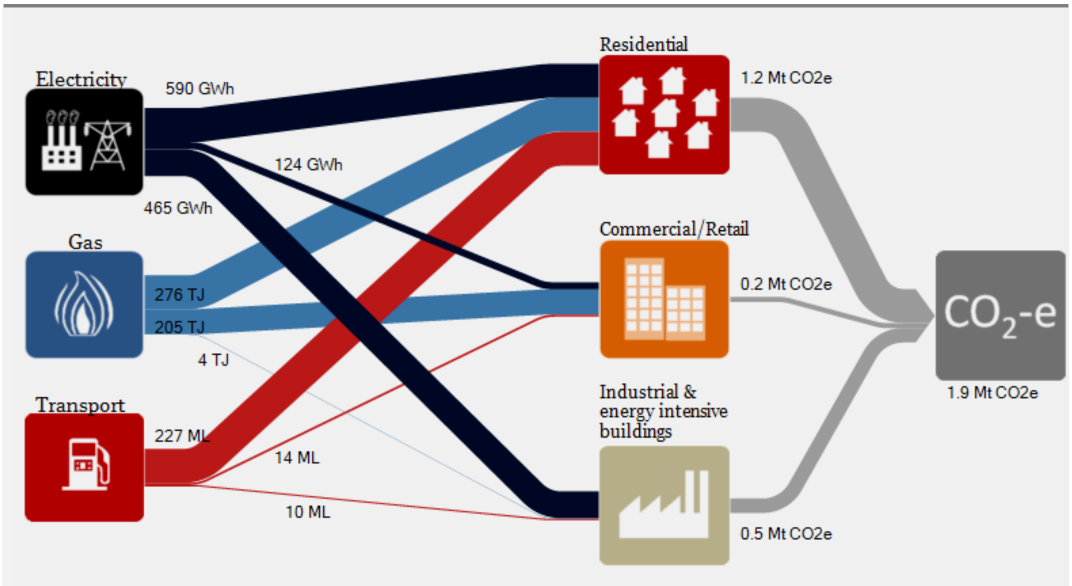

Figure 4: Energy Flows and Greenhouse Gas Emissions for Lake Macquarie (2007/08)

The key energy flows shown in Figure 5 have been derived from:

- Residential dwelling energy use including; Ausgrid metered electricity and Jemena metered gas consumption data from all single, attached and multi-unit dwellings.
- Residential travel fuel including; all Lake Macquarie resident private vehicle and public transport use.
- Commercial, retail and industrial building energy use including; Ausgrid metered electricity and Jemena metered gas consumption data from all non-residential buildings.
- Commercial, retail and industrial travel fuel including; journey to work travel for all employees whose place of work is in the Lake Macquarie LGA.

Residential Sector

The residential sector is Lake Macquarie's largest source of energy related greenhouse gas emissions, contributing 30% of total emissions. The majority of these emissions come from water heating and electrical appliances.

For new residential dwellings, BASIX requires dwellings to be built to reduce their greenhouse gas emissions by 40%. Post occupancy analysis by Ausgrid and the NSW Department of Planning, however, has suggested that new dwellings in Lake Macquarie are achieving only a 20% reduction in greenhouse gas emissions (Energy Australia 2010).

Transport Sector

High car use and associated transport greenhouse gas emissions reflect the low density urban form of Lake Macquarie. Lake Macquarie's distance from Sydney means that a certain percentage of residents will have long daily journeys to work and most of this travel will be in private vehicles.
These factors are largely endemic to the Lake Macquarie LGA and restrict the ability to implement large scale changes to transport patterns within the LGA. However, trips to access

services (such as shopping) were, on average, relatively short compared to commuting trips. This provides an opportunity to shift these local trips to alternative modes of transport, such as walking and cycling (Figure 5).

LAKE MACQUARIE TRIPS BY PURPOSE

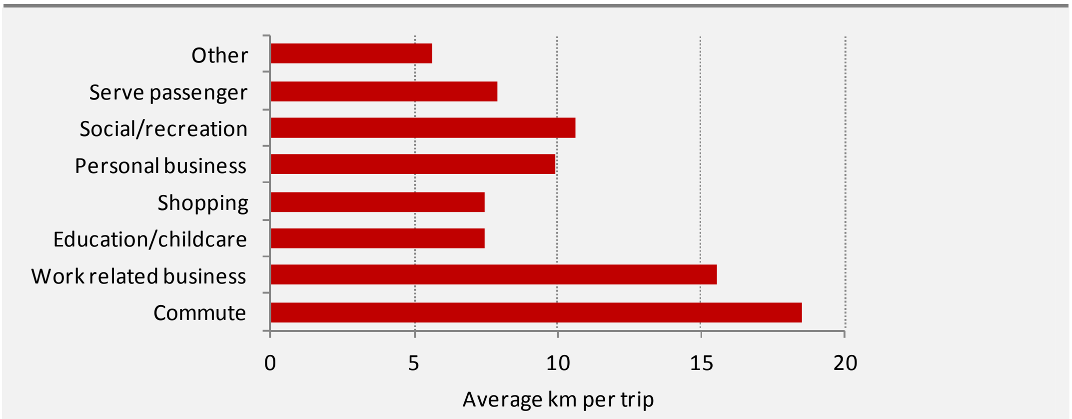

Figure 5: Average distance by trip type for Lake Macquarie residents (Transport and Population Data Centre Australia)

Commercial Sector

Commercial and retail buildings contribute 8% to the total Lake Macquarie energy related greenhouse gas emissions. Average commercial and retail energy consumption and associated greenhouse gas emissions are primarily driven by lighting and equipment such as computers and air conditioning units.

Hospitals, including Lake Macquarie, Gateshead, Belmont, Toronto, and Warners Bay Private Hospitals, are a specific commercial building type that presents high thermal loads for embedded co-generation and trigeneration.

Industrial Sector

Due to some data gaps in industrial floor space and high voltage energy customers, some uncertainty remains with the contribution and projection of energy consumption associated with industry in Lake Macquarie. This lack of data presents a constraint on the extent to which Lake Macquarie City Council can address energy resilience through changes to its industrial sector.

Lake Macquarie City Council is currently undertaking more detailed land use surveys on commercial and industrial lands across the local government area. This data will be used to further inform current and projected energy consumption and greenhouse gas emissions across Lake Macquarie through the Lake Macquarie Energy Futures Model.

Projected Growth in Lake Macquarie

Lake Macquarie is expected to grow by approximately 41,000 people (35,000 dwellings) and 66,000 jobs by 2030. In 2007, approximately 87% of all dwellings were single detached homes. This urban form is expected to continue with single dwelling contributing to more than 70% of new dwellings built between 2007 and 2030.

Assuming 2011 consumption levels, and as a result of this growth, Lake Macquarie's emissions are projected to increase by approximately 39% between 2007 and 2030, and assuming similar growth patterns, approximately 55% by 2050 (Figure 6).

This increase in consumption assumes the continuation of some existing policies that will curb energy consumption and greenhouse gas emissions, including BASIX requirements and the Federal Government Renewable Energy Target (RET), which aims to achieve 20% renewable energy by 2020.

The highest increase in energy consumption and associated emissions will primarily come from commercial and retail buildings. This is due to the expected growth in Lake Macquarie's employment. Despite this growth, the largest contributors to emissions will continue to be residential dwellings and transport.

PROJECTED GREENHOUSE GAS EMISSIONS

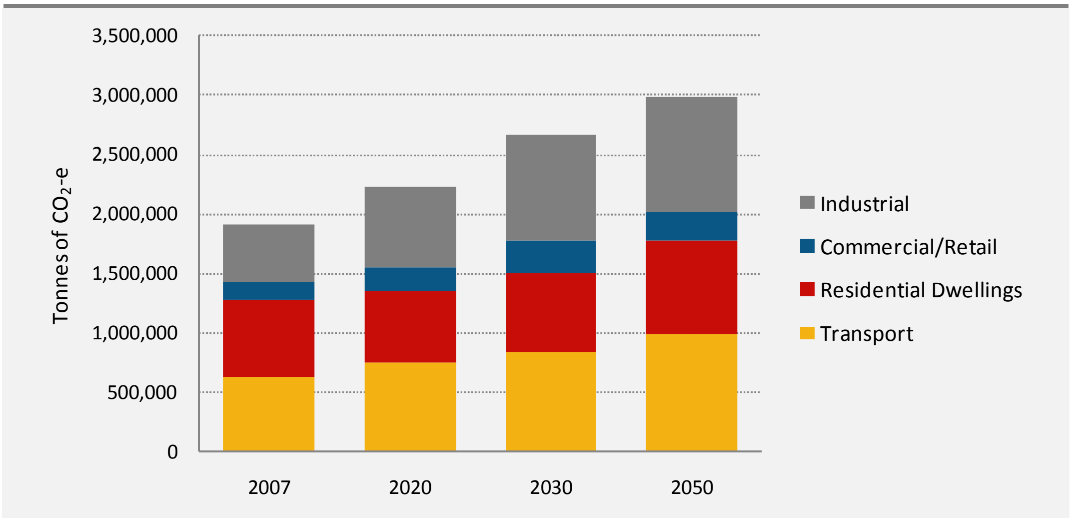

Figure 6: Base year + projected greenhouse gas emissions by sector for Lake Macquarie

3 Energy Resilient Future Scenarios

To determine the energy future of Lake Macquarie, three different energy resilient future scenarios were modelled using the Lake Macquarie Energy Futures Model (Table 1). The impact of each scenario on greenhouse gas emissions is illustrated in Figure 7 and Table 2.

1. **No Action** – a scenario where Lake Macquarie City Council takes no direct action in reducing energy consumption and greenhouse gas emissions

2. **Carbon Neutral** – actions required to achieve the existing greenhouse gas emission reduction target of 3% per year on 2007 levels, achieving carbon neutral by 2050.

3. **Local Action** – those actions that Lake Macquarie City Council has more direct influence and control.

EMISSION REDUCTIONS IN 2050

Reductions by 2050:	No Action	Carbon Neutral	Local Action
% reduction below 2007 levels (base year):	-27%	100%	17%
% reduction in per capita emissions below 2007 levels:	9%	100%	41%
Annual emissions per capita (tonnes CO2-e):	9.4	0.0	6.1
Total emission reductions per year (tonnes CO2-e):	588,000	2,860,000	1,290,000

Table 1: Emission reductions in each scenario by 2050

EMISSION REDUCTIONS OVER TIME

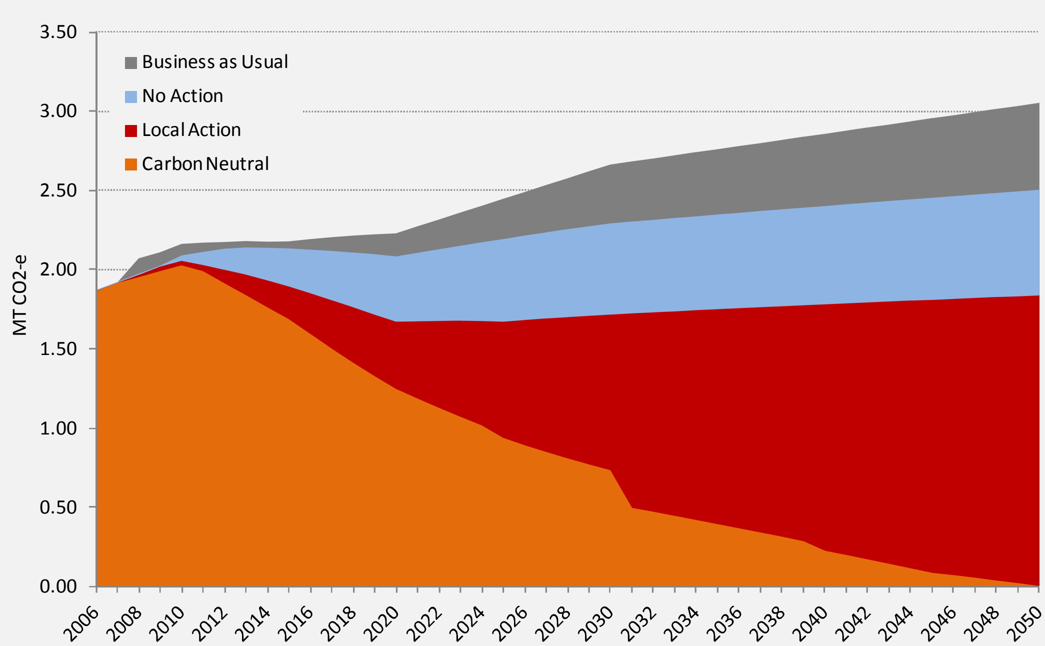

Figure 7: Cumulative Emission reductions by 2050 for each modelled scenario

SCENARIO SUMMARY

Strategy	Intervention	No Action	Carbon Neutral	Local Action
Energy Efficiency	Appliances	0.0%	10.4%	1.0%
	Lighting	4.0%	10.8%	10.4%
	Thermal Efficiency	0.0%	2.2%	2.2%
Fuel Switching	Hot Water	3.8%	4.4%	4.4%
	Heating	0.0%	1.8%	0.2%
	Trigeneration	0.01%	12.1%	1%
	Cooking	0.0%	0.4%	0.4%
Renewable Energy	Residential Solar PV	0.3%	7.5%	2.4%
	Solar Thermal	0.01%	1.9%	0.01%
	Community Solar PV	0.0%	4.1%	0.8%
	Wind	0.0%	0.7%	0.1%
	Greenpower	1.1%	8.8%	8.4%
Transport	Vehicles & Mode Shift	8.2%	20.5%	10.6%
	Electric Vehicles	2.0%	14.3%	3.0%

Table 2: Action-by-action emission reductions for each scenario by 2050

The impact of each scenario on energy resilience is illustrated, based on their modelled effect on household affordability and operating costs (Figure 8). Reducing the city of Lake Macquarie's reliance on private vehicles and improving access to decentralised electricity generation options will reduce greenhouse gas emissions but at the same, reduce household expenditure and increase the resilience of individuals to adapt and respond to rising fuel and electricity prices.

HOUSEHOLD ENERGY COSTS IN 2050

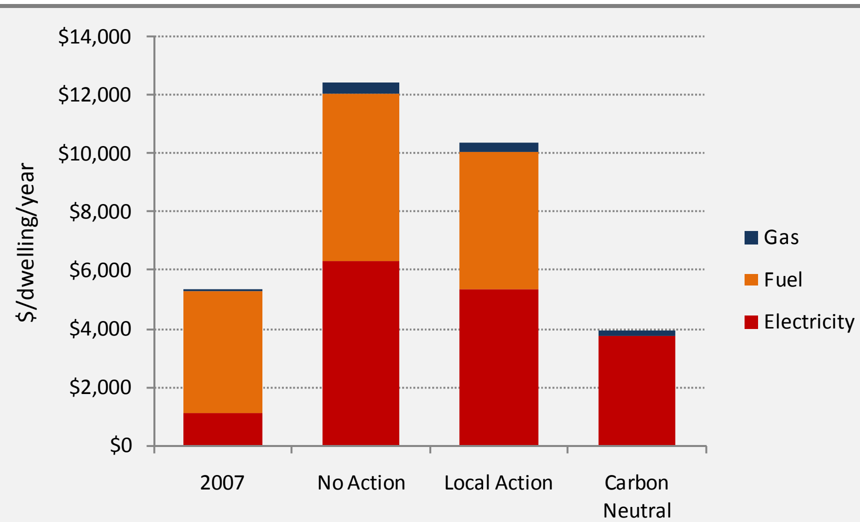

Figure 8: Average annual energy costs per dwelling in 2050 compared to 2007 for each modelled scenario

HOUSEHOLD ENERGY COSTS OVER TIME

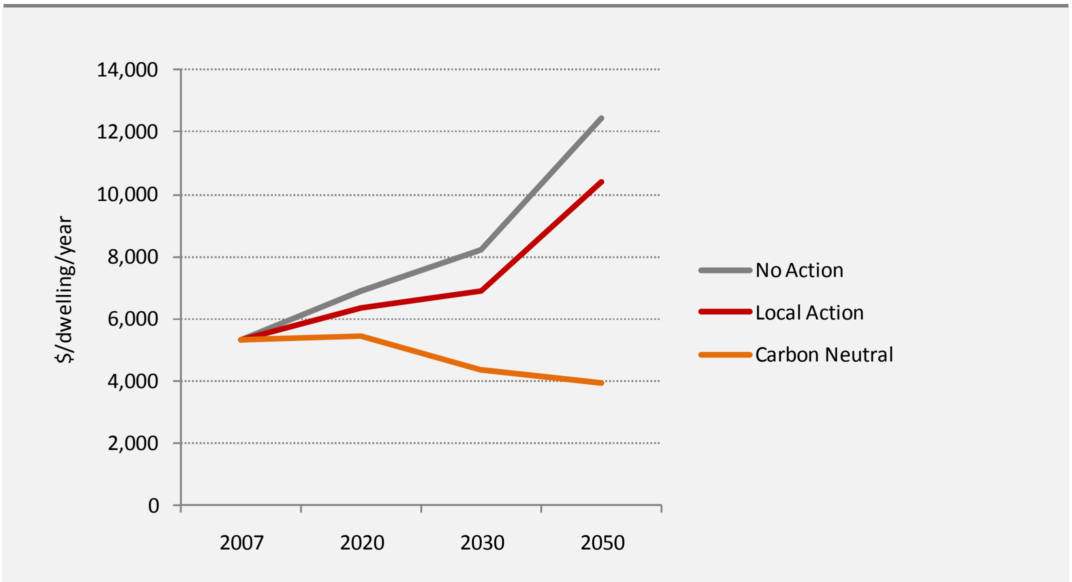

Figure 9: Average annual energy costs per dwelling over time for each modelled scenario

No Action Scenario

The No Action scenario assumes a future where Lake Macquarie City Council takes no direct action in reducing energy consumption or greenhouse gas emissions.

