ATTACHMENT A

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Executive summary

Purpose

The City of Darwin is a major user of electricity (spends $2 million annually on electricity) and is keen to develop strategies to reduce its overall energy bill and reduce its Greenhouse Gas (GHG) footprint. The City of Darwin wants to develop an energy strategy to establish emission reduction targets for the period 2017-18 to 2029-30, prepare for the opening up of a competitive electricity market in the Territory, and develop fully costed options to reduce energy costs and reduce emissions.

This report, prepared by both Marsden Jacob Associates (Marsden Jacob) and Entura, summarises the levelised cost analysis of various initiatives that could reduce energy costs and/or reduce emissions, and provides forecasts of the City of Darwin's energy use and emissions over the forecast period with and without those initiatives implemented. It is also provides a recommendation on the overall target for energy use and emission reductions by 2030.

Investment Framework

Our review of the investment framework for investment in renewable technologies and energy efficiency projects provided the following conclusions:

- International politics will influence Australia's and consequently, the Territory's, adoption of energy efficiency and greenhouse gas emissions targets. The NT Government (Labor) has committed to a renewable energy target of 50 per cent by 2030. Such a target will have a major impact on the generation mix in the Darwin Katherine Interconnected System (DKIS), which will impact the City of Darwin's emissions even if no direct action is taken by the City of Darwin to reduce emissions (i.e. the base case is altered).
- International oil prices play a significant role in determining the domestic gas price and subsequently the electricity generation price in the Territory (i.e. high proportion of generation is gas fired). MJA is forecasting rising oil prices and hence rising gas prices which will drive up wholesale and retail electricity prices and improve the economics of investments in renewable and energy efficiency projects.
- The current electricity market reforms in the Territory are noted as presenting both opportunities and challenges for future electricity supply negotiations. A complexity in the assessment of renewable energy projects for the City of Darwin is to understand the extent to which Territory reform will move retail tariffs towards a competitive and non-subsided landscape – an outcome which is also noted as impacting the relative attractiveness of solar PV, for example.

A number of opportunities are emerging beyond renewable energy generation (wind, solar, hydro) as technology changes. Energy storage benefits, including behind the meter options, electric vehicles and advantages of community scale renewable energy projects were canvassed for further consideration. Matching of these projects to funding available from the Clean Energy Finance Corporation (CEFC) and ARENA will enable City of Darwin to more easily realise carbon abatement opportunities.

Base Case Energy Use and Emission Forecasts

The base case forecasts of future energy demand and emissions are provided in Chapter 4 of the report. Energy forecasts were broken into three segments: Asset electricity demand (net) which is the demand by facilities after allowance for onsite solar PV production; street lighting electricity demand; and, vehicle energy demand.

Future demand for all of the above services is forecast to increase by an annual average growth rate of 0.6 per cent per annum. Increased energy demand is driven by the increased demand for services in line with population growth in Darwin (based on historical trends).

The emissions profile for the City of Darwin does not track the energy demand profile since it is assumed that that significant investment in large-scale renewable energy is made over the forecast period to align with the NT Government's commitment to renewable energy. As a result of the investment in large-scale solar (370 MW), the emission intensity of electricity from the DKIS falls from 0.55 (tonnes CO_2^e per MWh) in 2017 to 0.33 in 2030. As a consequence, the overall City of Darwin emissions are forecast to fall from 5301 tonnes of CO_2^e in 2017 to 4200 tonnes of CO_2^e in 2030 in the base case.

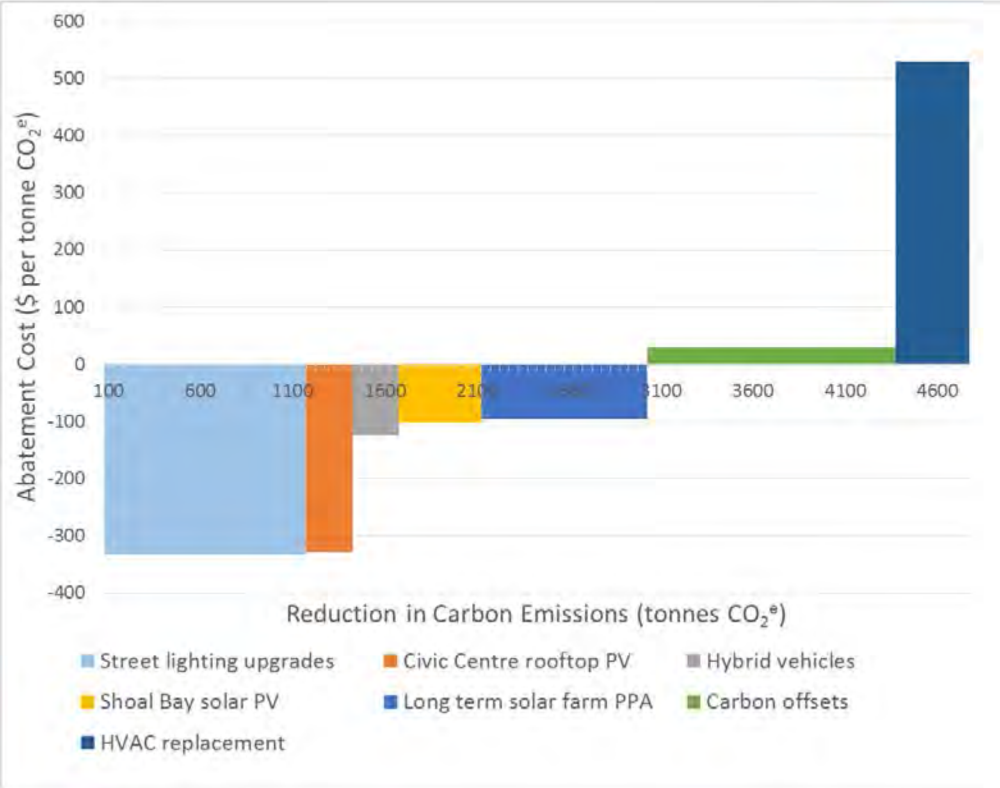
Costed Options to Reduce Energy Use and Emissions

Marsden Jacob and Entura have assessed, and in most cases, determined the levelised cost and carbon abatement potential of the following options.

- Installation of a solar PV system at the Shoal Bay Waste Management Centre;
- Installation of rooftop solar at the Civic Centre;
- Put in place a power purchase agreement with a large-scale solar farm developer to help underwrite the project;
- Utilisation of waste streams at the Shoal Bay Waste Management Centre to produce electricity;
- Installation of energy efficient public lighting;
- Replacement of existing Heating, Ventilation and Air Conditioning (HVAC) systems with more energy efficient systems (i.e. accelerated replacement);
- Putting in place electricity procurement arrangements (i.e. reverse auction) to reduce energy costs;
- Upgrading electricity metering at selected sites to enable retailers to offer innovative products (e.g. time of use tariffs) that could reduce electricity costs;
- Continue to replace conventional vehicles using either petrol or diesel with hybrid (e.g. electric/petrol), battery electric vehicles (BEV) and/or compressed natural gas (CNG) vehicles;
- Purchase of green energy offsets.

For the projects assessed, we have calculated the Abatement Cost Curve for a range of projects if the project results in a net reduction of emissions. This is shown in the following figure and indicates that a number of projects are financially viable and deliver substantial emission reductions for the City of Darwin. Many of these projects are not dependent on the introduction of a carbon price, except for the purchase of carbon offsets and accelerated HVAC replacement. In the latter case, it is only viable to replace existing HVAC systems at the end of their useful life.