Under this scenario, existing state and federal government policies are expected to **result in a reduction in greenhouse gas emissions of approximately 19%** against BAU projections and cumulatively save approximately 588,000 tonnes of CO2-e by 2050. Per capita emissions will decrease by 9% on 2007 levels. These emission savings are due to:

- The federal government renewable energy target
- The requirement that new homes meet BASIX compliance
- The phase out of electric storage hot water systems
- Technological improvements in lighting and vehicle efficiency

Due to the expected growth of residential and commercial development across Lake Macquarie, greenhouse gas emissions are expected to increase by 27% on 2007 levels (Figure 10).

EMISSION REDUCTIONS

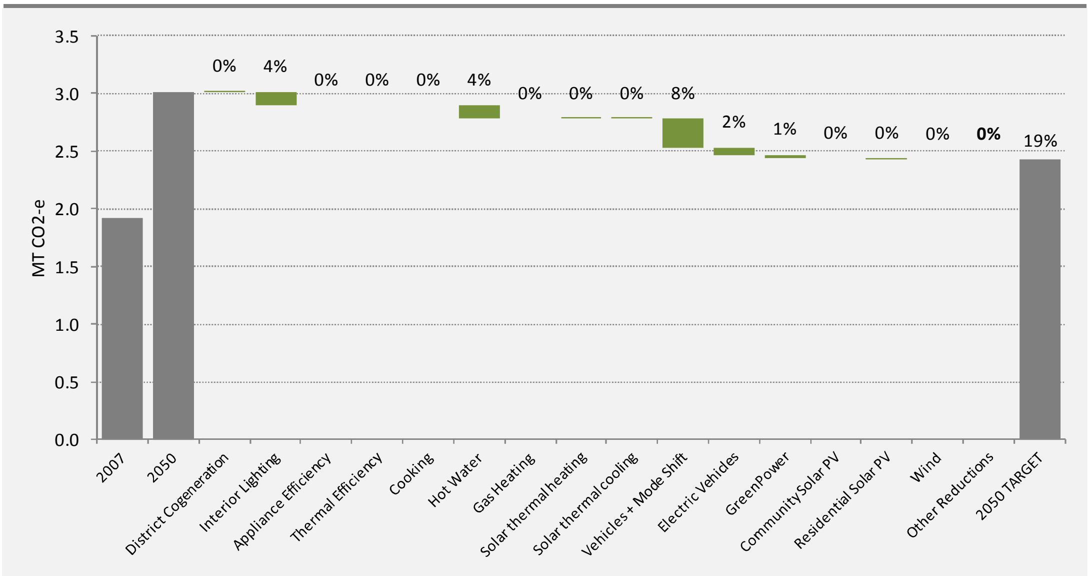

Figure 10: Reductions in emissions against under a No Action scenario

As shown in Figure 11, under the No Action scenario household operating costs associated with energy bills and transport fuel are expected to increase by approximately 132% or $7,046 by 2050 (in 2011/12 dollars). These energy price increases are primarily due to rising electricity prices as a result of network infrastructure upgrade costs and expected increases in wholesale gas and fuel prices, however the likely implications of a price on carbon is also a contributing factor.

HOUSEHOLD ENERGY COSTS UNDER A NO ACTION SCENARIO

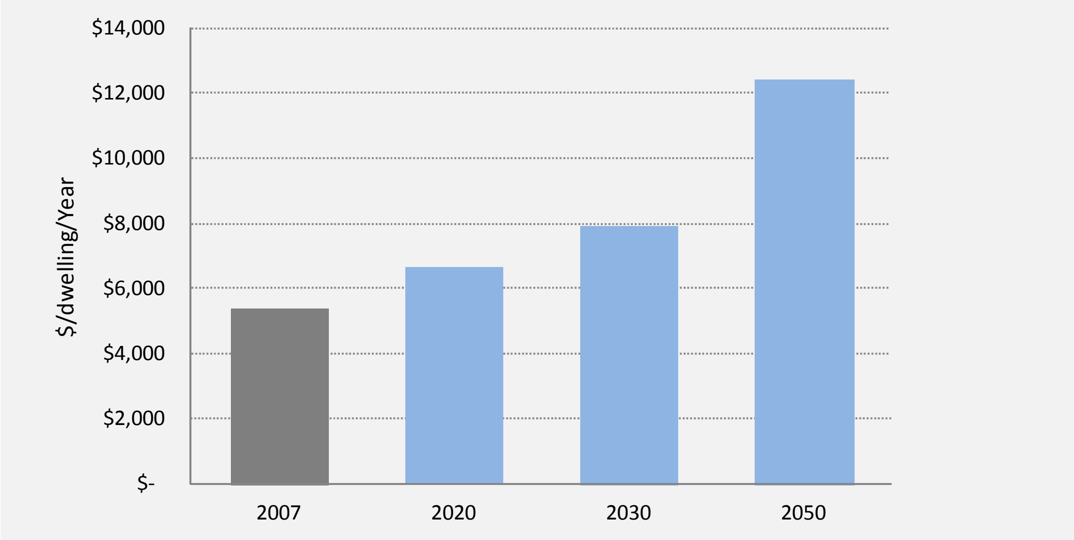

Figure 11: Average Annual Energy Costs Per Dwelling in a No Action Scenario

Note: Energy price projections are based on extrapolating the historical 10 year trend in electricity, gas and fuel costs as published in the Australian Bureau of Statistics Consumer Price Indices.

Without direct action and influence from Lake Macquarie City Council and its community, energy consumption and greenhouse gas emissions will continue to increase and household energy resilience will decline.

The following two scenarios outline a future where direct action from both Lake Macquarie City Council and support from state, federal government and the wider resident and business community can significantly reduction greenhouse gas emissions and increase energy resilience.

Carbon Neutral Scenario - Meeting the 3% pa Emission Reduction Target

The Carbon Neutral scenario outlines the actions and interventions required to meet Lake Macquarie City Council's yearly 3% emission reduction target.

Under this scenario, significant actions will **achieve carbon neutrality and cumulatively save approximately 2,860,000 tonnes of CO2-e by 2050**. Per capita emissions will be reduced by 100% on 2007 levels. These emission reductions were achieved through significant interventions in:

- Energy efficiency – 50% reduction in appliance energy consumption and a 60% reduction in residential lighting energy consumption
- Fuel switching – 100% solar hot water systems in single dwellings and a proportion of commercial and industrial trigeneration run off a renewable gas source
- Renewable energy generation – equivalent to approximately 600,000 MWh, consisting of 138,000 MWh of commercial scale PV, 24,000 MWh of commercial scale wind and the remaining renewable energy sourced from Greenpower outside the LGA
- Electric Vehicles – 100% of vehicles are electric and run off renewable energy equivalent to approximately 32,000 MWh of additional renewable energy generation
- Mode shifting and vehicle efficiency – a major shift to public transport and active transport and a 50% increase in vehicle efficiency
- Residential thermal efficiency increases to 8 stars.

EMISSION REDUCTIONS

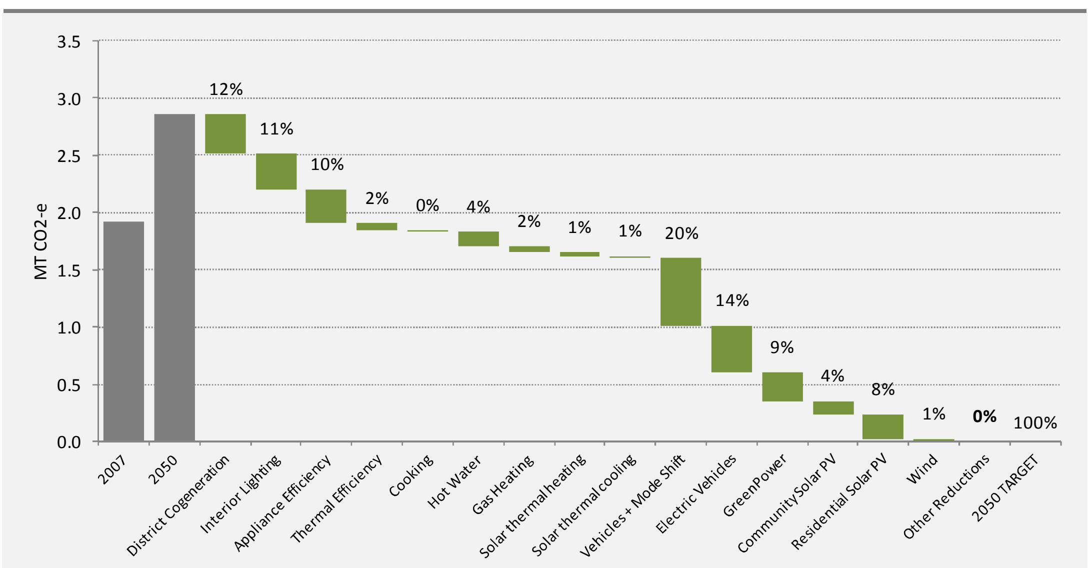

Figure 12: Reductions in emissions against BAU projections under a Carbon Neutral scenario

Box 1: Renewable Gas

Renewable gas or biogas is produced from the biological breakdown of organic waste including sewage, biomass, green waste, municipal waste, food waste and crop residue. It is comprised primarily of methane and carbon dioxide. It can be cleaned and upgraded to natural gas standards – this is known as bio-methane.

Renewable gas is commonly produced and captured at landfill sites and sewage works, avoiding emissions of the highly potent greenhouse gas methane into the atmosphere. Despite growth in the development of such projects, the amounts produced remain very small in comparison with conventional natural gas.

The City of Sydney is currently undertaking analysis on the potential of renewable gas through a Decentralised Energy Master Plan for Renewable Energy. For more information see: http://www.cityofsydney.nsw.gov.au/environment/EnergyAndEmissions/GreenDecentralisedEnergy.asp

The social marginal abatement cost of the actions required to achieve carbon neutrality by 2050 are outlined in Figure 13. In this graph the height of the bar shows the abatement cost per tonne of CO2-e avoided, whilst the width is proportional to the greenhouse abatement achieved. While a proportion of the actions will reduce emissions at cost saving to society, significant costs will be associated with those additional actions required to meet the 3% per capita per annum emission reduction target.

MARGINAL ABATEMENT COST CURVE

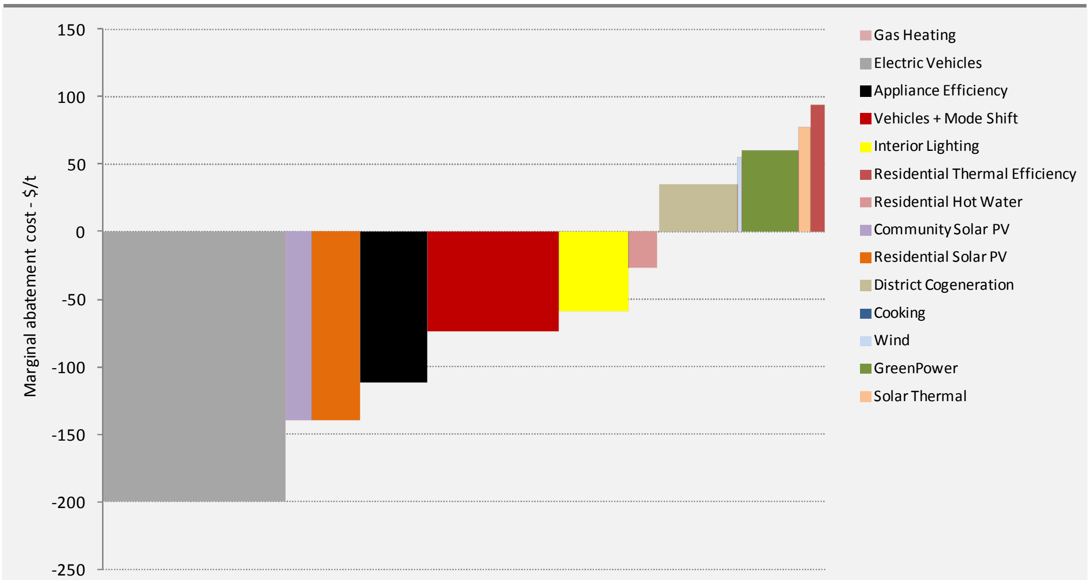

Figure 13: Social marginal abatement cost curve of actions under a Carbon Neutral scenario
*Please see p66 for explanation of Marginal Abatement Costs

Under the Carbon Neutral scenario, expected increases in energy prices (highlighted in the No Action scenario) will be off-set by significant reductions in electricity use (Figure 14). The increase in consumption which can be observed between 2030 and 2050 is due to the roll-out of electric vehicles.

HOUSEHOLD ELECTRICITY CONSUMPTION

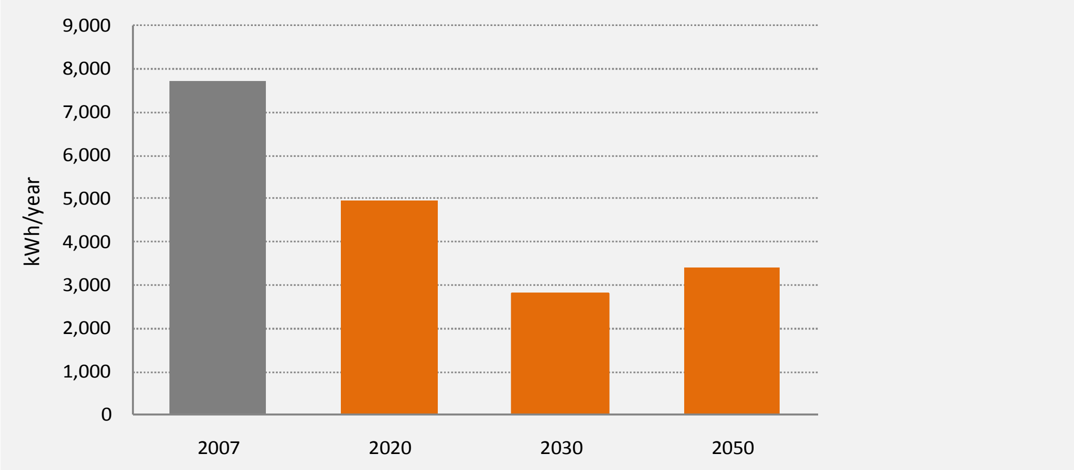

Figure 14: Average annual household electricity consumption in Lake Macquarie under a Carbon Neutral scenario

By 2050 household energy costs from electricity, gas and transport fuel are expected to decrease by 37% or $1,990 (in 2011/12 dollars) (see Figure 15). This represents a very sizeable $9,000 saving when compared to annual household energy costs in the No Action scenario in 2050.

HOUSEHOLD ENERGY COSTS UNDER A CARBON NEUTRAL SCENARIO

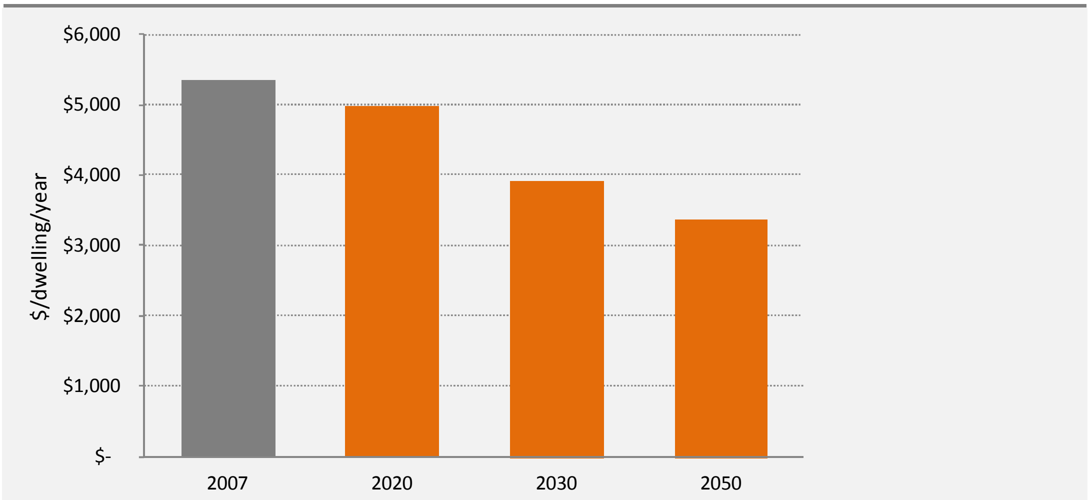

Figure 15: Average Annual Energy Costs Per Dwelling in a Carbon Neutral Scenario

Note: Energy price projections are based on extrapolating the historical 10 year trend in electricity, gas and fuel costs as published in the Australian Bureau of Statistics Consumer Price Indices.

The savings required to off-set increasing energy costs will largely come from reduced energy consumption from improved appliance and lighting efficiency, local household electricity generation from solar PV and switching from petrol fuel to electric powered vehicles (Figure 16).

ANNUAL HOUSEHOLD SAVINGS

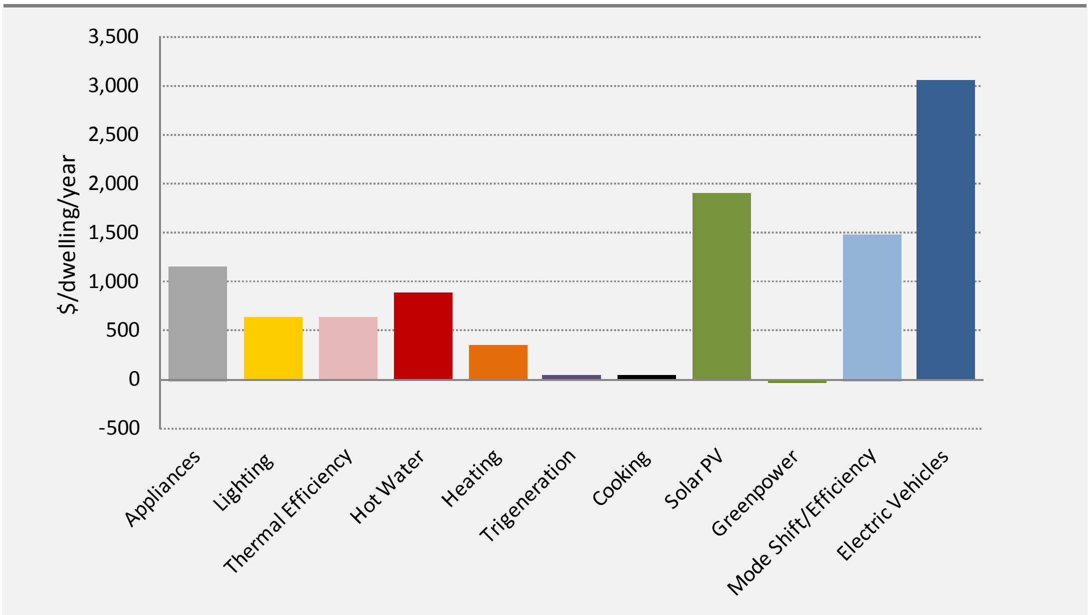

Figure 16: Annual savings on average energy costs per dwelling (compared to Business as Usual energy use projections) in 2050 under the Carbon Neutral scenario

While the Carbon Neutral scenario outlines the actions and interventions required to achieve carbon neutrality, the following scenarios highlights what proportion of the 3% emission reduction target Lake Macquarie City Council can more directly influence.

Local Action Scenario

The Local Action scenario identifies actions that Lake Macquarie City Council have a higher governance role in achieving, and clearly delineates the emission reductions that Lake Macquarie City Council could feasibly take responsibility for towards achieving the 3% emission reduction target.

Under this scenario, actions undertaken and influenced by Lake Macquarie City Council will **achieve a 42% reduction in greenhouse gas emissions** and cumulatively save approximately 1,278,000 tonnes of CO2-e by 2050. Per capita emissions are 35% below 2007 levels. These emission reductions were achieved through significant interventions in:

- Lighting efficiency – a 50% reduction in energy consumption for lighting both residentially and commercially
- Hot water – 80% of single and attached dwellings switch to solar hot water
- Mode Shifting – active transport increases six-fold whilst public transport increases from 8% to 13% of all travel, and car use accounts for 10% less travel
- Electric Vehicles – 20% of all residents adopt electric vehicles powered by renewable electricity
- Greenpower – 20% of the remaining electricity purchased in Lake Macquarie is Greenpower accredited
- Residential thermal efficiency increases to 7 stars.

EMISSION REDUCTIONS

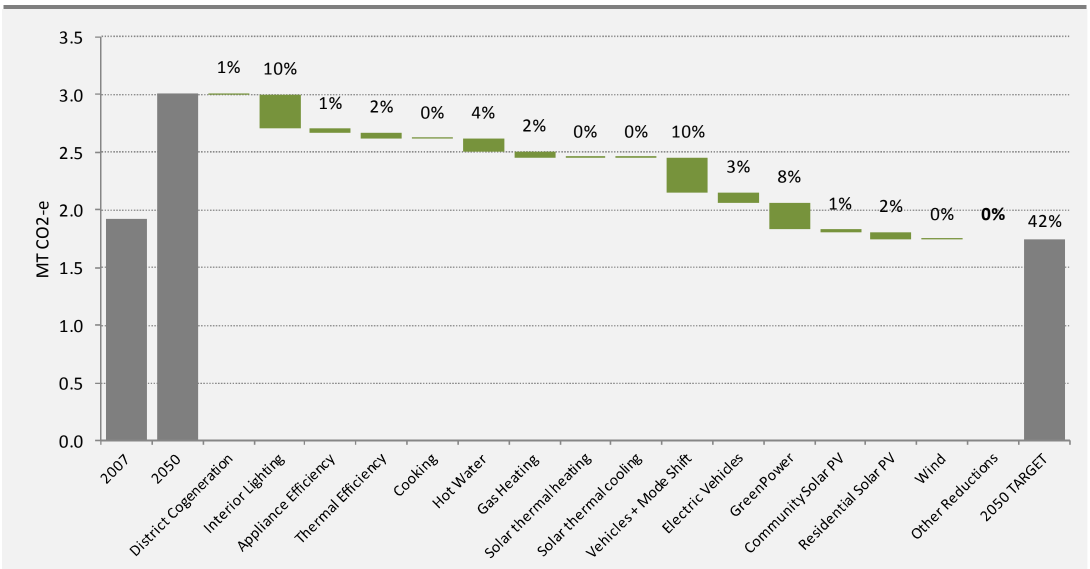

Figure 17: Reductions in emissions against BAU projections under a Local Action scenario

The marginal abatement cost of the actions required to achieve the Local Action scenario reductions by 2050 are outlined in Figure 18.

MARGINAL ABATEMENT COST CURVE

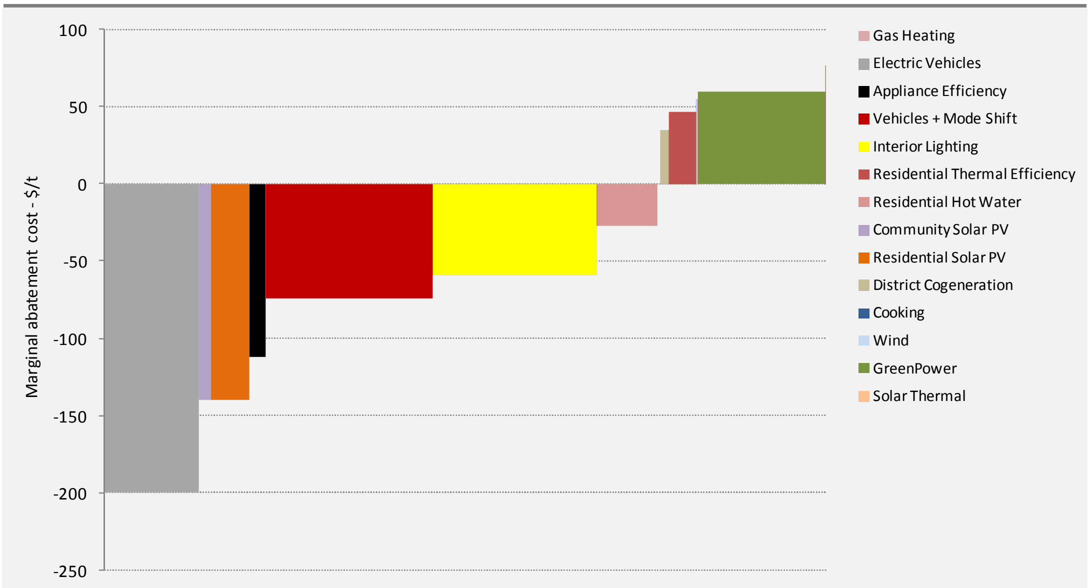

Figure 18: Marginal abatement costs for each action under a Local Action scenario
*Please see p66 for explanation of Marginal Abatement Costs

Note, the marginal abatement cost for solar thermal is $77 per tonne of CO_2-e abated, however the amount of abatement is too small to appear on the graph in Figure 18.

Under the Local Action scenario, household operating costs associated with electricity, gas and fuel consumption are expected to increase by 94% or $4,460 (in 2011/12 dollars) (see Figure 19). Despite the expected increase in energy costs, savings of $2,550 will be achieved compared to the No Action scenario, primarily through improved hot water efficiency, local household electricity generation from solar PV and reducing car reliance and switching from petrol fuel to electric powered vehicles (Figure 20).

HOUSEHOLD ENERGY COSTS UNDER A LOCAL ACTION SCENARIO

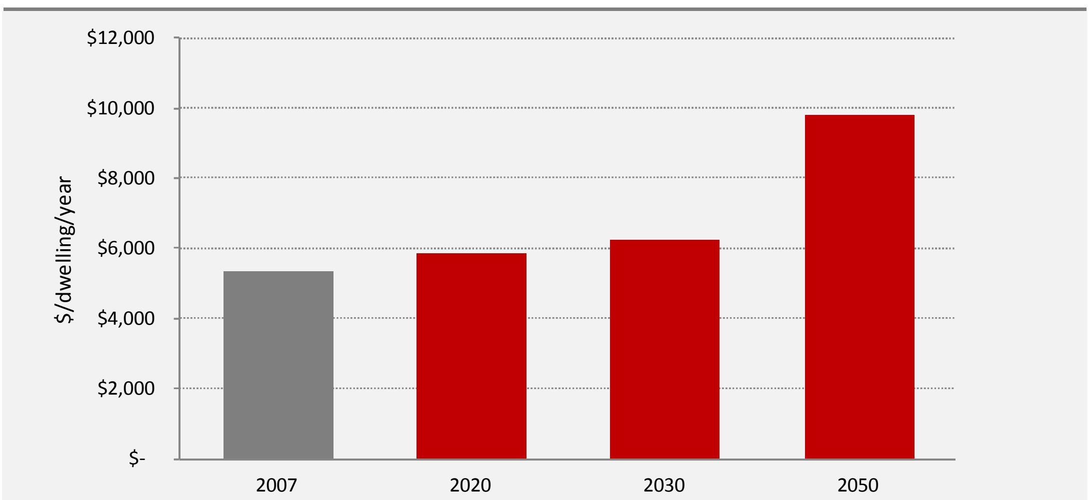

Figure 19: Average Annual Energy Costs Per Dwelling in a Local Action Scenario

HOUSEHOLD SAVINGS UNDER A LOCAL ACTION SCENARIO

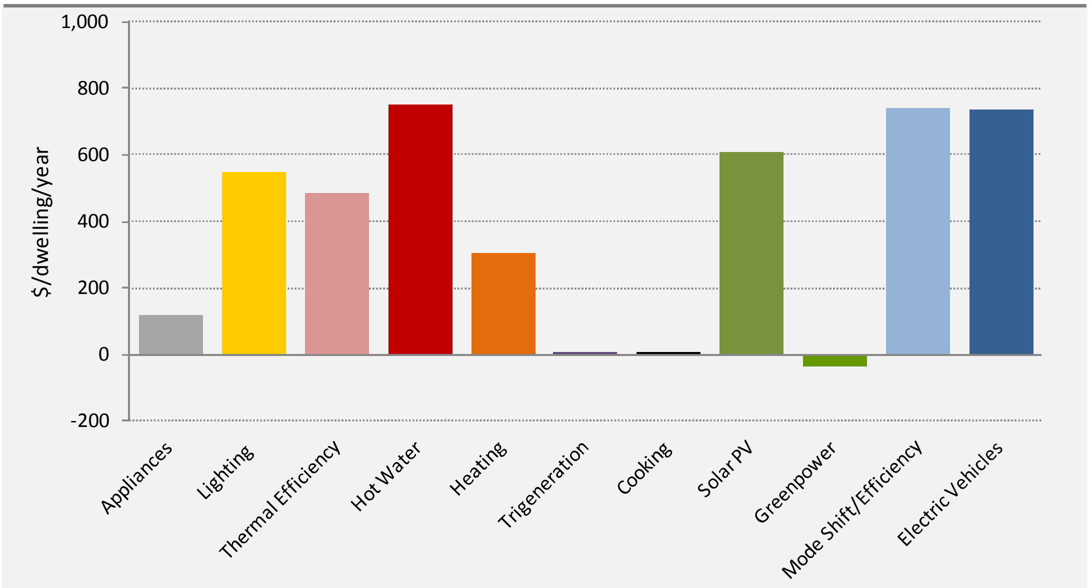

Figure 20: Annual savings on average energy costs per dwelling (compared to Business as Usual energy use projections) in 2050 under a Local Action scenario

4 Detailed Action Profiles

Each Energy Future Scenario is based on a series of energy efficiency, alternative energy and transport related actions. Each of these actions has different environmental, cost and governance implications. The extent to which each action can contribute to improving the energy resilience of Lake Macquarie depends on these implications.

In developing the three scenarios, each potential action was assessed quantitatively (using the Energy Futures Model) and qualitatively to determine the related environmental, cost and governance issues. This analysis was utilised to determine the extent to which each action should be utilised in each of the three scenarios. In addition, the level of deployment for each technology was also determined based on relative benefit/cost and influence in achieving each strategy (see Chapter 5). A summary of this analysis is provided in Table 3, while the detailed analysis for each action is described in further detail below.

ANALYSIS OF EMISSION REDUCTION ACTIONS

	Technology	Environmental	Emission Reductions	Social	Economic	Governance
Energy Efficiency						
Appliance Efficiency	High	High	High	High	High	Low
Lighting Efficiency	High	Moderate	High	High	High	Moderate
Residential Thermal Efficiency	High	Low	Low	Moderate	Moderate	Low
Fuel Switching						
Hot Water	High	High	Moderate	High	High	Moderate
Heating	High	Low	Low	Moderate	Moderate	Low
Trigeneration	Moderate	Moderate	High	Moderate	Moderate	Moderate
Cooking	High	Low	Low	Low	Low	Low
Renewable Energy						
Residential Solar PV	High	Moderate	Moderate	Moderate	Moderate	Moderate
Commercial Solar PV	High	Moderate	Low	Low	Moderate	High
Solar Thermal	Moderate	High	Low	Low	Moderate	Moderate
Wind	High	High	Low	Low	High	Moderate
GreenPower	n/a	High	High	Low	Moderate	Low
Travel + Transport						
Residential Mode Shift	n/a	High	High	High	High	Moderate
Vehicle Fuel	High	High	High	High	High	Low
Electric Vehicles	Low	Moderate	High	Moderate	High	Moderate

Technology — *Maturity and reliability of technology*
Environmental — *Lifecycle and environmental health impacts*
Emission Reductions — *Reduction in energy use + greenhouse gas emissions*
Social — *Social benefit, including household affordability and community health*
Economic — *Cost benefit, including upfront and on-going costs*
Governance — *Influence of Lake Macquarie City Council to implement*

Table 3: Analysis of actions based on technological reliability, environmental and social benefit, economic (cost/benefit) and governance factors.

Energy Efficiency

Appliances

Action Description

Electrical appliances, such as televisions, washing machines and fridges, were responsible for approximately **35% of average household greenhouse gas emissions** in 2007. Actions to improve the energy efficiency of appliances are a key component of reducing emissions from residential dwellings.

The Federal Government's Minimum Energy Performance Standards (MEPS) mandate a minimum level of performance for some appliances including refrigerators, freezers, air conditioners and televisions. Over time, these standards increase, resulting in improved energy performance. However, these improvements are often counter-acted by homes adding multiple appliances (such as two fridges) and appliances that are not covered by MEPS (such as computers and stereos).

Technical Specifications

Under the No Action scenario it is assumed that there will be no net decrease in Lake Macquarie's consumption of energy for appliances. This takes into account energy savings resulting from the federal government's Minimum Energy Performance Standards (MEPS), whilst also recognising a trend of increasing overall energy consumption as appliances have become larger, more complex and more numerous.

For the Carbon Neutral scenario a 50% reduction in appliance energy consumption below 2007 levels is assumed whilst the Local Action scenario assumes only a 5% total reduction. For both of these scenarios, additional action to reduce appliance energy consumption beyond MEPS would be required.

Environmental Outcomes

EMISSION REDUCTIONS BELOW BUSINESS AS USUAL

Appliance Efficiency	No Action	Carbon Neutral	Local Action
2020	0.0%	3.1%	0.2%
2030	0.0%	5.5%	0.5%
2050	0.0%	10.4%	1.0%

Table 4: Emission reductions from appliance efficiency actions

In promoting the replacement of older appliances with more efficient models, any lifecycle issues such as recovery and recycling should be considered. Furthermore, when replacing inefficient heaters, the poor indoor air quality associated with unflued gas heaters should be noted.

Social and Economic Outcomes

The appliance energy efficiency improvements shown in the Carbon Neutral and Local Action scenarios are assumed to have a -$112 marginal abatement cost per tonne of CO_2-e abated (see appendix). This means that actions to improve the energy efficiency of appliances will save money over time, despite more efficient appliances often having greater upfront costs than less efficient options. These higher upfront costs can represent a barrier to low income households and should be considered in order to assist this section of the market.

Reducing the energy consumption of household appliances by 50% will result in annual savings of $2042 per dwelling by 2050. This will be particularly important in low-income households where energy bills represent a considerable proportion of total income.

Governance Implications

The decision of what household appliance to purchase is a private decision and Lake Macquarie City Council has limited direct influence over the efficiency of appliances. Improvements in MEPs standards are likely to be more significant than Council initiatives in the long-term, and Council should play a role in lobbying for these changes.

Despite this, Council could assist in improving the energy efficiency of household appliances by implementing grants or programs that complement Federal MEPS regulations. Such actions could include:

- Buy-back schemes in which Council provides rebates for residents and commercial businesses to replace old appliances with more efficient models.

- Community engagement through community education programs which emphasise the advantages in reduced energy consumption of energy efficient appliances and the savings they can deliver to households.

- Initiatives targeted at reducing energy consumption from specific high-priority appliances, for example targeting electronic appliances by offering a rebate for energy smart power boards. Council could consider applying to the Federal Government's Low Carbon Communities Program for funding for such grants (for more information see: http://www.climatechange.gov.au/government/initiatives/low-carbon-communities.aspx).

Lighting

Action Description

In Lake Macquarie, lighting is responsible for **9% of residential emissions and along with equipment such as computers represents up to 72% of commercial emissions**[1]. Making improvements in lighting efficiency is therefore critical to achieving the emission reduction targets Lake Macquarie has committed to.