City of Darwin's Emission Abatement Cost Curve ($000's per annum)



Energy Use and Emission Reduction Forecasts

We have estimated forecast energy use and emissions reductions assuming the following initiatives are implemented:

- Installation of a solar PV system at the Shoal Bay Waste Management Centre;
- Installation of rooftop solar at the Civic Centre;
- Put in place a power purchase agreement with a large-scale solar farm developer to help underwrite the project;
- Installation of energy efficient public lighting at end of life, except for Mercury Vapour lights which are replaced with LED lighting in accordance with the Minamata convention.
- Replacement of existing HVAC systems with more energy efficient systems (i.e. accelerated replacement);
- Replace conventional vehicles using either petrol or diesel with hybrid (electric) vehicles.

It should be noted that many of the initiatives are dependent on the deployment of solar PV systems. It is our understanding that the Power and Water Corporation (PWC) have received more than 100 proposals for large-scale solar systems to date. The deployment of solar systems will be dependent on meeting technical requirements for network connection as well as permitting these generation source to export surplus power to the wholesale electricity market, or permitting owners of these systems to net meter (further discussed in Section 7.1.1). However, given the NT government is committed to a 50 per cent renewable energy target by 2030 and the opening up of the competitive electricity market, reforms to permit the increased penetration of solar generation are likely.

Territory Generation has already indicated that it wants to develop future solar projects and would work with the City of Darwin to develop these projects.

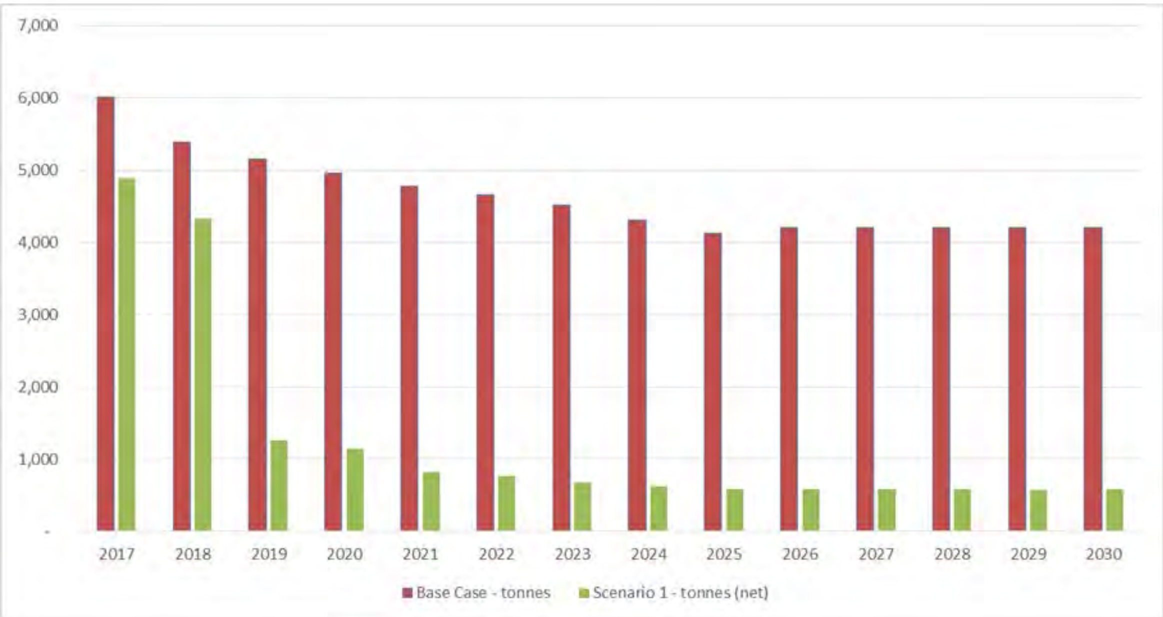
Shown below is total energy use if the initiatives are implemented. What this shows is that overall energy consumption is reduced by 30 per cent by 2030 when compared to the base case – emissions also reduce by 30 per cent over the study period.

Energy Use Forecasts – Alternative Scenario 1 (MWh per annum)

While energy consumption and the associated emissions have reduced, there is a further reduction in emissions because the City of Darwin is using renewable energy from solar PV to meet most of its power needs (and sell surplus power to others). Based on the solar Power Purchase Agreement (PPA) and on-site solar investment by the City of Darwin, solar PV is supplying the City of Darwin with over 6000 MWh per annum.

As a result, the net emissions for the City of Darwin (after taking into account the zero emissions from electricity generated from solar PV), are only 13.8 per cent of total emissions in the Base Case by 2030. Over the entire period, emissions avoided are around 47,000 tonnes.

Emission Levels (tonnes of $CO_2{}^{e}$) – Base Case and Scenario 1



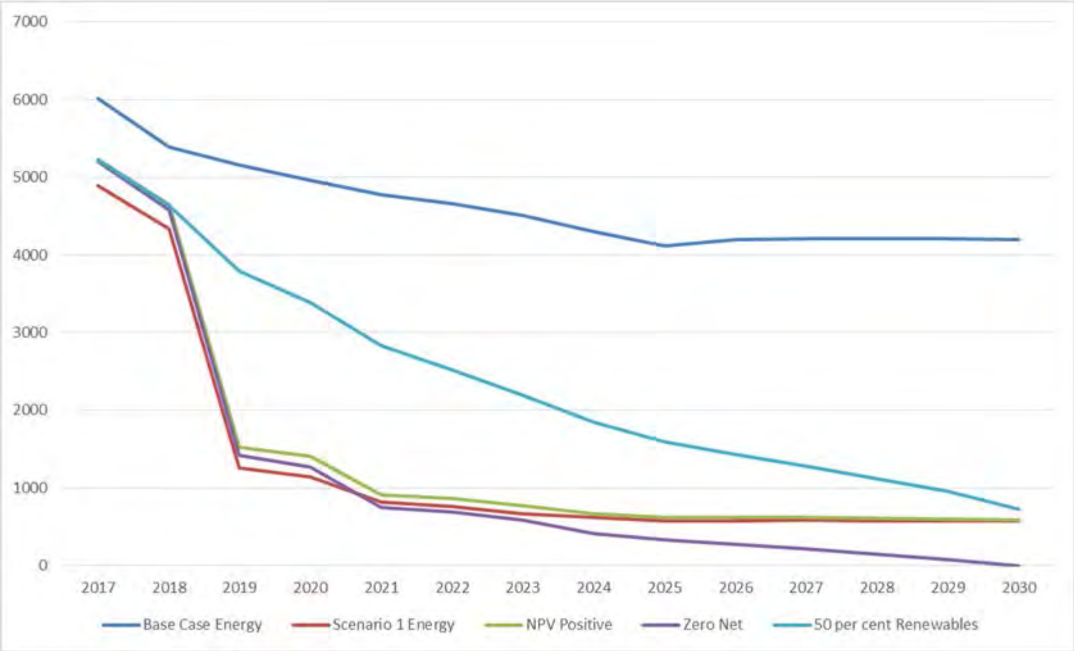
The capital investment required to achieve these reduction is $9.8 M by 2030.

Alternative Scenarios

Alternative Scenarios (and emission reduction targets) that have been considered in this study, after consultation with the City of Darwin, include the following:

- Zero emissions – implementing measures to ensure that the City of Darwin has zero (net) emissions by 2030.
- NPV Positive Projects Only – implementing measures that are economically viable.
- 50 per cent Renewables – achieving a 50 per cent renewable energy target by 2030.