Due to regulations and technological change, the energy efficiency of lighting is improving. Like appliances, lighting technology is regulated through the Federal Government's Minimum Energy Performance Standards. Recently the Government established regulations to phase out inefficient incandescent bulbs in favour of more energy efficient options such as compact fluorescent and light emitting diodes (LED). These technologies can significantly reduce the lighting energy consumption.

Technical Specifications

The No Action scenario assumes a 20% reduction in residential and commercial lighting energy consumption by 2030. This takes into account the ongoing improvement in lighting efficiency due to Federal Government regulations and technological improvements.

In the Carbon Neutral scenario, household lighting's energy consumption is reduced by 60% below 2007 levels by 2030. Commercial lighting consumption is reduced by 50%.

For the Local Action Scenario, residential and commercial energy consumption is reduced by 50%.

There are five common types of lighting:

- **Traditional incandescent lighting** (general lighting service, GLS) : efficacy of approximately 13 lumens per watt (lm/W), currently being phased out
- **Halogen lighting**: able to achieve efficacy of up to 25 lm/W – has become increasingly common over the last decade however it is much less efficient than alternatives such as fluorescent or LED technology.
- **Standard fluorescent and compact fluorescent lights**: 50-70 lm/W, very common due to its low cost, long life-time and reasonable efficacy. They also have a good colour index and are often preferred in applications where lighting quality is important. Slowly being overtaken by high-efficiency T5 tubes which can achieve up to 95 lm/W
- **High intensity discharge lights**: The source of light in these lamps is an ionised gas plasma, with the gas determining the characteristics of the light such as colour and efficiency. They are characterised by very bright light that is often considered undesirable in residential settings. Mercury-vapour lights represent the lower end of the efficiency range at 40-50 lm/W,

[1] This figure was determined based on analysis of metered data provided by Ausgrid, calibrated to the urban form and local climate of Lake Macquarie. It should be noted that appliances and equipment includes air handling and circulation units.

whilst sodium lamps can achieve up to 170 lm/W. The yellow colour of these lamps makes them generally suitable only for street lighting where colour rendering is unimportant. Midway between these, metal-halide lamps are increasingly used in supermarkets and retail areas where their efficiency of 110 lm/W and white appearance is of much value. Within the high-efficiency range each light fitting could cost a few hundred dollars, making them an investment more common in commercial settings.

- **LED**: LEDs span a wide range of efficiencies from 40 lm/W up to 110 lm/W, although the most common mass-produced LED lighting generally achieves efficacy of 70 lm/W. They have potential for widespread application including in residential settings because of their long lifetime and good light quality.

  Great care must be taken with purchase of LED lamps to ensure that their lifetimes will meet the expectation of 50,000 hours and represent the best available technology. At present, cost and availability is the main barrier to greater uptake, with LED lightings costing approximately 5-6 times more than fluorescent lighting. The technology is under rapid development, however, and is likely to become the most cost-effective and efficient lighting technology in the near future, with efficiency gains of at least 50% and significant decline in costs expected within five years.

Environmental Outcomes

EMISSION REDUCTIONS BELOW BUSINESS AS USUAL

Lighting Efficiency	No Action	Carbon Neutral	Local Action
2020	2.2%	5.6%	1.8%
2030	4.0%	10.6%	4.7%
2050	4.0%	10.8%	10.4%

Table 5: Emission reductions from lighting efficiency actions

Additional Environmental Concerns

It should also be noted that some types of energy efficient lighting options contain mercury. Whilst the amount of mercury in any one light fitting is very small, it can nevertheless contribute to leak from landfill sites if not appropriately disposed of and cause household exposure.

Mercury is highly toxic to human health and according to the World Health Organisation (2007) exposure to it is a serious public health issue. Therefore the risk of long-term, low-level environmental exposure should be considered from an environmental health perspective when comparing lighting options.

Social and Economic Outcomes

The lighting energy efficiency improvements shown in the two emission-reduction scenarios can be achieved at a marginal abatement cost of -$59 per tonne CO_2-e avoided (see appendix), meaning savings of $59 are achieved for each tonne of CO_2-e avoided.

Under the Carbon Neutral scenario households will save on average approximately $448 per year on their energy bills due to reduced energy consumption for lighting (Figure 16). The Local Action scenario delivers slightly lower savings at approximately $374 per year (Figure 20).

Governance Implications

The energy performance of lighting is federally regulated through MEPS. However, MEPS only mandates a minimum performance standard. Even with these standards, there is a wide range of performance across different lighting technologies.

The Energy Savings Scheme established by the NSW Government provides an incentive for non-residential energy consumers to install energy efficient lighting, creating Energy Savings Certificates which can be sold to recoup some of the upfront costs.

In order to meet the ambitious reductions in lighting energy consumption, Council may need to implement actions which support MEPS and encourage residents and businesses to choose the most efficient lighting technologies. Such actions could include:

- Community engagement through community education programs which emphasise the advantages in reduced energy consumption of energy efficient appliances and the savings they can deliver to households.
- Retrofitting Council's assets with more efficient technology.
- On-bill financing programs in which Council partners with energy utilities to provide on-bill financing for lighting upgrades (for more information see: http://www.lowcarbonaustralia.com.au/page/financial-products-and-services).
- Assisting businesses retrofit the lighting technologies in their buildings through environmental upgrade agreements. The *NSW Environmental Upgrade Agreements* legislation enables businesses to access low interest loans to finance energy efficiency upgrades. These loans can then be repaid through changes to their local government rates (for more information see: http://www.environment.nsw.gov.au/grants/).

Residential Thermal Efficiency

Action Description

The design and fabric of a building can affect its energy use and likely greenhouse gas emissions.

Shading, insulation and improved glass (double glazing) can reduce the energy needed to heat and cool a building. By reducing the influence of outside temperatures on a home, these improvements can keep warm air trapped within a building during winter and cold air trapped during summer; therefore reducing the amount of energy required for heating and cooling.

In addition to design, the thermal mass of a building can act as an energy reservoir and improve the ability of a building to retain heat during the colder months of the year.

Technical Specifications

The Nationwide House Energy Rating Scheme (NatHERS) is an initiative of Commonwealth, State and Territory Governments through the Ministerial Council on Energy that provides a framework which allows various computer software tools to rate the potential thermal energy efficiency of Australian homes. For more information see: www.nathers.gov.au.

Under the no action scenario, all new residential dwellings are assumed to achieve a 5 star NatHERS thermal efficiency rating.

For the local action and carbon neutral scenarios, new dwellings achieve an 8 star rating.

Environmental Outcomes

EMISSION REDUCTIONS BELOW BUSINESS AS USUAL

Lighting Efficiency	No Action	Carbon Neutral	Local Action
2020	0.0%	1.2%	1.2%
2030	0.0%	1.6%	1.6%
2050	0.0%	2.2%	2.2%

Table 6: Emission reductions from lighting efficiency actions

Social and Economic Outcomes

Improvements in residential thermal efficiency are achieved through improved building design and building fabric. While small improvements in thermal efficiency can be made through small capital expenditure (such as orientation, roof insulation or shading), larger improvements in thermal efficiency may require significant expenditure in actions such as the installation of high performance glass, improved building materials, or wall insulation. As such, while thermal efficiency improvements from 5 to 6-star rating can be achieved at a marginal abatement cost of -$159 per tonne CO_2-e avoided, improvements to 7-star can be achieved at $47 per tonne.

In addition, improving residential thermal efficiency can result in some small reductions in resident's annual energy costs. The improved efficiency can also improve the comfort and "liveability" of Lake Macquarie's homes, resulting in homes that are easier to heat in winter and cool in summer.

Governance Implications

The NSW Government's BASIX Scheme covers thermal performance for new dwellings. As a result, Lake Macquarie City Council is unable to regulate thermal performance standards beyond BASIX compliance. Council can, however, provide incentives for new homes to achieve a greater thermal energy performance rating or to residents that upgrade the thermal efficiency of their home (by measures such as increasing their home insulation).

Fuel Switching

Residential Hot Water

Action Description

The energy required to heat water produces 30% of all residential greenhouse gas emissions in Lake Macquarie.

There are a number of water heating technologies available to households. These include electric storage, electric instantaneous, gas storage, gas instantaneous, solar hot water with electric boost, solar hot water with gas boost and electric heat pump.

Under the Federal Government's Minimum Energy Performance Standards (MEPS), electric storage hot water systems are due to be phased out. However, this does not guarantee the most efficient options will be chosen in its place. Constraints such as cost and availability of gas connections could affect the take up of the most efficient solar hot water options.

Technical Specifications

The phase-out of electric hot water systems is included in the No Action scenario, which assumes 50% of single and attached dwellings switch to solar hot water by 2050. This scenario assumes the vast majority of solar hot water uptake will come from single and attached dwellings rather than multi-dwellings and commercial or industrial buildings where limited roof area makes solar hot water options less practical.

The Local Action and Carbon Neutral scenarios assume a much greater uptake of solar hot water systems in single and attached dwellings (80% and 100% respectively). A detailed list of the selections made in each scenario is provided as an appendix to this report.

Conventional electric hot water systems use an electric element to heat hot water. While this, in itself is a very effective process, the overall efficiency is very low because of efficiency losses in the generation and transmission of electricity at thermal power stations.

Direct combustion of the fuel to heat water is employed in gas hot water systems and this, together with the lower carbon content of natural gas compared to coal, provides gas with a considerable advantage in terms of overall fuel use efficiency and greenhouse emissions. Recently, some instantaneous gas hot water systems have achieved a 7 Star Energy Rating, avoiding the "standing" heat losses incurred by storage water heaters. In the past few years, more efficient "condensing" versions of both gas storage and gas instantaneous water heaters have become available.

Electric heat pump systems extract heat from the ambient air ("air-sourced") or use the ground ("ground-sourced") as their source of thermal energy. They use approximately 1/3 of the electricity that electric water heaters use. These heat pump systems often claim to be "solar" and indeed receive recognition in the form of Renewable Energy Credits (RECs) similar to those awarded to direct solar-thermal collectors. In reality their mode of heating from the sun is somewhat indirect, although systems combining heat pumps and solar thermal collectors are now available. Cold outside temperatures can severely impact the efficiency of heat pumps and the winter performance of these systems is of concern in some climates.

Solar water heaters feature a solar-thermal collector placed on the roof of the dwelling to catch maximum direct sunlight and a storage vessel so that heated water can be provided overnight to users. An auxiliary “boost” source of energy (electricity or gas) is provided to the system in case of unfavourable weather or to otherwise support a hot water demand that is greater than the solar harvest.

As with photovoltaic systems, the location of the solar-thermal collectors is an important consideration and maximum solar access is vital. Shadowing due to neighbouring buildings and trees can have a large impact on the efficiency of the installation and can erode system performance to the level of the boost system. In the case of electric boost, this will represent substantial increase in greenhouse emissions. In the case of electrically-boosted systems, it is important to note that, unless their operation is controlled by a timer to operate only from off-peak power, boosters connected to continuous supply could turn on at any time of the day and give rise to higher electricity bills for owners as well as generate peak load issues for energy distributors.

Water efficiency should be considered alongside energy in the delivery of higher efficiency hot water systems. In particular, efficient showerheads and washing machines reduce the need for hot water, and therefore influence the energy demand placed on the hot water generating systems.

Environmental Outcomes

EMISSION REDUCTIONS BELOW BUSINESS AS USUAL

Hot Water	No Action	Carbon Neutral	Local Action
2020	3.6%	4.2%	4.3%
2030	3.8%	5.5%	5.2%
2050	3.8%	4.4%	4.4%

Table 7: Emission reductions due to hot water fuel shifting

Social and Economic Outcomes

Solar water heating enables significant savings over time, with an estimated marginal abatement cost of -$27 per tonne of CO_2-e (see appendix).

As a major component of household energy consumption, actions to encourage the uptake of solar hot water provide long-term benefits to residents in the form of lower energy bills. The actions to increase solar hot water show annual savings for each dwelling of approximately $955 for the Carbon Neutral scenario (Figure 16) and approximately $940 for the Local Action scenario (Figure 20).

Governance Implications

The Federal Government previously encouraged the uptake of solar water heaters through a $1000 rebate under the Renewable Energy Bonus Scheme. A $600 rebate for heat pump systems was also available. Both schemes have now ceased.

With these rebates and the phase out of electric storage hot water, there is a strong incentive already in place to choose more efficient water heating alternatives. However, Council could compliment these initiatives through actions of their own:

- In 2010 Council negotiated a group discount on solar hot water systems for LGA residents. This program could be extended upon and repeated depending on the success of the initial program.
- On-bill financing programs in which Council partnered with energy utilities to provide on-bill financing for energy efficiency technology upgrades (for more information see: http://www.lowcarbonaustralia.com.au/page/financial-products-and-services.
- Assisting businesses retrofit water heating technology in their buildings through environmental upgrade agreements. The *NSW Environmental Upgrade Agreements* legislation enables businesses to access low interest loans to finance energy efficiency upgrades. These loans can then be repaid through changes to their local government rates. For more information see: http://www.environment.nsw.gov.au/grants/.

Box 2: Gas Connection Constraints + Opportunities

Currently, only 30% of the Lake Macquarie Local Government area is connected to natural gas. Of those customers connected 58% use natural gas for hot water and 58% use natural gas for heating needs.

Local Government Area	*% of Gas Network Area Penetration*	*% of Gas Customers with Hot Water*	*Percentage of Gas Customers with Heating*
Lake Macquarie	30%	58%	58%
Gosford	40%	60%	56%
Wyong	40%	63%	52%
Newcastle	80%	55%	53%

Gas take-up within the Lake Macquarie LGA (Source: Jemena 2011)

Discussions with Jemena have provided significant information on the potential opportunities to increase the connection and use of natural gas in Lake Macquarie. Existing gas connection is available on the eastern side of Lake Macquarie from the Wallarah Peninsular development at Murrays Beach in the south to the Northern border with Newcastle Shire. Gas connection exists on the western side of the Lake in the Morisset area and Jemena is currently extending that network to supply a growing gas demand at Cooranbong. Gas is also available from Toronto through to Cameron Park in the North.

In urban infill areas, Jemena is analysing the opportunities to extend the network into existing areas by partnering with gas appliance manufacturers to offer installation packages with finance options. This is currently being investigated at Redhead. High level analysis by Jemena indicates that, at this stage, the area between Morisset and Toronto is an area of the LGA where growth of the gas network would not appear to be feasible.

Opportunities for fuel switching for cooking and heating were also analysed as part of this strategy. While not providing a significant reduction in greenhouse gas emissions, there is potential for small reductions from using gas in place of electric cooking. As gas connections are expanded across Lake Macquarie in new and existing areas, this will provide an additional opportunity for emission reductions. In addition to the environmental benefits, gas cooking can help improve the energy resilience of Lake Macquarie's residents as in some cases gas cooking can be a cheaper alternative then electric cooking.

Trigeneration

Action Description

Trigeneration is a process whereby natural (or renewable) gas is burned in an engine to generate electricity. Because the engine is powered by gas rather than coal, it can produce 40% fewer greenhouse gas emissions than traditional coal-fired electricity.

"Tri-generation" is a term often used interchangeably with cogeneration which is the simultaneous generation of electricity and usable heat. Here, the term "tri" explicitly means that heat harnessed from the cogeneration plant is used to power a heat-driven cooling (HDC) process to enable the plant to not only supply demands for heat such as space heating and hot water, but also to supply space cooling generally for buildings and/or homes.

Technical Specifications

Under the No Action scenario, it is assumed that 10% of the total commercial floor space in the Lake Macquarie LGA is connected to trigeneration for heating, cooling and hot water requirements. This is based on the existing trigeneration system at Charleston Square with some other minor building by building systems implemented over the long term.

The Carbon Neutral scenario assumes a much greater take up of trigeneration: 50% for multi-unit dwellings and 75% for commercial and industrial floor space by 2030.

The Local Action scenario assumes that 20% of the multi-unit, commercial and industrial floor space is connected to trigeneration by 2030.

Cogeneration plants can range in design and size. Conventional cogeneration plants use a spark ignition reciprocating piston engine, however gas turbines are not uncommon at the very large end of the power range. Some smaller "micro-turbine" systems are also available in the 30-100 kW range. Reciprocating engines are generally more efficient than turbines in terms of converting the chemical energy in the fuel to electrical energy. However, turbines can have some convenient advantages in terms of the amount and temperature of the heat that is produced as a by-product of the engine operation.

Fuel cells can provide an alternative to engine-based systems. A fuel cell is able to generate electricity directly and can do so with an efficiency of 55% or more compared to a reciprocating engine with an efficiency generally below 40%. The small (2 kW electric) BlueGen ceramic fuel cell is an example where heat is recovered from the electrochemical reaction and made available for water heating.

The size of cogeneration systems is usually specified in terms of the rated maximum electrical power of the plant. For heating-only applications, cogeneration units are available with an electrical size of 1 kW and greater. The HDC equipment required to supply cooling from a cogeneration installation is usually only economic at a cogen power of 100 kW and above and so this is generally a feature of larger cogeneration plant with a capacity of 10 MW or more.

Trigeneration is most effective in areas with a high density of thermal energy demands. This allows waste heat to be used without significant pipe or distribution losses. In addition, specific opportunities exist within the industrial areas and numerous hospitals across the Local Government Area.

Hot water demands for sterilisation, general cleaning, personal hygiene, laundry and space heating together with chilled water and refrigeration demands for space cooling, storage of medical supplies & food and equipment cooling are all significant end-uses of thermal energy in any major hospital. Here, gas-fired cogeneration together with solar-thermal, could readily offer very large energy and greenhouse savings.

Environmental Outcomes

EMISSION REDUCTIONS BELOW BUSINESS AS USUAL

Trigeneration	No Action	Carbon Neutral	Local Action
2020	0.01%	2.2%	0.2%
2030	0.01%	7.1%	0.5%
2050	0.01%	12.1%	1%

Table 8: Emission reductions due to trigeneration

Trigeneration does emit oxides of nitrogen (NO_x) which are air pollutants capable of irritating the eyes, nose, throat and lungs. NO_x emissions also contribute to ozone depletion. These air quality issues need to be considered in determining appropriate use of trigeneration.