Emission (tonnes) trajectories by Scenario



It should be noted that the level of emissions is broadly similar by 2030 (either 0 or < 1000 tonnes per annum). The reason for this is that in most instances it is economic for the City of Darwin to implement initiatives that reduce energy costs and emissions to these levels.

Implementation Plan

A range of targets have been outlined above. To a large extent the achievement of various energy use and emission reduction targets is highly dependent on installing solar installations at the Civic Centre and at the Shoal Bay Waste Management Facility, as well as purchasing energy from a large-scale solar farm (via a Power Purchase Agreement).

The deployment of solar systems will be dependent on meeting technical requirements for network connection as well as permitting these generation sources to export surplus power to the wholesale electricity market, or permitting owners of these systems to net meter (further discussed in Section 7.1.1).

However, given the NT government is committed to a 50 per cent renewable energy target by 2030 and the opening up of the competitive electricity market, Marsden Jacob is confident that reforms will be implemented to permit the increased penetration of solar generation.

A high level implementation plan for the major initiatives outlined in this paper are provided in section 7.2.

Glossary

Abbreviations

Abbreviation	Expanded name
ARENA	Australian Renewable Energy Agency
ASX	Australian Securities Exchange
BEV	Battery Electric Vehicle
CCA	Climate Change Authority
CCGT	Combined cycle gas turbine
CEFC	Clean Energy Finance Corporation
CEIF	Clean Energy Innovation Fund
COAG	Council of Australian Governments
COP21	2015 Paris 21st Conference of Parties
CNG	Compressed Natural Gas
CPI	Consumer Price Index
DKIS	Darwin-Katherine Interconnected System
DSM	Demand Side Management
EU	European Union
EV	Electric Vehicles
FiT	Feed-in-Tariff
FY	Financial Year
GHG	Greenhouse gas
GVM	Gross Vehicle Mass
HPS	High pressure sodium
HEV	Hybrid Electrical Vehicle
HV	High Voltage
HVAC	Heating, ventilation and air-conditioning
ICE	Internal Combustion Engine
I-NTEM	Interim Norther Territory Electricity Market
LCOE	Levelised cost of energy
LED	Light-emitting diode
LGCs	Large-scale Generation Certificates
LNG	Liquefied natural gas
LPS	Low pressure sodium
LRET	Large-scale Renewable Energy Target
MH	Metal-halide

Abbreviation	Expanded name
MJA	Marsden Jacob Associates
MV	Mercury vapour
NEGI	Northern Gas Pipeline
NTEM	Northern Territory Electricity Market (final market design)
PHEV	Plug-in Hybrid Electric Vehicle
PPA	Power purchasing agreement
PV	Photovoltaic
PWC	Power and Water Corporation (NT)
RCM	Reserve Capacity Mechanism
RECs	Renewable Energy Certificates
Rooftop PV	Rooftop Photovoltaic
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale Technology Certificate
SUV	Suburban Utility Vehicle
UPS	Uninterruptible power supply
WEM	Wholesale Electricity Market (WA)

Units of measure

Abbreviation	Unit of measure
bbl	barrel of oil
GJ	Gigajoule (1 billion joules)
GW	Gigawatt
GWh	Gigawatt hour
km	Kilometres
kVa	Kilovolt ampere (1,000 volt amps)
m^2	Square meters
MMBtu	One million British Thermal Units (~1.055 PJ)
mtpa	Million tonnes per annum
MW	Megawatt (1 million joules per second (electricity))
MWh	Megawatt hour (3,600 million joules)
PJ	Petajoule (1 million gigajoules)
TJ	Terajoule (1 thousand gigajoules)

1. Introduction

1.1 Background

The City of Darwin is a major user of electricity (spends $2 million annually on electricity) and is keen to develop strategies to reduce its overall energy bill and reduce its Greenhouse Gas footprint. The City of Darwin wants to develop an energy strategy to establish emission reduction targets for the period 2017-18 to 2029-30, prepare for the opening up of a competitive electricity market in the Territory, and develop fully costed options to reduce energy costs and reduce emissions.

Marsden Jacob and Entura were appointed to assist in the development of the Energy Strategy. The key tasks undertaken in the development of the Strategy include the following:

- Develop an understanding of the current energy investment framework in the Northern Territory. This includes understanding the implications of a diversified retail electricity market and renewable investment in the Territory on future energy use / emissions produced by the City of Darwin;
- Development of various emissions reduction targets for the City of Darwin;
- Identification of options to reduce energy use and greenhouse gas emissions and provide estimates of the costs of implementing those options (i.e. capital and operating);
- Develop an implementation plan to deliver cost, energy, greenhouse gas emissions reductions.

The energy strategy covers the following energy uses and technologies:

- Small scale solar power generation **-** for example continued rooftop solar installation, including covered car parks;
- Large scale solar options on City of Darwin land (including the Shoal Bay Waste Management Facility);
- Energy efficiency;
- Improved HVAC systems;
- Electricity storage including battery technologies;
- Demand management to deliver cost savings;
- Energy from waste through pyrolysis or other innovative technologies;
- Bio waste collection and methane generation;

The strategy outlines various financial options for funding the above mentioned projects.

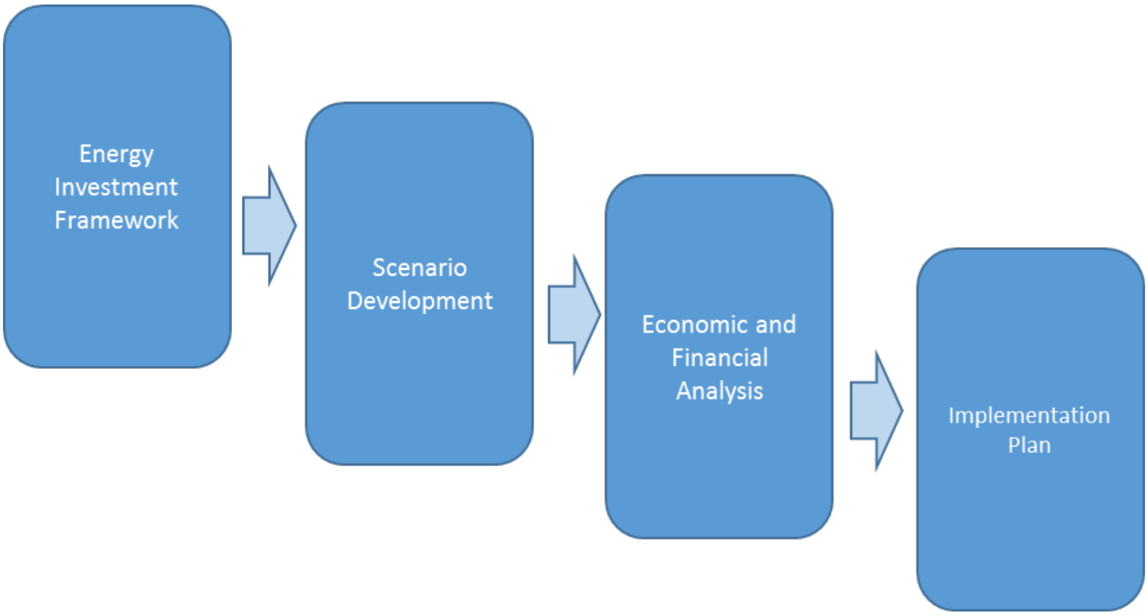
1.2 Methodology

Our approach to this study is summarised below (and in Figure 1):

- Develop a comprehensive understanding of the energy investment framework in the NT, including understanding international, national and local factors;
- Develop scenarios for the reductions in future energy use and GHG emissions;

- Estimate the levelised cost of generation electricity from various technologies ($/MWh) and the costs of abatement ($/tonne of CO_2^e GHG) for each technology option and initiative;
- Develop an implementation plan for various technologies and initiatives to deliver on the preferred energy use and GHG reduction scenario.