Social and Economic Outcomes

Trigeneration costs an estimated $35 per tonne CO_2-e avoided (see appendix). These costs would be borne predominantly by the commercial/industrial/public operators for large-scale applications. The Energy Futures modelling tool shows a $19 saving per household in the Carbon Neutral scenario and a $2 saving per household in the Local Action scenario, due to reduced energy costs for residents (who are not assumed to pay the capital costs).

Care must be exercised in terms of sizing cogeneration plants. This is because, unless a real or virtual private wire network has been established by the owner of the cogeneration plant, the price paid for electricity by the local supply authority will be low in comparison to the price paid by their customers and so export of electricity to the grid is generally uneconomic. For the supply of electricity to a commercial building, the cogeneration plant is conventionally sized for a “base load” between the peak and shoulder electricity tariff periods (7am to 10pm) and is shut down outside of these hours. Residential electricity demand is not usually subject to time of use tariffs however and, unless an off-site client can be secured to purchase any excess generation, the export of electricity from a residential cogeneration plant is also an uneconomic proposition.

Sizing of the cogeneration plant must also bear in mind that the production of heat in excess to requirements represents a waste of fuel energy. Generally speaking, by sizing on the basis of average daily thermal demand, the cogeneration plant will be small enough to avoid export of electricity to the grid. Thermal storage and the use of gas boost boilers and electric boost chillers to support the cogeneration installation during times of high demand and also during maintenance greatly facilitates optimal sizing of the plant.

Governance Implications

Trigeneration installation remains fairly uncommon in Australia, and is unlikely to occur on a significant scale in Lake Macquarie in the absence of targeted initiatives driven by Council.

As Lake Macquarie is a relatively low-density city comprised primarily of detached dwellings, the Council should consider prioritising the most strategic applications of trigeneration on sites that have high energy use within a small area, for example commercial, industrial and multi-dwelling sites.

Cogeneration systems are becoming of increasing interest to third parties and, depending on the system size, some energy utilities and cogeneration specialists are installing and retaining ownership of plant from which they derive an income by selling generated electricity together with thermal energy in the form of hot water, space heating and space cooling. This is known as a BOOM or Build Own Operate Maintain system which generally incur lower upfront capital costs compared to a Design and Construct (or D&C) model where a building owner owns and operates the system outright.

Utilities might also benefit from cogeneration when it is installed in areas that have a constrained electricity supply from the grid and also when it is coupled with heat-driven cooling to remove summer air conditioning loads off the grid and, effectively, on to gas (see Box 4).

Actions to support implementation include:

- On-bill financing programs in which Council partnered with energy utilities to provide on-bill financing for alternative energy upgrades. For more information see: http://www.lowcarbonaustralia.com.au/page/financial-products-and-services.

- Assisting businesses retrofit alternative energy supplies for their buildings through environmental upgrade agreements. The *NSW Environmental Upgrade Agreements* legislation enables businesses to access low interest loans to finance energy efficiency upgrades. These loans can then be repaid through changes to their local government rates. For more information see: http://www.environment.nsw.gov.au/grants/.

Box 3: Case Study –101 Miller St, North Sydney and Rooty Hill RSA

At 101 Miller St, North Sydney, the largest commercial building in North Sydney, a cogeneration plant designed and installed by Cogent Energy has been in operation since 2008.

The plant is comprised of two 1,166 kW MTU Series 4000 cogeneration engines that are connected in parallel to the grid. Each engine is coupled to a 750 kW Thermax exhaust absorption chiller. The absorption chillers are fully integrated into the building's chilled and condenser water systems.

The plant is set up to operate either in grid parallel import or island mode and operates automatically during the peak and shoulder demand periods or during grid outages as emergency backup.

For more information see: http://cogentenergy.com.au/101-miller-street/

Rooty Hill RSL in Western Sydney, Australia's largest RSL club, has installed an 1,000 kilowatt trigeneration system which was developed by consulting company Haron Robson. The system consists of a Clarke Energy-manufactured Jenbacher engine and an absorption chiller installed by Caps Australia.

Installed at a cost of $4.5 million, it is expected to reduce Rooty Hill RSL's carbon emissions by up to 50 per cent. The engine will operate during peak and shoulder periods, turning on when power prices increase during the day and turning off when energy prices revert to off-peak rates later in the evening

For more information see: http://www.sustainabilitymatters.net.au/case_studies/43880-Tri-generation-plant-at-RSL

Renewable Energy

Solar PV

Action Description

Solar photovoltaic panels (solar PV) convert sunlight directly to electricity. The NSW solar bonus scheme (gross feed-in tariff) drove significant investment in roof-top solar panels across NSW. To date, over 300 MW of solar capacity has been installed as a result of this scheme. Lake Macquarie has a relatively high penetration of solar PV compared to other local government areas in NSW with over seven percent of households installing solar panels, equivalent to approximately 10 MW of peak generation.

Technical Specifications

The zone rating for solar PV in Lake Macquarie is approximately **1.38 MWh/kW peak**, meaning that for every kW peak of solar PV installed, 1.38 MWh of renewable electricity is generated each year by an ideally sited PV system. Solar PV requires good siting and orientation to ensure it will meet this expected maximum electricity output and lends itself to residential development with a high proportion of roof space to energy demand where a significant proportion of the energy demanded in the building can be harvested through roof top solar i.e. low to moderate density development.

The No Action scenario assumes that in the absence of the State Government's gross feed in tariff, there is little additional uptake of solar PV beyond the current 7% of installed capacity. Because this capacity has been almost entirely installed since 2007 it was included in the analysis. The Carbon Neutral scenario expands installation to 95% of single dwellings, 75% of attached dwellings and 50% of multi-dwellings. It also includes a 100 MW Community Solar PV project. The Local Action scenario assumes installation on 30% of single and attached residential dwellings and 5% of multi-dwellings, as well as a 20 MW of community solar PV.

Most PV installed on rooftops is either mono-crystalline or poly-crystalline. These operate with an efficiency of between 15% to 18%. A lower cost form is thin-film or "amorphous" PV and is of generally lower efficiency (9-11%) so installation over a greater area is required to achieve the same output as crystalline panels. Thin-film panels are able to be applied to roofing and integrated into buildings more readily than crystalline panels, due to their more compact nature and appearance, improved shadow tolerance and lower costs.

Solar PV technology is making rapid advancements, with technologies such as 'solar paint' emerging. Solar paint refers to tiny sized solar panels made from nano-crystals with a diameter of just a few millionth of a millimetre. Solar paint can be integrated into the building, (e.g. solar roof and solar windows). However the production of solar paint is a time-consuming and costly process and more research is required before this technology is commercialised.

Solar PV only makes a tiny contribution to total electricity generation at present, therefore although electricity demand will benefit from the extra electricity generated by PVs, the effect is small. In addition, from a technical point of view, the grid is robust and should be able to handle the feeding back of the PV inverters without any adverse impacts. However, Ausgrid's submission to IPART as part of the State Government's review into solar feed in tariff schemes stated that Ausgrid has experienced some design and cost implications in areas of high solar PV concentration from the need to maintain voltage levels so that customer's inverters do not switch off. It also found that higher voltage levels cause by a high concentration of solar PV could have an adverse effect on customer's appliances.[2]

Environmental Outcomes

EMISSION REDUCTIONS BELOW BUSINESS AS USUAL

Residential Solar PV	No Action	Carbon Neutral	Local Action
2020	0.4%	5.5%	1.7%
2030	0.3%	8.1%	2.6%
2050	0.3%	7.5%	2.4%
Community Solar PV			
2020	0.0%	1.1%	0.5%
2030	0.0%	2.7%	0.9%
2050	0.0%	1.9%	0.8%

Table 9: Emission reductions due to solar PV (both residential and community-scale)

There is potential for significant adverse local environmental and health impacts to occur during the manufacturing of solar PV panels, due to the toxic, hazardous and flammable substances used. The specific risks depend on the type of solar cell being produced and the chemicals inputs required. Silicon panels have traditionally used lead to solder panels (used in the manufacture of many electronic goods), which creates a hazardous waste problem at the end of the panel's lifecycle. The manufacture of most electronics, including solar panels, is shifting to compliance with ROHS (Restriction of Hazardous Substances) Directive which requires lead-free solder and the elimination of other heavy metal materials.

Social and Economic Outcomes

The costs of solar PV have declined significantly over recent years, with social marginal abatement cost of approximately -$140 per tonne, depending on the system size and market value attributed to exported electricity (see appendix explanation of Marginal Abatement Costs included in this report). The costs may be reduced significantly as the technology becomes cheaper and market changes should therefore be monitored closely.

While there is variation, for the purposes of a high level strategy, this report has assumed a social marginal abatement cost of -$140/tonne based on most homes installing a 1.5 to 2 kW system. Variation depends on the proportion of exported electricity and the market value that is attributed to this commodity.

Under the Carbon Neutral scenario actions to install solar PV residentially would achieve household savings of $1,910 annually by 2050. Under the Local Action scenario savings of $610

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[2] Ausgrid's IPART submission can be accessed from:
http://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0CFcQFjAD&url=http%3A%2F%2Fwww.ipart.nsw.gov.au%2Ffiles%2Fd7f4b577-2184-4692-9dec-9f910119e09a%2FSubmission_-_Solar_feed-in_tariffs_-_Ausgrid_-_Peter_Birk_-_11_October_2011_-_Website_version.pdf&ei=k2rRT66GIMP9mAWJncWlBg&usg=AFQjCNHd3v46gs5lKRQ2VHj6P8gDTkQW3w

annually per dwelling can be achieved by 2050. Community solar PV plants do not deliver any energy savings at a household level.

Governance Implications

Solar PV has experienced sudden growth over the last few years. Generous rebates and feed-in-tariffs formerly offered by state and federal governments have now come to an end and although unit costs continue to decline, it is unlikely the same rate of take up will continue.

In the absence of these incentives, take up of renewable energy is still being supported by the Federal Government's Renewable Energy Target (RET). The RET seeks to accelerate the deployment of renewable energy technologies such as wind, biomass and geothermal. However, because the RET mandates a certain percentage of renewable energy that must be delivered, if a renewable project receives funding through the RET then the emissions reductions delivered by that project would not be additional to the savings that would otherwise have occurred. If Lake Macquarie City Council wants to seek emissions reductions that are additional, then it will not be able to seek financial support through the RET.

The community will benefit from investment in solar PV through the lower carbon-intensity of grid electricity. The community, however, has the potential to go beyond the RET through the uptake of residential solar PV and the construction of large scale community solar plants.

Council should consider monitoring household solar PV installations to determine whether it is achieving the potential outcomes outlined in the various scenarios. Installations are currently monitored via the Ausgrid website (see http://www.ausgrid.com.au/Common/About-us/Sharing-information/Information-map.aspx).

If monitoring determines that installations are falling short of the modelled outcomes, Council may consider an alternative investment scheme or grant funding to encourage greater uptake or consider a community owned approach to the implementation of local renewable energy (see below).

Whilst community solar PV has the potential to achieve large scale reductions, a plant of 100 MW (as referred to in the Carbon Neutral scenario) would be amongst the largest solar power stations in the world, requiring over 700,000 square metres of panels.

The 20 MW plant described in the Local Action scenario would still be a significant undertaking. Measures to fund this plant could be achieved through cooperative finance models in which community members are able to purchase shares in the plant (See Box 5 – Community Owned Renewable Energy).

Solar Thermal

Action Description

Solar thermal technology uses the suns energy to generate thermal energy and can be used for space heating and cooling. In Australia the technology is not often used, however it is more common in Europe.

Charlestown Square has an existing solar thermal system to provide space heating and cooling for the centre.

Technical Specifications

Under the No Action and Local Action scenarios it is assumed that no further solar thermal capacity is installed, beyond the existing Charleston Square installation.

Under the Carbon Neutral scenario, 80,000 m^2 of panel area is installed to supply thermal energy for commercial and industrial purposes. Where these buildings are already supplied with thermal energy from trigeneration plants, this energy displaces the thermal energy from the trigeneration system with renewable solar energy, reducing the amount of trigeneration needed.

Solar thermal consists of two main types, defined by the way they capture and convert sunlight. Solar thermal collector systems absorb and transfer heat energy directly and are more applicable to households and small scale installations. Solar thermal reflectors reflect and focus heat energy at an absorption tube, capable of producing much higher temperature and are hence higher quality than solar thermal collectors, however they are harder to apply and installation and maintenance costs are greater.

As solar thermal collectors produce heat directly, they are often used as a heat source for hot water systems or as an energy source for any heat driven HVAC. Any building that requires a large amount of thermal energy (e.g. an aquatic centre) will benefit from solar thermal collectors because the capital cost of solar thermal collectors are much lower than PV panels of the same size and they are easier to maintain.

Environmental Outcomes

Under the Local Action scenario savings are almost negligible at 0.01% by 2050. In comparison, the Carbon Neutral scenario delivers a 1.8% reduction.

EMISSION REDUCTIONS

Solar Thermal	No Action	Carbon Neutral	Local Action
2020	0.0%	0.9%	0.01%
2030	0.0%	1.3%	0.01%
2050	0.0%	1.9%	0.01%

Table 10: Emission reductions due to solar thermal

Social and Economic Outcomes

Solar thermal heating and cooling is capable of reducing greenhouse gas emissions at a social cost of $77 per tonne of CO_2-e avoided (see appendix). These costs assume that installation occurs on a large-scale, in conjunction with existing trigeneration facilities to convert waste heat to cool air. The economic costs and benefits therefore do not affect residents of Lake Macquarie at the level of household energy bills.

Governance Implications

Solar thermal heating and cooling is best suited to large buildings and sites where it is combined with Trigeneration. As such it is likely to be installed predominantly on commercial and industrial sites, however, large Council buildings and facilities could also participate.

The technology is rarely used in Australia and receives no targeted government support, however installations deemed to replace up to 1MW of electricity generation through the solar heating of water are able to generate small-scale technology renewable energy certificates from the Federal Government.

As with other clean energy actions, the expansion of solar thermal heating and cooling could be supported by Lake Macquarie City Council by partnering with building managers and energy utilities or finance providers to install it on appropriate sites, using on-bill financing or environmental upgrade agreements using the new *Environmental Upgrade Agreements* state legislation.

Box 4: Case Study – Charlestown Square

As part of a redevelopment on the Charlestown Square shopping centre, a solar thermal cooling plant has been installed to provide air conditioning for the centre. Developed in partnership with the CSIRO, the solar thermal unit will operate in conjunction with the site's cogeneration plant.

A series of parabolic mirrors are installed on the roof of the complex to concentrate and collect heat that is sent to absorption chillers along with heat from the cogeneration plant to produce chilled water which runs the air-conditioning system.

Wind

Action Description

Wind energy can be generated at various scales from small scale turbines to community and commercial scale wind turbines.

To be successful, wind projects require unobstructed, laminar wind flow; the support of a community educated on wind energy; appropriate zoning, and at times even legislative support.

In urban areas, it is difficult to find non-turbulent wind zones. Open land can be scarce and finding space to site a turbine appropriately (a minimum of 10 meters above any obstacle within a 175 metre distance), can be difficult.

Technical Specifications

Wind speed affects the efficiency and cost effectiveness of wind turbines. Average wind speeds in Lake Macquarie are estimated to be 6 metres per second, however, this could vary depending on location – in particular higher wind speeds may be achieved if wind turbines are situated offshore.

Under the No Action scenario it is assumed no new wind turbines are installed in the Lake Macquarie Local Government Area.

Under the Carbon Neutral scenario 17 wind turbines are installed by 2050, with a generating capacity of 50 MW. In the Local Action scenario only 3 wind turbines are installed with 9 MW of generating capacity.

Environmental Outcomes

EMISSION REDUCTIONS

Wind Turbines	No Action	Carbon Neutral	Local Action
2020	0.0%	0.0%	0.1%
2030	0.0%	0.3%	0.1%
2050	0.0%	0.7%	0.1%

Table 11: Emission reductions due to wind turbines

Economic Outcomes

Wind turbines reduce emissions at a social marginal abatement cost of approximately $55 per tonne of CO_2-e avoided (see appendix).

Wind turbine installation would not affect residents of Lake Macquarie at the level of household energy bills.

Governance Implications

Good selection of a wind turbine site is critical to economic development of wind power. In August of 2011, a consultant undertook wind resource analysis to assess the viability of installing up to two 5 kW wind turbines at up to five possible sites in the City. In the study, the consultant performed wind flow modeling of the whole Local Government Area and also of 5 2x2km areas identified by LMCC. In addition, LMCC have supplied the coordinates of 5 possible turbine locations for the consultant to calculate the expected energy yield. It is given as a gross and net central estimate taking into account likely losses. The results of the study found that the specified locations may produce between 7.1 and 10.1 MWh/year with a 5kW turbine at 18 meters hub height. The wind speeds identified in this study (Figure 21) highlight that Lake Macquarie is an unlikely location for commercial scale wind turbines.