Figure 1: Methodology for Developing the Energy Strategy



1.3 Data sources and limitations

The primary data sources used to develop this energy strategy are outlined below. The accuracy of inventory and projections are therefore subject to the completeness and reliability of the data made available to the project team. An overview of the methodology to address any data gaps encountered by the project team is outlined below. Primary data sources provided through the City of Darwin and used to develop the initial base case include:

- City of Darwin's utility tracking database, Planet Footprint, which provides records of electricity consumption;
- vehicle inventory as of January 2017 and annual fuel usage reports for the period 1 July 2004 to 30 June 2016;
- population and household forecasts for City of Darwin;
- public lighting inventories provided by the City of Darwin.

The Planet Footprint database does not provide complete coverage of electricity consumption from council buildings. Specifically, some buildings do not have entries or have partial entries.

1.4 Dollars and Escalations

The basis of dollars presented in this report is as follows:

- All dollars are real 1 January 2017 Australian dollars unless otherwise specified.

2. Current energy use

2.1 Overview and trends

Energy consumption at City of Darwin sites and emissions come from four main sources:

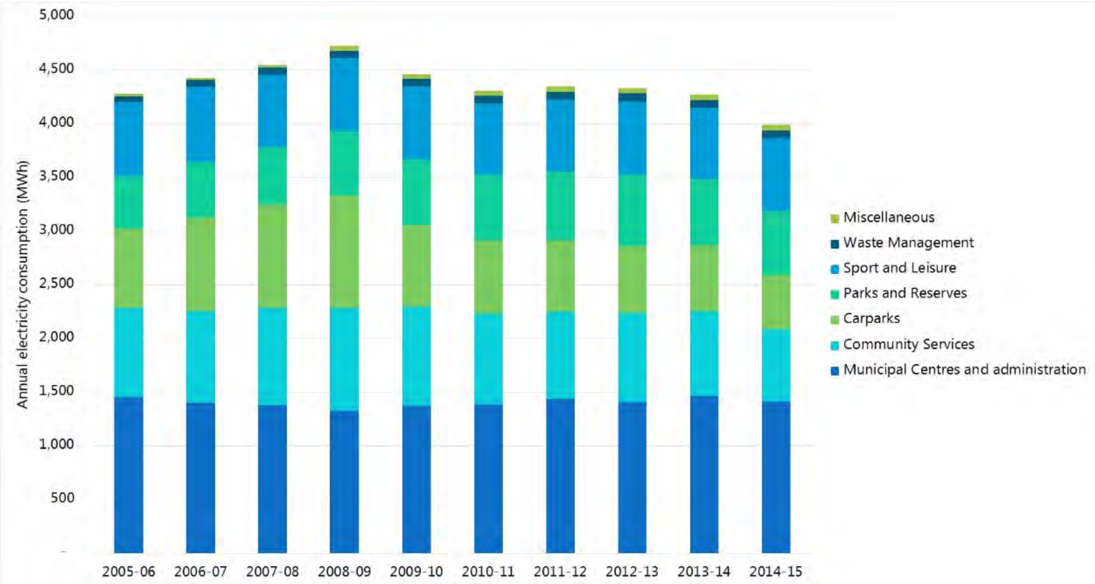
- Electricity consumption at building sand facilities, some consumption of which is offset by solar PV installations;
- Electricity consumption via unmetered public lighting sources (street lights and tariff lights);
- Fuel consumption by the Council's vehicle fleet; and
- Shoal Bay Waste Facility.

The detailed review of current energy use is address in the following sections.

2.2 Buildings and facilities

Figure 2 presents a summary of historical data on electricity consumption at City of Darwin sites and Table 1 (overleaf) provides data for the most recent five year period as well as the average annual growth rate for each category. Detail on the classifications for each sites are provided in Appendix A.

Figure 2: Historical electricity consumption at City of Darwin sites (by category)



Source: Marsden Jacob analysis of City of Darwin data

The Figure shows total electricity consumption has been steadily declining since 2008-09. This coincides with increasing availability of energy efficient technologies – such as energy efficient light globes– and reflects the City of Darwin's historical efforts to reduce electricity consumption and emissions.

Each category of building and facility is discussed in turn in the subsequent section. This information formed the background against which options for reducing City of Darwin's energy consumption and emissions were developed. Details for on-site solar PV and diesel back up generation are also included in subsequent sub-sections.

Table 1: Electricity usage at buildings & facilities (kWh)

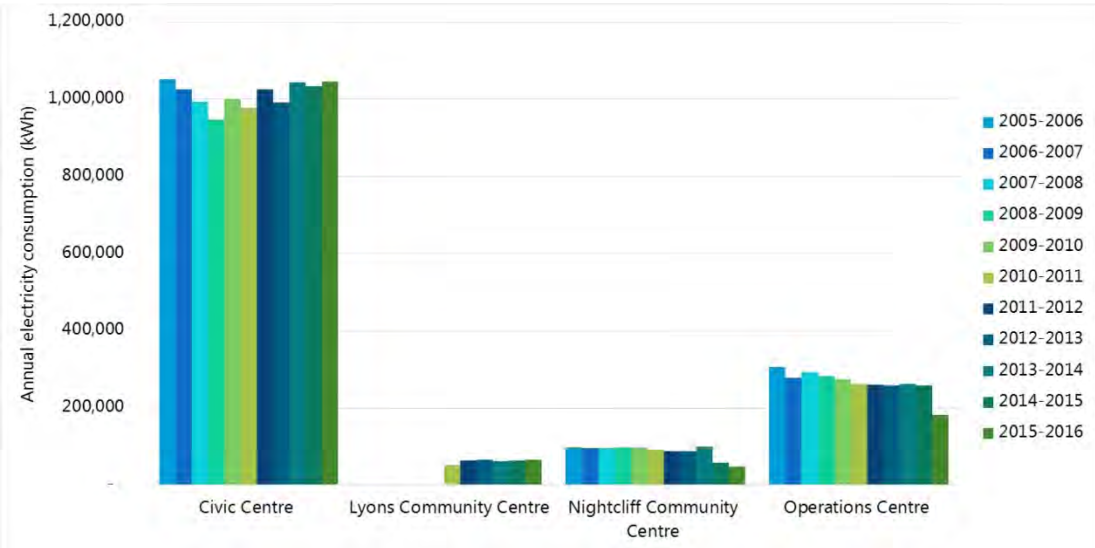
	2011-12	2012-13	2013-14	2014-15	2015-16
Municipal Centres and administration	1,437,631	1,404,898	1,467,392	1,413,611	1,343,187
Sport and Leisure	674,506	686,216	668,446	684,580	690,027
Community Services	813,677	834,334	786,645	668,887	588,363
Parks and Reserves	641,477	660,384	613,400	593,425	605,446
Carparks	658,993	621,922	614,011	505,788	493,450
Miscellaneous	50,304	51,154	53,904	56,246	58,658
Waste Management	68,140	72,662	67,636	66,840	120,084
Street lights (metered)	68,140	72,662	67,636	66,840	68,140
Total	4,437,658	4,426,387	4,362,318	4,078,905	3,988,174

Source: City of Darwin

2.2.1 Municipal centres and administration buildings

- Civic Centre
- Lyons Community Centre
- Nightcliff Community Centre
- Operations Centre