WIND SPEEDS IN LAKE MACQURIE

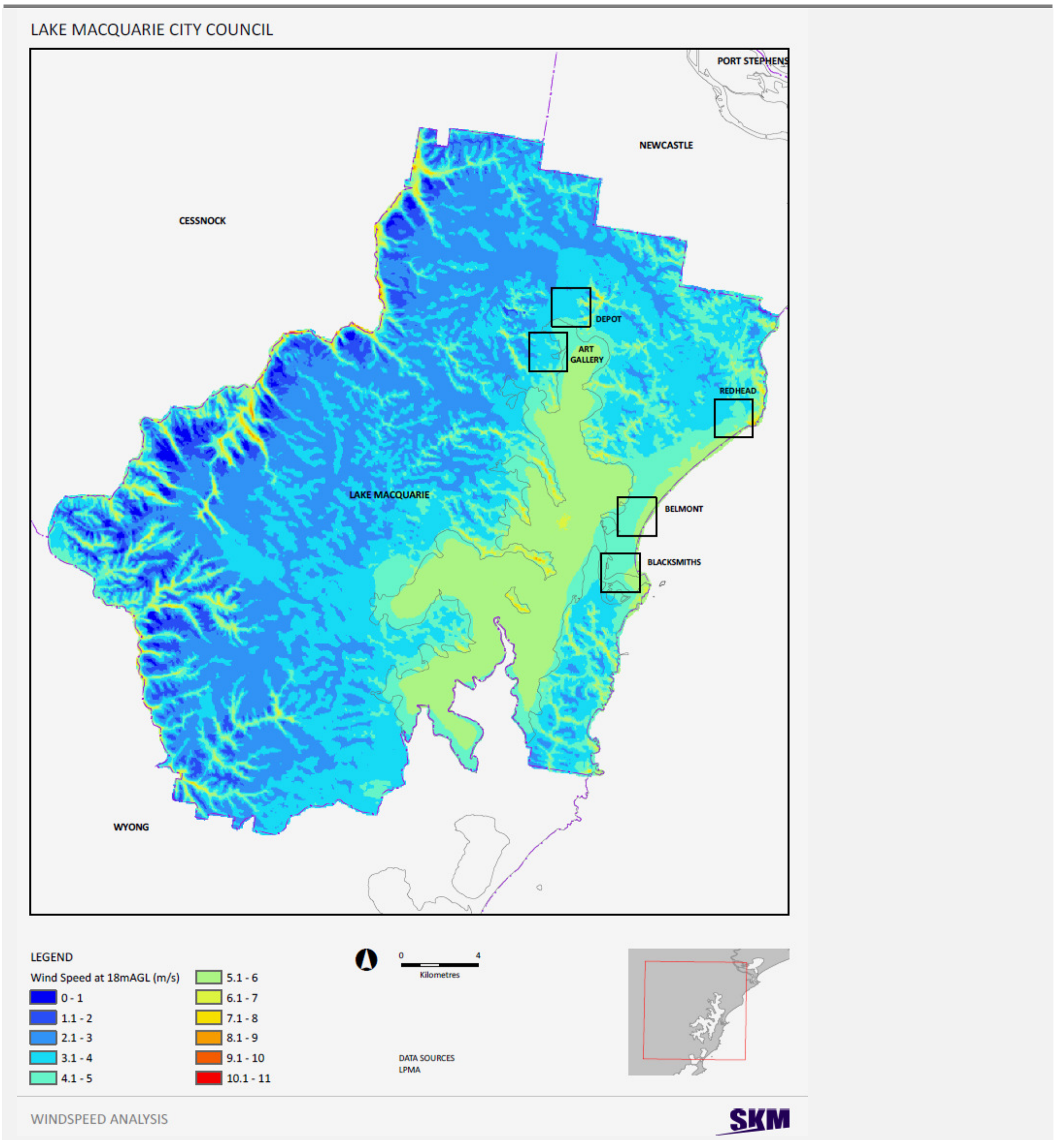

Figure 21: Wind speeds across Lake Macquarie LGA

Additional studies commissioned by CSIRO and AEMO highlighted average to high wind speeds of approximately **5.5 to 7 metres per second** at approximately 80 metres across most areas of the Lake Macquarie LGA.

Aside from the availability of wind itself, other factors include the availability of transmission lines for connection to the grid, the value of energy to be produced, the cost of land acquisition, land use considerations, and environmental impact of construction and operations, including bird migration paths. Commercial scale wind turbines (>100 kW power capacity), reaching total extended heights of 120 metres or more, require substantial amounts of land and access to electricity transmission lines. Small turbines (1 - 100 kW) can be used to offset electricity at, or distribute electricity from, homes, businesses and government facilities. Recently, “urban” turbines (generally vertical axis wind turbines) have gained popularity in media, but are inefficient due to their lower height and small swept area.

In urban areas, it is difficult to find non-turbulent and/or unobstructed space to site a turbine appropriately (typically requiring a minimum of 10 metres above any obstacle within a 175 metre distance). Whilst only 22% of the land area of the Lake Macquarie LGA is zoned for urban uses (residential, commercial, industrial and infrastructure uses), much of the remaining land is comprised of the lake itself, and uncleared vegetation including national parks.

Like solar, uptake of wind energy is currently being driven by the Federal Government’s Renewable Energy Target. This provides financial incentives to develop renewable energy. However, because the RET mandates a certain percentage of renewable energy that must be delivered, if a renewable project receives funding through the RET then the emissions reductions delivered by that project would not be additional to the savings that would otherwise have occurred. If Lake Macquarie City Council wants to seek emissions reductions that are additional, then it will not be able to seek financial support through the RET.

Measures to fund large scale wind generation could be achieved through cooperative finance models in which community members are able to purchase shares in the plant (See Box 5 – Community Owned Renewable Energy).

Box 5: Community Owned Renewable Energy

Community owned renewable energy is often solar PV or wind energy that is locally owned by residents, investors, businesses, schools, utilities, or other public or private entities living in the local community. The key feature is that local community members have a significant, direct financial stake in the project beyond land lease payments and tax revenue. This often assists in renewable energy projects gaining community support and therefore receiving planning and construction approval. Projects may be used for on-site power or to generate wholesale power for sale.

Australia’s first example of this approach to local renewable energy generation is Hepburn Wind. The Hepburn Wind Project is a wind farm built and owned by a community co-operative. The project includes two individual 2 MW wind turbines which are projected to produce enough energy for 2,300 households. Hepburn Wind Project formally launched their share offer on 25 July 2008, and as of May 2011 over 1,400 members had subscribed a total of $8.7 million. The project has secured over $13.1 million in funding with the additional funds being bank debt and Government grants. Shares have been issued with priority to the local residents of Daylesford and Hepburn Springs.

More information about Hepburn Wind is at: hepburnwind.com.au/about

Greenpower

Action Description

The four previous renewable energy actions concern renewable energy projects located within the Lake Macquarie LGA. There are limitations to siting renewable energy projects within an urban environment, such as Lake Macquarie. These can include:

- Community opposition.
- Lack of available land.
- Cost of available land.
- Less than ideal renewable resources such as consistent wind speeds and solar radiation compared to other potential sites.

An option for overcoming these limitations is to purchase Greenpower from renewable projects located outside Lake Macquarie's LGA.

Any organisation that is eligible to purchase Renewable Energy Certificates is eligible to develop and accredit a Greenpower Product. This accredited renewable electricity is then bought by energy retailers and can be purchased by individual energy consumers. The accreditation program is a joint initiative of state governments across Australia and is managed by the National Green Power Accreditation Steering Group.

By purchasing accredited Greenpower products, customers are assured that their purchases are going to additional renewable energy projects and are not funding projects that would otherwise have occurred. In particular, Greenpower projects must be additional to the Federal Government's Mandatory Renewable Energy Target (MRET).

Technical Specifications

In the analysis, Greenpower covers all electricity used in the Lake Macquarie LGA, once local renewable and low carbon generation sources (trigeneration, solar PV, community solar and wind) are accounted for.

Greenpower purchases currently average approximately 2% of all residential electricity sales. The No Action scenario assumes that this amount remains static through to 2050.

In the Carbon Neutral scenario 100% Greenpower is purchased in Lake Macquarie by 2045, equating to 497,673 MWh annually. This is necessary to ensure Lake Macquarie reaches carbon neutrality by 2050.

In the Local Action scenario 20% of all electricity purchased in Greenpower by 2020, or 334639 MWh each year.

Environmental Outcomes

EMISSION REDUCTIONS

Greenpower	No Action	Carbon Neutral	Local Action
2020	0.3%	9.9%	10.5%
2030	1.1%	8.3%	9.4%
2050	1.1%	8.8%	8.4%

Table 12: Emission reductions due to Greenpower purchase

Social and Economic Outcomes

Greenpower provides greenhouse gas abatement at an average social cost of $60 per tonne of CO_2-e avoided (see appendix). The consumer price of Greenpower is dependent on the retailer and therefore is variable, however major energy retailers currently charge between 5.5 cents/kWh (Origin) and 6.6 cents/kWh (Energy Australia) on top of usual energy prices for 100% Greenpower. The costs would be borne wholly by individual households and businesses that choose Greenpower, as well as by Council.

The per dwelling cost of implementing 100% Greenpower across the entire LGA would be $99 annually by 2050 under the Carbon Neutral scenario, whilst implementing only 20% Greenpower in the Local Action scenario would cost $61 annually.

Governance Implications

Currently, Greenpower is a voluntary program for residents and commercial businesses. There are no mandates or requirements to purchase Greenpower electricity. However, to meet the Carbon Neutral and Local Action Scenarios, significantly greater purchases of Greenpower will be required from residents and businesses within Lake Macquarie.

There are, however, measures to encourage greater take-up of Greenpower amongst residents and businesses. Brisbane City Council has recently implemented a group discounting program in which Council negotiates with electricity utilities to establish a scheme where residents can opt in to receive a percentage of Greenpower at no additional cost (for more information see: http://www.brisbane.qld.gov.au/environment-waste/green-heart-program/index.htm).

Travel and Transport

Residential Mode Shift and Fuel Efficiency

Action Description

Opportunities to reduce transportation fuel use, costs and associated greenhouse gas emissions are limited due to specific physical and location based constraints within the Lake Macquarie LGA. However, while these constraints do exist, there are still actions which Lake Macquarie City Council can implement which will help improve energy resilience in the transport sector.

Resident travel and employee travel contribute 35% and 4% to the total Lake Macquarie energy related greenhouse gas emissions respectively. With car travel used for 90% of household travel and 81% of employee travel, reducing emissions from car use and switching to lower/zero emission transport modes is essential.

Shifting residential transport away from car use to public transport and active transport and improving the fuel efficiency of vehicles will be central to achieving Lake Macquarie's emission reduction targets.

Technical Specifications

Under the No Action scenario no change to the car reliance of residents is projected and a 25% improvement in vehicle fuel efficiency is assumed.

In the Carbon Neutral scenario car use declines from 89% of all travel to 69% of all travel , with public transport increasing from 8% to 21% of km travelled and active transport growing from 1% to 8%. Vehicles are 50% more fuel efficient than the current average. The Local Action scenario assumes public transport use increases to 13% and active transport use grows six-fold to 6%, whilst car trips decline more modestly to 79% of travel. Fuel efficiency improvements remains at 25%.

Environmental Outcomes

Mode shifting and vehicle efficiency delivers approximately 20% reductions in emissions by 2050 under the Carbon Neutral scenario, compared to approximately 10% reductions under the Local Action scenario.

A significant reduction in air pollution from vehicle use would accompany these reductions, representing an important environmental co-benefit. It should be noted, however, that initiatives which encourage greater diesel use in order to improve efficiency will result in an increase in diesel particulate air pollution - a known carcinogen with a range of significant human health impacts. Diesel particulate matter is also a key component of global black carbon emissions and a recent United Nations Environment Programme (UNEP) report found that reducing these short-lived emissions could play an important role in reducing warming over the next 50 years.

EMISSION REDUCTIONS

Mode Shift & Vehicle Efficiency	No Action	Carbon Neutral	Local Action
2020	4.7%	10.5%	5.4%
2030	8.2%	16.6%	8.8%
2050	8.2%	20.5%	10.6%

Table 13: Emission reductions due to mode shifting and vehicle efficiency

Social and Economic Outcomes

The two-pronged action of reducing transport emissions through mode shift and improved vehicle efficiency can be implemented with net savings of $74 per tonne of CO2-e avoided (see appendix). This analysis is based on the average fuel costs of running a car and does not incorporate additional savings that may be achieved through owning fewer vehicles and broader infrastructure savings that could be achieved through prioritising public transport over private vehicle infrastructure requirements.

These savings will be shared by all residents in the form of reduced fuel bills for private transport. Under the Carbon Neutral scenario each household will save $1491 on annual energy bills by 2050 due to mode shifting and fuel efficiency measures, whilst under the Local Action scenario annual savings of $746 per dwelling will be achieved.

These measures will significantly increase resilience to increases in oil prices.

There will also be significant co-benefits from mode shifting in the form of improved community health – not only from greater levels of physical activity but from improved air quality.

Governance Implications

Lake Macquarie City Council is limited in the actions which it can take to influence vehicle mode shift and improve vehicle efficiency. This is because transport policy and infrastructure spending, especially public transport infrastructure, are largely administered by the State and Federal Governments. Additionally, vehicle purchases are made by individuals and vehicle performance standards are set by the Federal Government.

However, there are areas in which Lake Macquarie City Council can influence vehicle emissions. Primarily, this can be achieved through urban planning. Where people live and their proximity to services affects residents transport decisions. By ensuring that future urban growth concentrates jobs and services near residents, Lake Macquarie City Council can encourage alternative transport options such as car-share, walking and cycling.

Lake Macquarie City Council can comple this action through investment in transport infrastructure, including bike lanes, and reduced car-parking.

Electric Vehicles

Action Description

Given the low-density of Lake Macquarie, car reliance is likely to remain high even with significant mode shifting. In conjunction with fuel-efficiency measures, electric vehicle uptake enables high greenhouse gas emissions from transport to be reduced, without requiring high density transport infrastructure investments which may not be feasible in Lake Macquarie.

Technical Specifications

Under the No Action scenario it is assumed that 13% of all vehicles are electric-powered by 2050. This growth has been modelled on the projects of the 2008 Garnaut Review.

The Carbon Neutral scenario assumes 100% adoption of electric vehicles and the Local Action scenario assumes only 20% adoption.

Some purchasers of battery EVs may elect to power their vehicle from purchased green power, however the No Action and Local Action scenarios conservatively assume that electric vehicles will be powered by the grid rather than by renewable energy. In contrast the Carbon Neutral scenario assumes 100% renewable energy is used to recharge them. This results in a requirement for 261,656 MWh of renewable energy generation per year.

Currently, the only purely battery-electric vehicles on the market are the mass-produced Mitsubishi iMiEV and a limited number of high-performance vehicles from Tesla. Other major manufacturers, such as Nissan and Renault, intend to sell plug-in EVs in Australia within the next 12 months.

Vehicle range is somewhat less than that of conventional gasoline or diesel-powered cars and is typified by the iMiEV which is reported to be able to cover a distance of 160 km with its 16 kWh Li-ion batteries, although in reality its urban driving range is likely to be closer to 110km. Full replenishment of such a battery will virtually double the electricity demand of a household, however, depending on the availability of other transport means, most vehicles will be expected to travel daily much shorter distances than their full range capability and so a 50% increase in the electricity demand of a typical household is likely to be a more realistic outcome of EV ownership. Nonetheless, recharge of this vehicle will impose at least another 2.4 kW (and potentially 4.8 kW) of power demand on the grid and the scheduling of home recharge will become an important strategy for utilities in managing network load.

Recharging at public and workplace car parks is also probable, however the extent of this is likely to be low in comparison to home recharge. Some flexibility to use garaged (i.e, plugged-in) vehicles for short-term supply of electricity back to the grid during times of high demand has been proposed, but Kinesis considers this to unlikely in the near term.

Other forms of electric vehicle, such as those powered by means of a fuel cell drawing on a hydrogen or natural gas energy supply, are not yet freely available on the market and, in Kinesis's view, are unlikely to make a foreseeable impact over the timescale covered by the project.

Environmental Outcomes

Electric vehicle use achieves a 13.7% emissions reduction by 2050 under the Carbon Neutral scenario. The Local Action scenario results in a 2.8% reduction.

EMISSION REDUCTIONS

Electric Vehicles	No Action	Carbon Neutral	Local Action
2020	0.8%	2.2%	1.3%
2030	2.0%	4.1%	2.8%
2050	2.0%	14.3%	3.0%

Table 14: Emission reductions due to electric vehicle use

It is also significant that through the uptake of non-petroleum-fueled vehicles, the associated local environmental impacts of unconventional oil extraction, such as tar sand oil, are reduced. Despite this, there are lifecycle issues associated with electric vehicle batteries and appropriate recycling systems should be utilised.

Social and Economic Outcomes

The social marginal abatement cost of electric vehicle implementation is -$200 per tonne of CO_2-e avoided (see appendix). This reflects the significant long-term savings on fuel costs. The economic savings will be experienced exclusively by vehicle owners, with average annual savings of $3051 per dwelling under the Carbon Neutral scenario and $736 under the Local Action scenario.

There will also be benefits for the public as a whole in terms of reduced air pollution emissions and decreased noise pollution.

Governance Implications

Achieving significant take up of electric vehicles will require considerable planning and preparation. To ensure Lake Macquarie is able to support the roll out of electric vehicles, Lake Macquarie City Council should address:

- Infrastructure needs, including renewable energy and “fast charge” charging stations.
- Energy needs, ensuring that the electricity grid can support increased demand; and
- Council planning and development controls to support the installation of infrastructure where required.

To speed up the initial uptake of electric vehicles, Council should consider:

- Incorporating electric vehicles into Council’s fleet
- Community engagement to raise awareness of electric vehicles by supporting high-profile commercial sector trials

5 Implementation

This *Strategic Plan* outlines a suite of actions and potential policy approaches that could be used to achieve Lake Macquarie City Council's 3% per capita per annum emission reduction target.

Achieving this target will require not only actions from Lake Macquarie City Council and its community, but significant intervention at the state and federal level.

This *Strategic Plan* has therefore identified those actions in which Lake Macquarie City Council and its community can have the most direct influence (Local Action scenario). Isolating the actions that could feasibly be undertaken by Council, or through its intervention enables Lake Macquarie City Council to direct and prioritise the organisation's carbon reduction efforts as strategically as possible.