Figure 3: Electricity usage at municipal centres and administration buildings



Source: City of Darwin

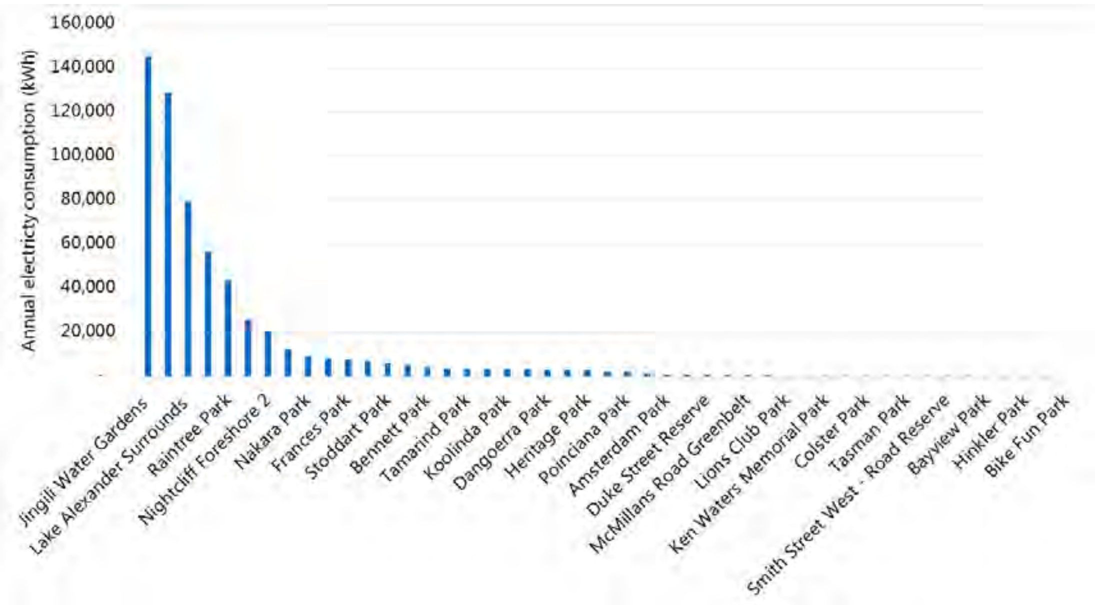
2.2.2 Parks and public facilities at parks

City of Darwin has extensive parks and gardens throughout the municipality, with 118 playgrounds, ranging from small parks to the all-inclusive Regional Playgrounds found at East Point Reserve, Anula Oval and Jingili Water Gardens.[1]

Available data indicated electricity consumption at 47 parks and reserves in 2015-16. The vast majority (80 per cent) of the parks consume only a small amount of electricity each year (less than 10,000 kWh per annum), however combined, the parks and reserve represent the fourth largest electricity consumption source in the Council.

In 2015-16, Jingli Water Gardens was the largest consumers of electricity (24.0 per cent of electricity for the parks and reserves category). Other locations with significant consumption in 2015-16 include: Mindil Beach Market Areas (21.3 per cent), Lake Alexander Surrounds (13.2 percent), Bicentennial Park (9.4 per cent) and Raintree Park (7.2 per cent).

Figure 4: Electricity use at parks and reserves (2015-16)



Source: City of Darwin

2.2.3 Sports and leisure centres

The City of Darwin's sport and recreation facilities includes seventeen ovals[2], including the premier Gardens Oval Complex, and three public swimming pools. Each type of facility is discussed in turn.

Sports ovals and sporting arenas

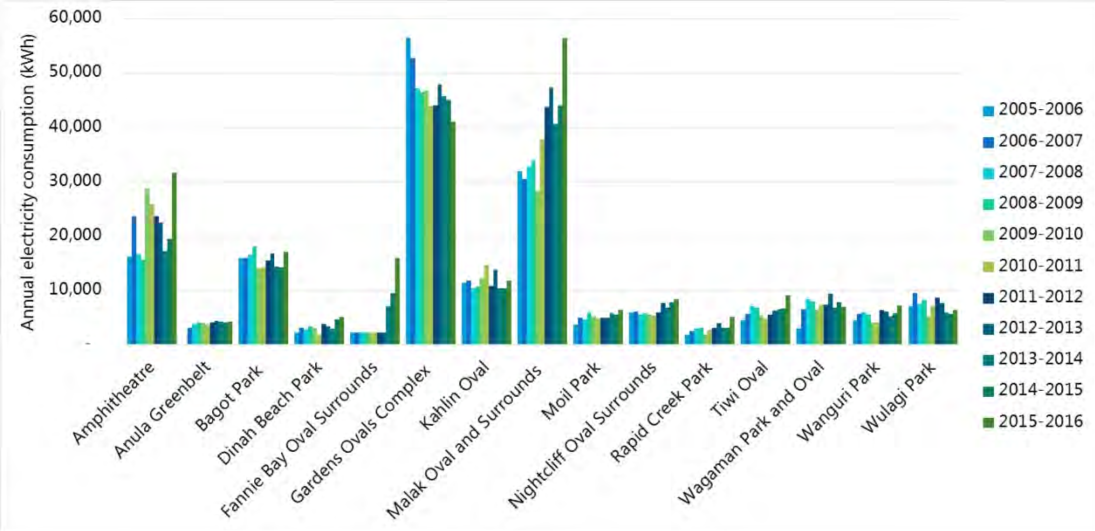
The City of Darwin's major sporting complex is the Gardens Oval Facility. The Garden's Oval Facility consists of and two large ovals (one with grandstands) as well as a clubhouse, offices and umpires rooms as well as onsite food and beverage facilities.

[1] City of Darwin, 'Recreation and Sport Facilities' webpage, accessed 27 Feb 2017. Refer to: http://www.darwin.nt.gov.au/live/your-community/recreation-and-sport/recreation-and-sport-facilities

[2] The electricity data for Garden Ovals Complex covers two ovals at this site.

The only other similar sized outdoor sporting venue is Malak Oval and Surrounds. New oval lights were installed at the oval and switched-on on 1 April 2015[3]. The lights allow for sports teams to train later in the evening and have resulted in an increase in electricity consumption at the site.

Figure 5: Electricity use at sports ovals



Source: City of Darwin

Swimming Pools

Each of the City's three public swimming pools cater to recreational and lap swimmers.

- The **Casuarina Pool** has an eight lane 50 meter main pool, a learn-to-swim pool and a toddler's pool.[4]
- The **Nightcliff Pool** has a six lane 50 meter main pool and a toddler's pool.[5] During 2015-2016 electricity consumption was increased due to the construction of the Nightcliff Café, which was drawing power from the Nightcliff Pool, this site is now separately metered.
- The **Parap Pool** has been closed since September 2016 whilst undergoing a major redevelopment. Construction is scheduled to be completed by December 2017 with the new site opening shortly afterwards. The newly developed site will be much larger – including both a 50 meter competition pool and a 25 meter program pool, a lagoon pool and wet play areas as well as additional office and sporting club spaces. The installation of solar PV at the site has been included in the development plans (and base case forecast).

The opening hours have been extended at both the Casuarina and Nightcliff pools whilst construction is ongoing at the Parap Pool, however the extended trading hours are not expected to make a significant different to the electricity consumed.

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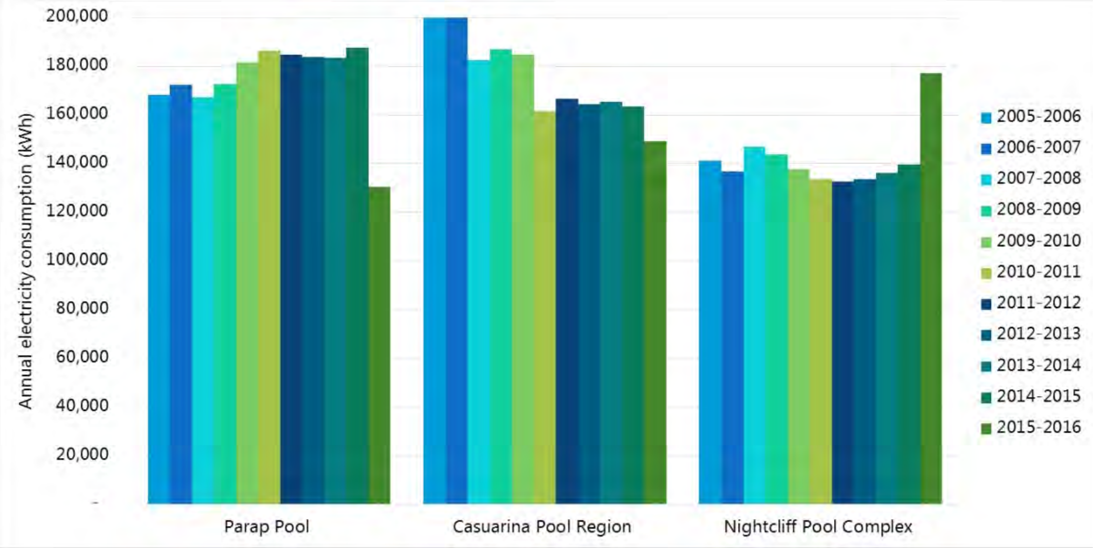
3 City of Darwin, 'Lighting Up Malak Oval' webpage, accessed 27 Feb 2017. Refer to: http://www.darwin.nt.gov.au/media-centre/news/lighting-malak-oval

4 http://www.darwin.nt.gov.au/live/your-community/recreation-and-sport/recreation-and-sport-facilities/public-swimming-pools/casua

5 http://www.darwin.nt.gov.au/live/your-community/recreation-and-sport/recreation-and-sport-facilities/public-swimming-pools/night

Figure 6: Electricity usage at swimming pools



Source: City of Darwin

2.2.4 Community service centres

The City of Darwin has four public libraries: Casuarina (Bradshaw Terrace), Darwin City (Civic Centre), Nightcliff (Pavonia Place) and Karama (Karama Shopping Centre).

Electricity consumption for the Darwin City library is captured in the data for the Civic Centre.

Casuarina is the largest of the City's libraries by electricity consumption (Figure 7). In May 2014, a 99.84 kW solar PV was installed at site and this has resulted in over 100,000 kWh reduction in electricity consumption per year (based on 2014-15 and 2015-16 results).

Despite the gains made through the installation of PV, consumption at Casuarina remains relatively high compared to other community service centres. Marsden Jacob understands the large consumption at Casuarina Library is partly due to the type of air conditioning system installed – the system restarts on a regular basis as the temperature drops which requires more electricity than comparative systems that remain on continuously. . The system was installed in 2008 when the library was last refurbished.[6]

Both the Karama and Nightcliff libraries have been refurbished in recent years. The Karama Library was refurbished in 2011 and the Nightcliff Library was refurbished in 2013[7].

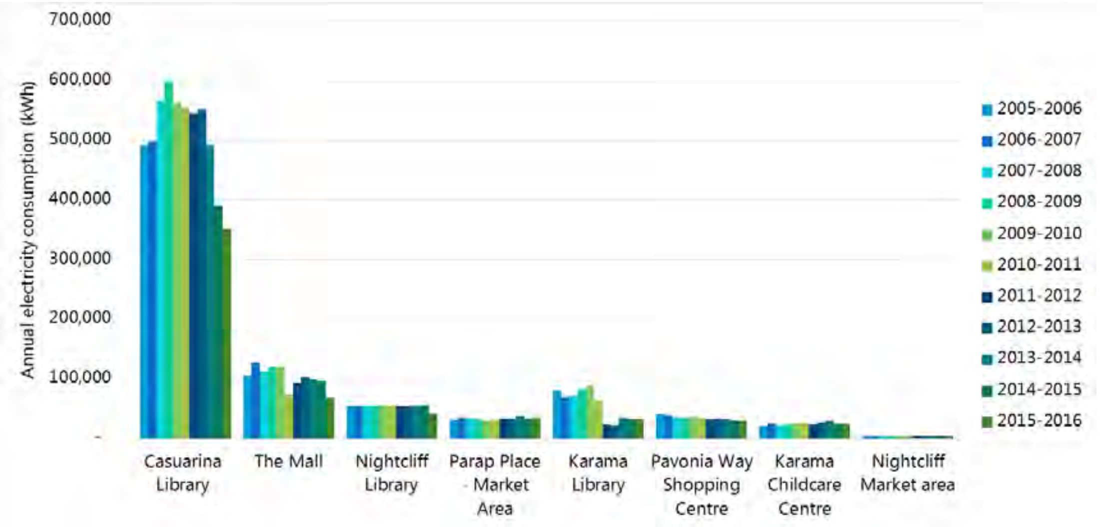
The Karama Childcare Centre and the Parap Place Market Area electricity consumption is also presented in Figure 7 with the community service centres. Each of these sites use relatively small quantities of electricity.

The City of Darwin sponsors seven Child Care Centres in the provision and maintenance of the building[8], however they are only responsible for the electricity consumption at Karama Childcare Centre (also referred to as the Top End Early Learning Centre).

6 City of Darwin, 'Libraries History' webpage, accessed 25 Feb 2017. Refer to: http://www.darwin.nt.gov.au/libraries/about-us/history

7 City of Darwin, 'Libraries History' webpage, accessed 25 Feb 2017. Refer to: http://www.darwin.nt.gov.au/libraries/about-us/history

Figure 7: Electricity use at community service centres



Source: City of Darwin

Electricity consumption at Pavonia Way is also included in Figure 7 (above). Electricity consumption at this site been reducing steadily overtime. The Nightcliff Market operates from this site and while 85 per cent of charges associated with the running of the markets are recouped from the Nightcliff Market Associates, Marden Jacob understands the energy consumption is included within Pavonia Way in the City of Darwin's database.

2.2.5 Car parks

Only a small number of the City's carparks are individually metered for electricity consumption[9]. Data was available for electricity consumption at four sites:

- Car Park - 54 & 60 Cavenagh Street
- Marina Boulevard Carpark
- West Lane Carpark – a multi-storey 6 level car park
- China Town Carpark – a multi-storey 8 level car park

Electricity consumption is highest in the larger multi-storey West Lane and China Town carparks (Figure 8). Electricity consumption at West Lane Car Park includes energy used at 11 tenancies located in the ground floor of this site as well as a small City of Darwin office. The City of Darwin includes an allowance for electricity costs in the lease agreements for these tenancies.

Energy efficiency measures including sensor lights and ongoing replacement to LED luminaires have been put in place at the West Lane site resulting in reducing consumption in recent years and it is anticipated the energy consumption at this site will level out going forwards.