Based on the Detailed Action Analysis (Chapter 4), Figure 22 and Table 15 provide a multi-variable analysis of the actions listed in the previous chapter, clearly highlighting the role and influence of Lake Macquarie City Council and the benefits and costs of each action in relation to greenhouse gas reductions and capital and recurrent costs.

This analysis provides Council with a strategic action framework to identify high priority actions for the short to medium term.

ENERGY RESILIENT ACTION FRAMEWORK

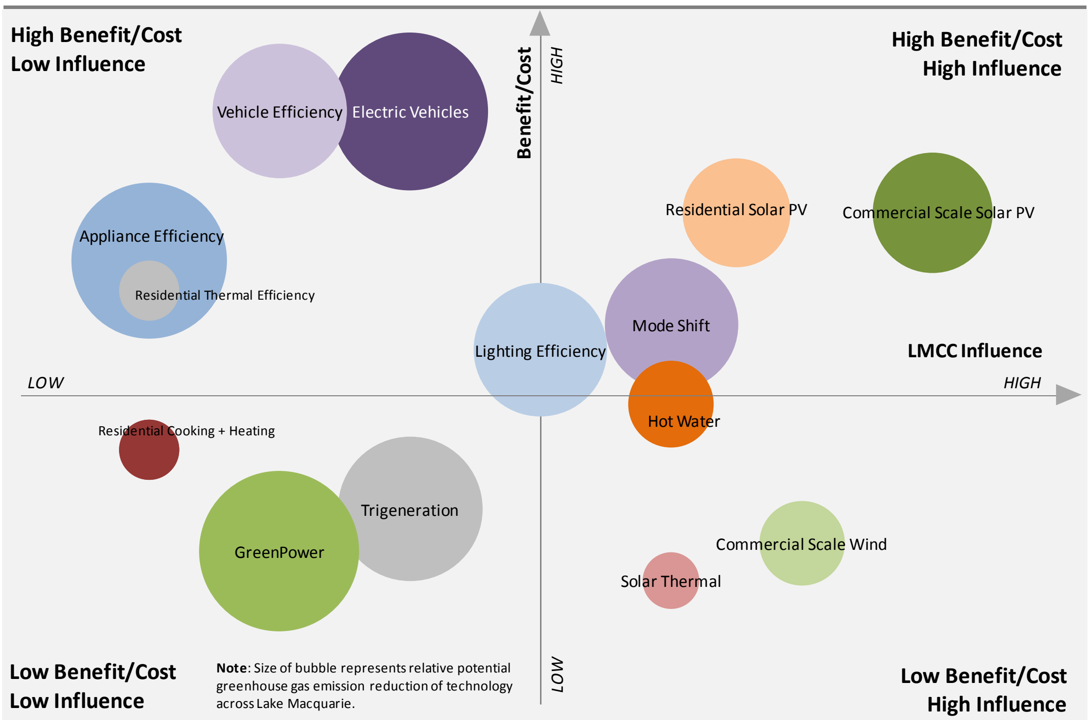

Figure 22: The strategic value of emissions reduction actions based on their comparative marginal abatement costs and level of Lake Macquarie City Council influence over their implementation.

STRATEGIC PRIORITISATION OF EMISSION REDUCTION ACTIONS

PRIORITY	ACTIONS
HIGH	Low Cost + Mid- High Influence: • Facilitate improved lighting efficiency • Increase the uptake of solar hot water • Facilitate lower car use through urban planning • Investigate the establishment of a community solar PV plant • Investigate the potential for establishing a partnership with a gas provider to facilitate higher gas availability and use throughout Lake Macquarie
MEDIUM	Mid-High Cost + Mid-High Influence: • Facilitate the continued uptake of residential solar PV • Investigate the establishment of community wind turbines
LOW	Low-Mid Cost + Low-Mid Influence: • Investigate the role of trigeneration in high thermal demand areas, such as major commercial centres, hospitals and industrial areas • Facilitate the uptake of electric vehicles • Lobby for improved vehicle fuel efficiency standards • Lobby for improved appliance efficiency standards • Investigate the scope for incentive schemes to support residential thermal efficiency

Table 15: Strategic prioritisation of actions based on relative marginal abatement cost and level of local government influence over implementation

High Priority Actions

Five actions emerge as having a negative marginal abatement cost (saving money over time) as well as having reasonable potential for Council to influence their implementation:

1. Improving the energy efficiency of the existing lighting stock across the LGA;

2. Encouraging the take up of solar hot water during the Federal government phasing out of electric hot water systems;

3. Strengthening Lake Macquarie's development around existing centres to allow residents to switch some of their trips to walking, cycling and public transport;

4. Implementing a commercial-scale solar PV project; and

5. Facilitating higher gas availability and use throughout Lake Macquarie.

These actions all represent moderate greenhouse gas abatement potential.

As discussed in the Detailed Action Analysis, targeted actions from Lake Macquarie City Council to upgrade residential and commercial **lighting and hot water** systems as inefficient systems are phased out can accelerate improvements in these sectors. Education programs, on-bill financing and energy upgrade agreements are options for Council to explore to influence these technology upgrades across the residential and non-residential sectors.

Urban planning has an important role to play in reducing future growth in emissions from transport through mode shift away from car use. The location and density of new development will determine how people travel within Lake Macquarie. Reviewing current planning policies to further support **infill development in existing centres** will not only allow residents to switch some of their trips to walking and cycling, but also support the feasibility of improved public transport across the local government area. In addition Council can play a direct role in establishing cycle paths to encourage shifts to active transport.

In addition, Council should investigate the potential for large scale **community owned solar PV**. Measures to fund this plant could be achieved through cooperative finance models in which community members are able to purchase shares in the plant.

Currently, only 30% of the Lake Macquarie Local Government area is **connected to natural gas**. Of those customers connected 58% use natural gas for hot water and 58% use natural gas for heating needs. Discussions with Jemena have provided significant information on the potential opportunities to increase the connection and use of natural gas in Lake Macquarie (see Box 3). Council should investigate the potential for establishing a partnership with a gas provider to facilitate higher gas availability and use throughout Lake Macquarie in order to increase the uptake of gas hot water, heating and cooking, as well as providing additional opportunities for gas-fired trigeneration where appropriate.

Medium Priority Actions

Renewable energy infrastructure projects were rated as having a higher level of Council influence over their implementation, but at a relatively high marginal abatement cost. These actions include:

- Residential solar PV
- Commercial and community scale wind

Residential solar PV has experienced sudden growth over the last few years. Generous rebates and feed-in-tariffs formerly offered by state and federal governments have now come to an end and although unit costs continue to decline, it is unlikely the same rate of take up will continue. Monitoring of residential solar PV installations through Ausgrid will determine whether additional action is needed by Council to further support this action (for more information see: www.ausgrid.com.au/Common/About-us/Sharing-information/Information-map.aspx).

In addition, Council should investigate the potential for large scale **community owned wind** installations. Measures to fund this plant could be achieved through cooperative finance models in which community members are able to purchase shares in the plant. Such a model has already been successfully used to finance wind turbines in Hepburn in Victoria (for more information see: http://hepburnwind.com.au/).

Low Priority Actions

Various actions with limited direct local government influence have high emission abatement potential. This has been highlighted in the relative difference between the Carbon Neutral and the Local Action scenarios outlined in this plan. These actions include:

- Fuel switching through trigeneration;
- the uptake of electric vehicles;
- vehicle fuel efficiency;
- appliance efficiency
- Greenpower purchase; and
- improvements in residential thermal efficiency

These areas can be seen as platforms for effective lobbying of state and federal governments, as inaction at these levels of government can be shown with the Energy Futures modelling to be a significant barrier to Lake Macquarie achieving carbon neutrality.

Council can act to increase their influence over several of these interventions, through, for example, the provision of community wide infrastructure to facilitate implementation. These actions are discussed in more detail below.

Trigeneration Opportunities

Embedded trigeneration energy generation represents a departure from the current approach to producing, distributing and consuming energy in urban environments that is still in its infancy. There are already numerous examples of poorly sized and commercially marginal installations, highlighting the challenges associated with implementation.

Due to Lake Macquarie's low-density urban form there are limited opportunities for trigeneration to be implemented, however industrial and commercial areas and hospitals across the LGA are likely to be strategic targets.

Hot water demands for sterilisation, general cleaning, personal hygiene, laundry and space heating together with chilled water and refrigeration demands for space cooling, storage of medical supplies & food and equipment cooling are all significant end-uses of thermal energy in any major hospital. Here, gas-fired cogeneration together with solar-thermal, could readily offer very large energy and greenhouse savings.

The industrial areas of Lake Macquarie are estimated to be responsible for a significant amount of total energy demand. Opportunities for energy and greenhouse gas emission reduction are largely unknown without detailed study of the specific industry energy needs.

While lighting and space conditioning efficiencies are applicable, synergies between different industries provide significant opportunities for embedded energy. For example, the drying process from one industry could draw on low-grade heat rejected from a neighbouring air conditioning or cooling process.

It was indicated throughout the project that a new industrial development is proceeding within the Lake Macquarie LGA. This development may present an opportunity for Lake Macquarie City Council to demonstrate the potential of embedded energy in industrial parks across the local government area.

It is recommended, that at a minimum, Lake Macquarie City Council consider the following when investigating the feasibility of a trigeneration:

- Demand side load modelling and leveraging synergies between different land use types
- Plant sizing, staging and operating conditions
- Network configuration and integration with existing infrastructure

- Governance and ownership models
- Fuel price and market sensitivity testing

Electric Vehicle Ready

Given the urban form and associated high car use across Lake Macquarie, electric vehicles will play a significant role in reducing greenhouse gas emissions. However, electric vehicle technology is still in its infancy and as such is recommended as a low priority at this stage.

Council is already pursuing community education and support for electric vehicles through events such as the Electric Vehicle Show and Electric Vehicle Festival. Achieving progressive take up of electric vehicles will require considerable planning and preparation. New infrastructure, including re-charge stations must be built and measures must be taken to ensure that the electricity grid can support increased demand.

Ensuring Council has an understanding of the infrastructure needs for electric vehicles and the Council planning and development controls support the installation of infrastructure when required, will encourage vehicle manufacturers to target Lake Macquarie as a potential market by making it easier for companies which propose to establish battery charging within the LGA.

In addition, Council will play a role in influencing the uptake of electric vehicles such as demonstrating electric vehicle use in its fleet or providing one or more renewable energy charging stations in select locations.

Greenpower

The large scale uptake of Greenpower has the ability to significantly reduce greenhouse gas emissions across the LGA. However, Greenpower is characterised by a relatively low benefit-cost and limited Council influence over their implementation (Figure 22). This indicates that this action should be a lower priority than other actions; however, in some instances there may be opportunities to increase influence over this action.

While Lake Macquarie residents and businesses are free to choose from where they purchase electricity, Councils have the ability to provide influence this decision through the provision of rebates or group discounting, as has been demonstrated in Brisbane City Council.

Residential thermal efficiency

The NSW Government's BASIX Scheme covers thermal performance for new dwellings. As a result, Lake Macquarie City Council is unable to regulate thermal performance standards beyond BASIX compliance. Council can, however, investigate the scope for incentive schemes to support new homes achieving higher residential thermal efficiency.

Future Technologies

New low carbon energy technologies and efficiencies, not yet available on the market, could provide further emission savings. Such technologies might include individual dwelling cogeneration systems, new technologies including hydrogen fuel cells and solar storage, and improved efficiencies in solar photovoltaic panels, solar thermal and lighting technologies. While expected changes in technology may allow Lake Macquarie to more easily achieve the 3% per capita per annum emission reduction target, these advances cannot be relied upon to achieve targets in the short-to-medium term.

However, Lake Macquarie is well placed to draw on partnerships and existing relationships to ensure the community is provided early opportunities to new low carbon technology. Existing opportunities and relationships include:

- CSIRO Energy Technology Centre – The Virtual Power Station (VPS) Project monitors and controls the output of many small renewable generation and storage systems to improve their uptake and cost effectiveness.
- Australian Solar Institute – located near Lake Macquarie is a $150 million commitment by the Australian Government to keep Australia at the forefront of solar innovation.
- Smart Grid Smart City trial – Lake Macquarie City Council is a consortium partner. This program will include a trial of a Council electric vehicle.

Appendix 1 Inputs from Energy Futures Model

No Action Scenario:

kinesis Lake Macquarie Energy Futures Model

POLICIES/STRATEGIES — **Year of analysis** 2050

Grid Greenhouse Gas Intensity

Grid GHG Coefficient: With Renewable Energy Target (RET) — Renewable Gas: FALSE — start year: 2031

Efficiency

Appliance Efficiency

start year	end year	SAVINGS tCO2-e	%
2007	2050	0	0.0%

0% energy reduction

Lighting

start year	end year	tCO2-e	%
2007	2030	119,531	4.0%

Residential	*Non-Residential*	
20%	20%	energy reduction

Residential thermal Efficiency

start year	tCO2-e	%
2007	0	0.0%

New Residential: 0% energy reduction — *Est. NatHERS rating*: 5

Fuel Switching

Hot water

start year	end year	tCO2-e	%
2007	2025	115,835	3.8%

	Solar	Gas	Heat Pump	Electric
single dwellings:	50%	20%	30%	0%
attached dwellings:	50%	20%	30%	0%
multi-dwellings:	5%	90%	5%	0%
commercial buildings:	10%	80%	5%	5%
industrial buildings:	10%	80%	5%	5%

Heating

start year	end year	tCO2-e	%
2007	2050	0	0.0%

	Gas	Electric
single dwellings:	21%	79%
attached dwellings:	21%	79%
multi-dwellings:	21%	79%

**Note: total % includes district thermal*

District Thermal

start year	end year	tCO2-e	%
2015	2030	1,098	0.0%

	penetration	hot water	heating	cooling
single dwellings:	0%	FALSE	FALSE	FALSE
attached dwellings:	0%	FALSE	FALSE	FALSE
multi-dwellings:	0%	TRUE	FALSE	FALSE
commercial buildings:	10%	TRUE	TRUE	TRUE
industrial buildings:	0%	TRUE	TRUE	TRUE

Cooking

start year	end year	tCO2-e	%
2007	2050	0	0.0%

	Gas Cooktops	Elec Cooktop	Gas Oven	Electric Oven
single dwellings:	21%	79%	3%	97%
attached dwellings:	21%	79%	3%	97%
multi-dwellings:	21%	79%	3%	97%

Renewable Energy

Residential Solar PV

	start year	end year	PV technology	tCO2-e	%
	2007	2007	Monocrystalline	8,947	0.3%

	% Installation	Panel Size		Panel Area	
single dwellings:	7%	1.5	kW/dwelling	11	m2/dwelling
attached dwellings:	7%	1.5	kW/dwelling	11	m2/dwelling
multi-dwellings:	0%	0.5	kW/dwelling	4	m2/dwelling

Solar thermal

	start year	end year	tCO2-e	%
	2007	2007	143	0.0%

	heating	cooling	
single dwellings:	0	0	m2 of panel area
attached dwellings:	0	0	m2 of panel area
multi-dwellings:	0	0	m2 of panel area
commercial buildings:	200	200	m2 of panel area
industrial buildings:	0	0	m2 of panel area

Community Solar PV

	start year	end year	PV technology	tCO2-e	%
	2015	2040	Monocrystalline	0	0.0%

generating capacity: 0 MW; panel area 0 m2; 0 MWh/year

Wind

	Start year	End year	tCO2-e	%
	2020	2050	0	0.0%

generating capacity: 0 MW; turbines: 0; 0 MWh/year

wind speed(m/s) 6

Greenpower Purchase

	Start year	End year	tCO2-e	%
	2011	2045	32,165	1.1%

2% of electricity; 37,930 MWh/year

Travel/Transport

Residential Mode Shift

	Start year	End year	tCO2-e	%
	2007	2050	248,383	8.2%

Car	89%	89%	of km travelled
Public transport	8%	8%	of km travelled
Active	1%	1%	of km travelled
Other	2%	2%	of km travelled

Vehicle Fuel

	Start year	End year
	2007	2030

Vehicle Efficiency 25% more efficienct than current average

Fuel emissions 0% reduction in GHG per km

Electric Vehicles

	Start year	End year	tCO2-e	%
	2015	2030	61,764	2.0%

13% of all vehicles are electric; 41,397 MWh/year

0% proportion powered by renewables

Public Transport

On Renewable Energy: FALSE

Start year: 2040

Other Strategies

	start year	end year	amount		tCO2-e	%
Electricity	2007	2050	0	kWh generated or reduced	0	0.0%
Gas	2007	2050	0	MJ generated or reduced		
Fuel	2007	2050	0	Litres generated or reduced		
Emissions	2007	2050	0	kg reduced		

Carbon Neutral Scenario:

kinesis **Lake Macquarie Energy Futures Model**

POLICIES/STRATEGIES — **Year of analysis** 2050

Grid Greenhouse Gas Intensity

Grid GHG Coefficient: With Renewable Energy Target (RET) — Renewable Gas: TRUE — start year: 2031

Efficiency — **SAVINGS**

Appliance Efficiency

start year	end year		tCO2-e	%
2007	2050		298,176	10.4%
50%	energy reduction			

Lighting

start year	end year		tCO2-e	%
2007	2030		309,956	10.8%
Residential	*Non-Residential*			
60%	50%	energy reduction		

Residential thermal Efficiency

start year		Est. NatHERS rating	tCO2-e	%
2007			62,398	2.2%
New Residential				
65%	energy reduction	8		

Fuel Switching

Hot water

start year	end year	tCO2-e	%
2007	2025	127,153	4.4%

	Solar	Gas	Heat Pump	Electric
single dwellings:	100%	0%	0%	0%
attached dwellings:	100%	0%	0%	0%
multi-dwellings:	10%	90%	0%	0%
commercial buildings:	10%	80%	5%	5%
industrial buildings:	10%	80%	5%	5%