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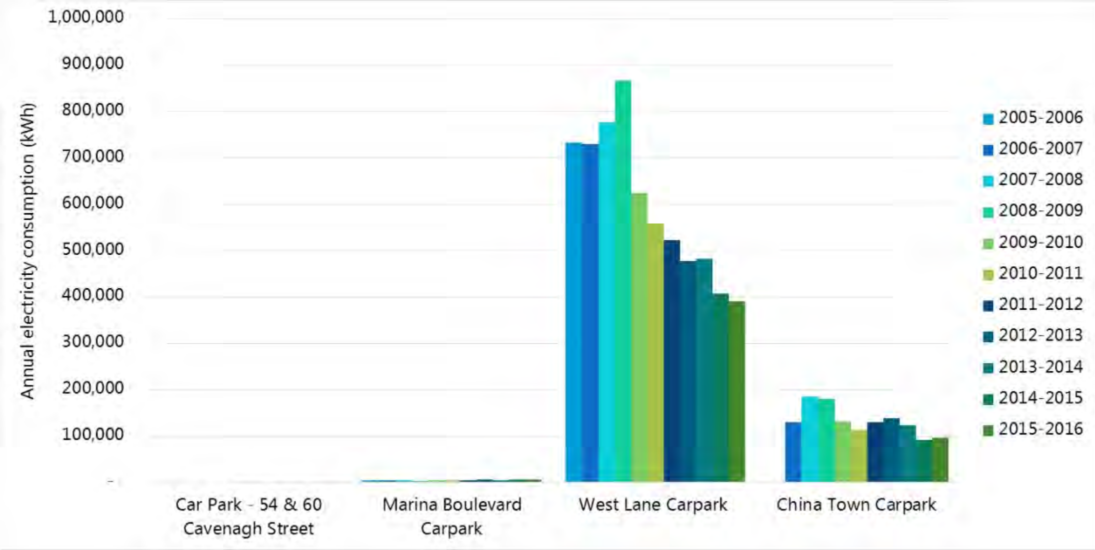
8 City of Darwin, 'Child Care Centres' webpage, accessed 25 Feb 2017. Refer to: http://www.darwin.nt.gov.au/live/your-community/services-children/child-care-centres

9 City of Darwin, 'Car Parks and Parking Zones' webpage, accessed 27 Feb 2017. Refer to: http://www.darwin.nt.gov.au/live/parking-traffic-and-transport/car-parks-and-parking-zones

Figure 8: Electricity use at Council owned car parks



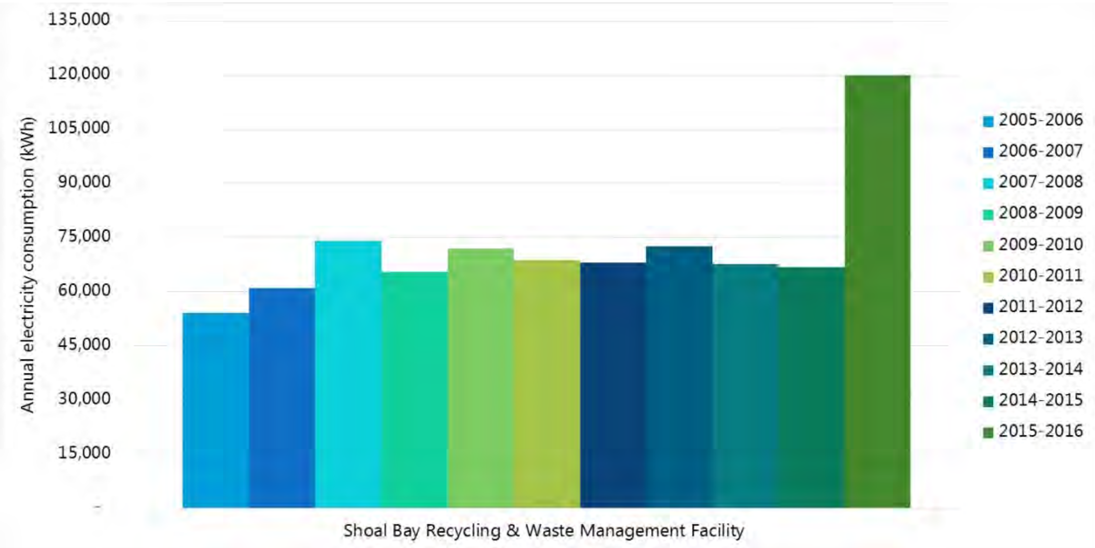
Source: City of Darwin

2.2.6 Waste management facilities

Electricity consumption at the Shoal Bay Recycling & Waste Management Facility has increased approximately doubled in 2015-16 compared to previous years (see Figure 9 below). The increase coincides with the installation of two 37 kW air compressors that power the pneumatic leachate pump system.

The higher level of electricity consumption is expected to represent the new norm going forwards in the absence of any further intervention.

Figure 9: Electricity usage at Shoal Bay Recycling & Waste Management Facility

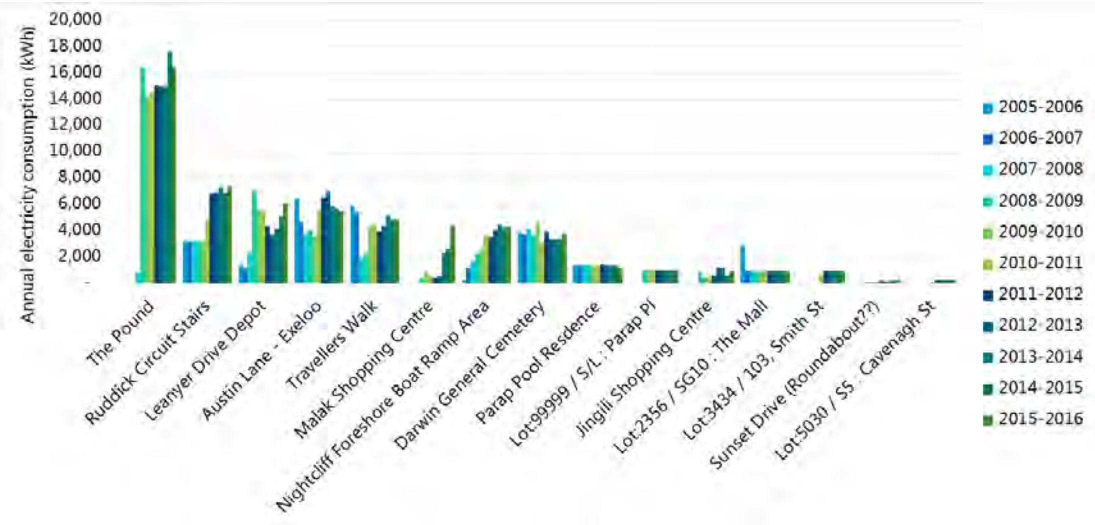


Source: City of Darwin

2.2.7 Miscellaneous

Data for a number of miscellaneous sites was included in the database. Figure 10 summarises the electricity usage at these sites. With the exception of the pound, most miscellaneous electricity consumption sites are pedestrian or walkway lighting.