Heating

start year	end year	tCO2-e	%
2007	2050	52,268	1.8%

	Gas	Electric
single dwellings:	50%	50%
attached dwellings:	50%	50%
multi-dwellings:	50%	50%

**Note: total % includes district thermal*

District Thermal

start year	end year	tCO2-e	%
2015	2030	346,516	12.1%

	penetration	hot water	heating	cooling
single dwellings:	0%	FALSE	FALSE	FALSE
attached dwellings:	0%	FALSE	FALSE	FALSE
multi-dwellings:	50%	TRUE	FALSE	FALSE
commercial buildings:	75%	TRUE	TRUE	TRUE
industrial buildings:	75%	TRUE	TRUE	TRUE

Cooking

start year	end year	tCO2-e	%
2007	2050	10,912	0.4%

	Gas Cooktops	Elec Cooktop	Gas Oven	Electric Oven
single dwellings:	50%	50%	7%	93%
attached dwellings:	50%	50%	7%	93%
multi-dwellings:	50%	50%	7%	93%

Renewable Energy

Residential Solar PV

	start year	end year	PV technology	tCO2-e	%
	2007	2030	Monocrystalline	215,234	7.5%

	% Installation	Panel Size		Panel Area	
single dwellings:	95%	2	kW/dwelling	14	m2/dwelling
attached dwellings:	75%	1.5	kW/dwelling	11	m2/dwelling
multi-dwellings:	50%	0.5	kW/dwelling	4	m2/dwelling

Solar thermal

	start year	end year	tCO2-e	%
	2007	2050	53,122	1.9%

	heating	cooling	
single dwellings:	0	0	m2 of panel area
attached dwellings:	0	0	m2 of panel area
multi-dwellings:	0	0	m2 of panel area
commercial buildings:	40,000	40,000	m2 of panel area
industrial buildings:	40,000	40,000	m2 of panel area

Community Solar PV

	start year	end year	PV technology	tCO2-e	%
	2015	2040	Monocrystalline	117,194	4.1%

generating capacity: 100 MW — panel area 724,638 m2 — 138,200 MWh/year

Wind

	Start year	End year	tCO2-e	%
	2020	2050	20,477	0.7%

generating capacity: 50 MW — turbines: 17 — 24,147 MWh/year

wind speed(m/s) 6

Greenpower Purchase

	Start year	End year	tCO2-e	%
	2011	2045	252,556	8.8%

100% of remaining electricity — 297,825 MWh/year

Travel/Transport

Residential Mode Shift

	Start year	End year	tCO2-e	%
	2007	2050	585,347	20.5%

Car	89%	69%	of km travelled
Public transport	8%	21%	of km travelled
Active	1%	8%	of km travelled
Other	2%	2%	of km travelled

Vehicle Fuel

	Start year	End year
	2007	2030

Vehicle Efficiency 50% more efficienct than current average

Fuel emissions 0% reduction in GHG per km

Electric Vehicles

	Start year	End year	tCO2-e	%
	2015	2050	408,183	14.3%

100% of all vehicles are electric — 261,656 MWh/year

100% proportion powered by renewables

Public Transport

On Renewable Energy TRUE

Start year 2040

Other Strategies

	start year	end year	amount		tCO2-e	%
Electricity	2007	2050	0	kWh generated or reduced	0	0.0%
Gas	2007	2050	0	MJ generated or reduced		
Fuel	2007	2050	0	Litres generated or reduced		
Emissions	2007	2050	0	kg reduced		

Local Action Scenario:

kinesis

Lake Macquarie Energy Futures Model

POLICIES/STRATEGIES — **Year of analysis**: 2050

Grid Greenhouse Gas Intensity

Grid GHG Coefficient	With Renewable Energy Target (RET)	Renewable Gas	FALSE	start year	2031

Efficiency

Appliance Efficiency

start year	end year		SAVINGS tCO2-e	%
2007	2050		30,119	1.0%
5%	energy reduction			

Lighting

	start year	end year		tCO2-e	%
	2007	2030		298,827	9.9%
	Residential	*Non-Residential*			
	50%	50%	energy reduction		

Residential thermal Efficiency

start year		*Est. NatHERS rating*	tCO2-e	%
2007			49,701	1.6%
New Residential				
45%	energy reduction	7		

Fuel Switching

Hot water

start year	end year	tCO2-e	%
2007	2025	110,147	3.7%

	Solar	Gas	Heat Pump	Electric
single dwellings:	80%	15%	5%	0%
attached dwellings:	80%	15%	5%	0%
multi-dwellings:	5%	90%	5%	0%
commercial buildings:	10%	80%	5%	5%
industrial buildings:	10%	80%	5%	5%

Heating

start year	end year	tCO2-e	%
2007	2050	50,603	1.7%

	Gas	Electric
single dwellings:	50%	50%
attached dwellings:	50%	50%
multi-dwellings:	50%	50%

**Note: total % includes district thermal*

District Thermal

start year	end year	tCO2-e	%
2015	2030	15,216	0.5%

	penetration	hot water	heating	cooling
single dwellings:	0%	FALSE	FALSE	FALSE
attached dwellings:	0%	FALSE	FALSE	FALSE
multi-dwellings:	20%	TRUE	FALSE	FALSE
commercial buildings:	20%	TRUE	TRUE	TRUE
industrial buildings:	20%	TRUE	TRUE	TRUE

Cooking

start year	end year	tCO2-e	%
2007	2050	5,250	0.2%

	Gas Cooktops	Elec Cooktop	Gas Oven	Electric Oven
single dwellings:	50%	50%	7%	93%
attached dwellings:	50%	50%	7%	93%
multi-dwellings:	50%	50%	7%	93%

Renewable Energy

Residential Solar PV

start year	end year	PV technology	tCO2-e	%
2007	2030	Monocrystalline	68,427	2.3%

	% Installation	Panel Size		Panel Area	
single dwellings:	30%	2	kW/dwelling	14	m2/dwelling
attached dwellings:	30%	1.5	kW/dwelling	11	m2/dwelling
multi-dwellings:	5%	0.5	kW/dwelling	4	m2/dwelling

Solar thermal

start year	end year	tCO2-e	%
2007	2007	143	0.0%

	heating	cooling	
single dwellings:	0	0	m2 of panel area
attached dwellings:	0	0	m2 of panel area
multi-dwellings:	0	0	m2 of panel area
commercial buildings:	200	200	m2 of panel area
industrial buildings:	0	0	m2 of panel area

Community Solar PV

start year	end year	PV technology	tCO2-e	%
2015	2040	Monocrystalline	23,439	0.8%

generating capacity: 20 MW | panel area 144,928 m2 | 27,640 MWh/year

Wind

Start year	End year	tCO2-e	%
2020	2050	3,686	0.1%

generating capacity: 9 MW | turbines: 3 | 4,347 MWh/year

wind speed(m/s) 6

Greenpower Purchase

Start year	End year	tCO2-e	%
2011	2045	231,847	7.7%

20% of electricity | 273,404 MWh/year

Travel/Transport

Residential Mode Shift

Start year	End year	tCO2-e	%
2007	2050	304,017	10.1%

Car	89%	79%	of km travelled
Public transport	8%	13%	of km travelled
Active	1%	6%	of km travelled
Other	2%	2%	of km travelled

Vehicle Fuel

Start year	End year
2007	2030

Vehicle Efficiency 25% more efficienct than current average

Fuel emissions 0% reduction in GHG per km

Electric Vehicles

Start year	End year	tCO2-e	%
2015	2030	86,584	2.9%

20% of all vehicles are electric | 58,032 MWh/year

0% proportion powered by renewables

Public Transport

On Renewable Energy FALSE

Start year 2040

Other Strategies

	start year	end year	amount		tCO2-e	%
Electricity	2007	2050	0	kWh generated or reduced	0	0.0%
Gas	2007	2050	0	MJ generated or reduced		
Fuel	2007	2050	0	Litres generated or reduced		
Emissions	2007	2050	0	kg reduced		

Appendix 2 Methodology and Assumptions

Data used to determine the greenhouse gas emissions for Lake Macquarie LGA was sourced from the following resources:

- Lake Macquarie City Council Lifestyle 2020 Review Discussion Paper
- Lake Macquarie City Council Commercial Centre Study 2009 Review
- NSW Department of Planning Lower Hunter Regional Strategy
- ABS Census population and dwelling counts
- Energy Australia metered electricity consumption data for Lake Macquarie Council area
- Jemena metered gas consumption data for Lake Macquarie Council area
- Energy Use in the Australian Residential Sector, 1986 – 2020, Australian Government Department of the Environment, Water, Heritage and the Arts (DEHWA), 2008
- Transport Data Centre Sydney Household Travel Survey
- Census Journey to Work Data: origin and destination travel distances by mode
- Australian Greenhouse Office (2008) National GHG Accounts Workbook
- Energy Australia (June 2010) BASIX Monitoring Report Electricity Consumption for 2007-08 and 2008-09
- Treasury (2011) Strong growth, low pollution, http://www.treasury.gov.au/carbonpricemodelling/content/overview/page4.asp

Details of additional data and key assumptions used in the analysis are documented below.

Residential Data

Residential energy consumption and greenhouse emission projections were projected to 2050 using dwelling growth rates. Per dwelling consumption was calculated by dividing total Energy Australia and Jemena (gas consumption) by total dwellings. The variation of consumption between dwellings was then calibrated using NSW Government BASIX base dwelling and new dwelling consumption figures.

For Lake Macquarie, these figures are:

Existing Dwellings	Detached	Attached	Multi-Unit
Electricity Consumption - kWh/Dwelling	9,882	8,110	6,433
Gas Consumption - MJ/Dwelling	20,714	16,719	13,158

Table 16: Existing residential dwelling consumption data

New Dwellings	Detached	Attached	Multi-Unit
Electricity Consumption - kWh/Dwelling	5,168	3,968	2,947
Gas Consumption - MJ/Dwelling	7,963	6,819	9,863

Table 17: New residential dwelling consumption data

Commercial, Retail and Industrial Data

Commercial & Retail energy and greenhouse gas consumption projections were projected to 2030 based on the potential growth for commercial development within the Commercial Centre Study 2009 Review (66,000 jobs). Projection also used data from Lake Macquarie City Council Lifestyle 2020 review discussion paper as a current consumption baseline.

Industrial sector electricity and gas consumption (and associated greenhouse gas emissions) have been estimated based on data provided by Jemena as well as analysis of non-residential (business tariff) electricity consumption data provided by Ausgrid.

Travel Data

Key Transport Indicators (a) by Local Government Area of Residence (LGA), 2007:

- Total kilometres by Lake Macquarie residents per day – 8,062,000
- Travel mode split

ABS Census – journey to work tables 2006

Solar PV annual electricity output

- Calculating renewable energy certificates (RECs) for small solar (photovoltaic) systems, Australian Government, office of the renewable energy regulator

Wind resource assessment

- CSIRO Land and Water (2003) Wind resources assessment in Australia - a planners guide, Wind energy research unit
- AEMO National Energy Network (2011) http://www.aemo.com.au/planning/2010ntndp_cd/Interactive/map.swf

Other references:

- University of Tasmania (2009). Energy Efficient Measures in Low Income Housing. Sub-Project One: Literature Review. A Report for the Tasmanian Government. Catherine Elliot & Elaine Stratford, School of Geography and Environmental Studies. Available at: http://www.climatechange.tas.gov.au/__data/assets/pdf_file/0018/111492/Energy_efficiency_measures_in_low_income_housing_UTas_report.pdf

- World Health Organisation (2007). Exposure to Mercury: A Major Public Health Concern. Available at: http://www.who.int/phe/news/Mercury-flyer.pdf

Greenhouse Gas Emission Intensity

Greenhouse gas emission intensities were sourced from the Australian Greenhouse Office National Greenhouse Accounts (NGA) Factors November 2008. Transport emissions were sourced from a variety of research documents.

Emission intensities used in this report are illustrated in Table 4:

Greenhouse Gas Emission Intensities	Emission Factor	
Year	2007	2050
Electricity (kgCO_2-e/kWh)	1.069	0.848
Gas (kgCO_2-e/MJ)	0.066	0.066
Transport (grams CO_2-e/km)		
Car as driver	312	312
Car as passenger	0	0
Bicycle/Walk	0	0
Bus	50	50
Train	48	48
Ferry or Tram	50	50
Other	156	156

Table 18: Greenhouse gas emissions intensities

Social Marginal Abatement Cost of Actions

A high level social marginal abatement cost curve has been generated for the strategies outlined in this plan. The marginal costs for each action are sourced from generic cost curve assessments undertaken by McKinsey, Climate Works and, where appropriate, through Kinesis project experience.

Abatement cost curves allow decision makers to instantly identify what measures should be undertaken to achieve the greatest abatement for the lowest cost. By using an abatement cost curve, any emissions reduction target can be immediately quantified in terms of cost and method of abatement.

Marginal abatement cost curves simultaneously show the abatement and cost of measures that save or reduce greenhouse gas emissions. Measures are ranked from lowest cost to highest, and each measure's abatement is shown. The "cost" of measures is based on their additional ("marginal") cost to implement, relative to any business as usual costs that would be incurred anyway, such as to operate and replace existing equipment. Measures which save more money than they cost are represented as having a negative marginal cost, and measures which incur a cost relative to business as usual for their abatement are represented as having a positive marginal cost.

The marginal cost of each measure is divided by its greenhouse gas abatement potential to assess its cost-effectiveness. Measures with the lowest cost per tonne of abatement maximise the benefits to society and minimise the costs of an emissions reduction strategy.

Due to their visual simplicity, marginal abatement cost curves are a clear and effective tool to identify and act upon abatement opportunities.

The social marginal abatement costs included in this report attempt to capture the full economic costs and benefits of each action through a societal perspective that includes full capital costs excluding any subsidies. It should be noted that this methodology incorporates market values, including existing tariff rates and does not attempt to attribute a monetary value to indirect social benefits which are not directly reflected in market prices.

Source:

- McKinsey & Company (2008) ‘An Australian cost curve for greenhouse gas reduction’, McKinsey Australia Climate Change Initiative.

- ClimateWorks Australia (2010) ‘Low carbon growth plan for Australia’, ClimateWorks Australia, Monash University, Victoria.

- Kinesis (2010) project experience

Information provided by Council on Existing Greenhouse Footprinting

An official council greenhouse gas emission report produced by Lake Macquarie City Council includes embodied emissions related to food and material consumption, emissions from waste to landfill, fugitive emissions from mining and other indirect sources of emissions.

The official council footprint has used state and national data scaled to Lake Macquarie as a means of filling the data gaps in the areas where data gaps have been identified in data provided by local utility distribution networks.

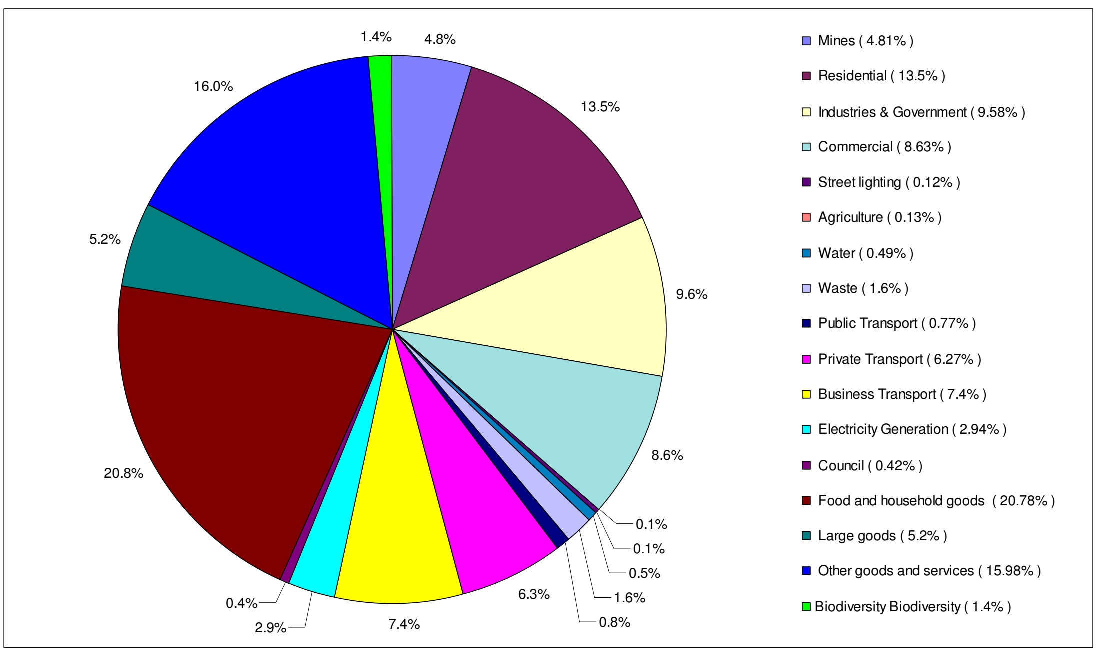

Figure 23: Breakdown of components of baseline (2007-2008) city-wide carbon emissions (total emissions 4,869,761 t CO_2-e and city population of 194,997)

Category	2007-08 ($t\ CO_2$-e)
Mines	234,028
Residential	657,464
Industries & Government	466,394
Commercial	420,249
Street Lighting	5,947
Agriculture	6,244
Water	23,790
Waste	77,832
Public Transport	37,532
Private Transport	305,302
Business Transport	360,203
Electricity Generation	142,986
Council	20,473
Food and Household Goods	1,011,915
Large Goods	252,999
Other Goods and Services	778,415
Biodiversity	67,988
TOTAL	4,869,761*
Population	194,996
Per Capita Emissions	24.97

Table 19: Official Council Greenhouse Gas Emissions