Figure 10: Electricity usage at miscellaneous sites

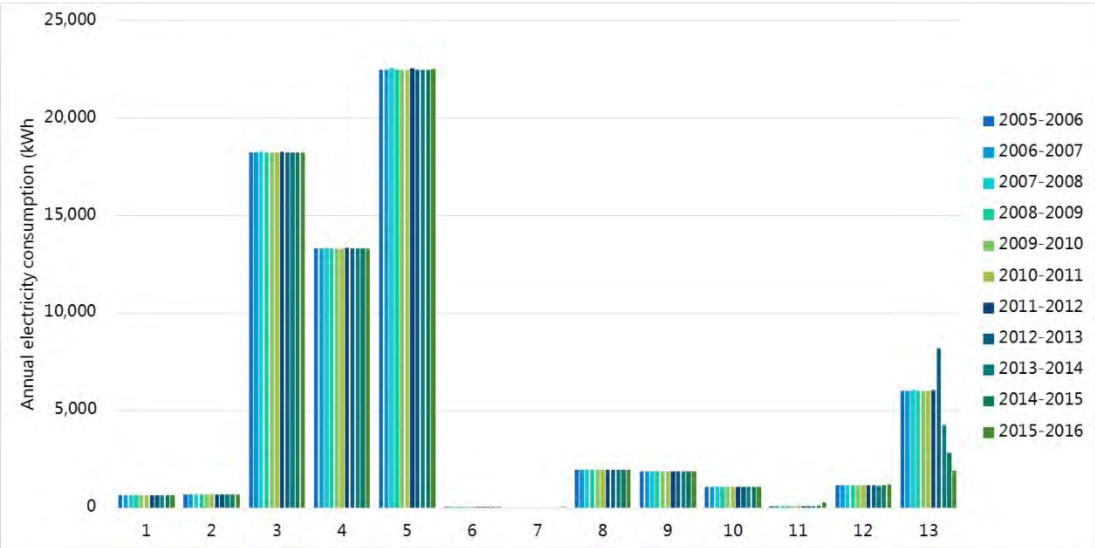


Source: City of Darwin

2.2.8 Street lights – metered

Within the City of Darwin database, thirteen metered streetlights are included. Electricity consumed at each of these sites appear consistent with the regular pattern of consumption expected from street lights.

Figure 11: Electricity usage from metered street lights



Source: City of Darwin

2.3 On-site solar PVs

Solar PVs have been installed at a number of City of Darwin's facilities (Table 2). Estimates of energy use at sites where PV has been installed have been taken into consideration. In most cases, presentation of electricity consumption at the site is presented net of solar unless otherwise specified.

Table 2: Solar PV installed at City of Darwin site

Facility name	Capacity	Installation date	Area	Metering
Casuarina Library	99.84 kW	12 May 2014	Unknown	Unknown
Operations Centre	Up to 99.6 kW	2015	Unknown	Unknown
Casuarina Pool	58 kW	27 July 2016	460 m2	Time of use (Jacana)
Nightcliff Pool	58 kW	27 July 2016	450 m2	Time of use (Jacana)
Nightcliff Café*	8 kW	Unknown	54 m2	Unknown
Bishop Street	Unknown	October 2015	Unknown	Unknown
Parap Pool	TBC	TBC	TBC	TBC

**Lessee pays capital and ongoing maintenance costs*

Shading denotes commissioned projects with future installation dates.

2.4 On-site backup generation

Back up generation is installed at a number of City of Darwin's facilities (Table 3). This information has been provided for completeness, however insufficient data is available to estimate the annual consumption of diesel fuel and emissions from use of back-up generation for this report.

Table 3: Back up generation

Facility name	Specifications	Installation date
Civic Centre (all services backup)	500 kVa	Late 2015 or early 2016
Civic Centre (essential services backup)	110 kVa, 60kVa UPS	December 2012
Operations Centre	250 kVa, 30 kVa UPS	2014
Operations Centre (spare backup)	65 kVa	Currently not in use
Shoal Bay Weighbridge Office	20 kVa, 2x1.5 kVa UPS	Unknown

2.5 Public lighting

The City of Darwin has two types of public lighting assets.

- **Street lights** are automatically switched on at dusk and their contribution the network peak is therefore small in the wet seasons/ summer, but more significant in inland areas during winter
- **Traffic lights** have an essentially constant demand profile throughout the year – most are 24 hour - and therefore make a much greater relative contribution to electricity demand than street lights on a unit light basis (not in aggregate).

From 2014/15, unmetered street lighting tariffs have been distinguished from 24 hour lights such as tariff lights. Over the period of several years, the price differential between the two will be increased until both tariffs become cost reflective.[10]

Street lights – current assets

There are currently 8,691 street lights installed in the City of Darwin, representing close to 40 per cent of the streetlights maintained by Power and Water Corporation in the NT.[11] Over half of the council's street lights are mercury vapour (MV) (55.3 per cent) and an additional third are high pressure sodium (HPS) (34.5 per cent). The remaining are of an unknown technology, LED, florescent (FLU), metal-halide (MH), or low pressure sodium (LPS) (Figure 12, below).

Assuming streetlights are scheduled to turn on at sunset and off at sunrise each day and the DK Emissions Intensity is 0.56 (as per the National Greenhouse Reporting Accounts), the estimated electricity usage from streetlights is 4,607 MWh and account for approximately 2,580 tonnes of CO2 emissions (Table 11).

Power and Water Corporation currently maintains and operates street lighting services on behalf of the City of Darwin while the council undertakes upgrades of the lights. An in principle agreement has been reached that from 1 January 2018 the Council will accept street light ownership[12]. Once the City takes over responsibility, more information on the current age and status of the lighting assets will be known. This information will enable change overs to be optimised with consideration to current maintenance and upgrade schedules.

Marsden Jacob understand that for the purposes of this energy strategy, the ownership agreement is unlikely to impact the responsibility for electricity charges and the upgrade of streetlights with the exception of lights that are affixed to PWC power poles.

In 2012, the council partnered with Power and Water Corporation to undertake a joint trail of 26 LED streetlights over a twelve month period[13].

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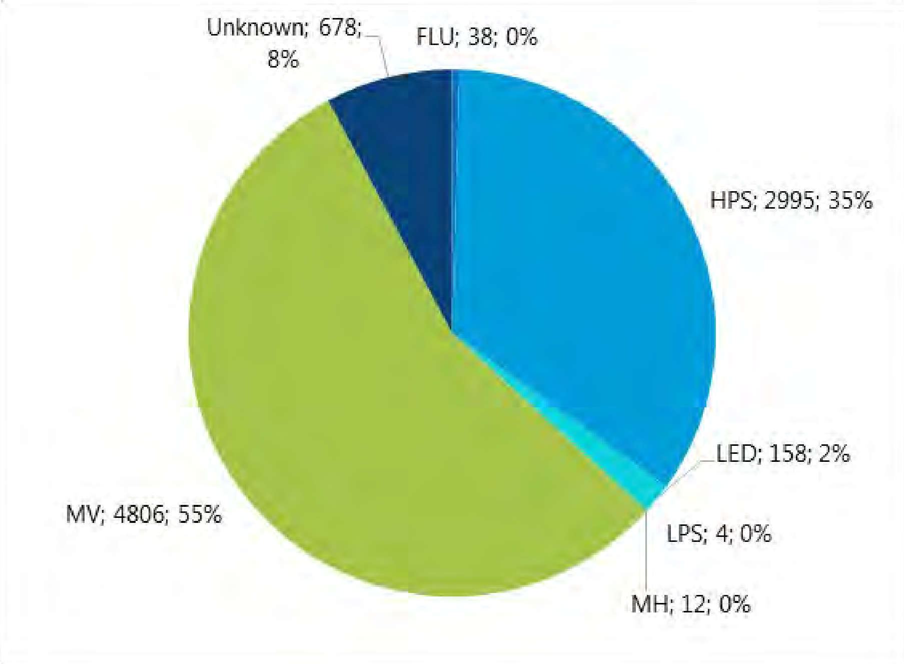
10 PowerWater, *Appendix A – Network Pricing Principles Statement and 2015-16 Network Pricing Proposal*, May 2015, page 22. Available at: http://www.utilicom.nt.gov.au/PMS/Publications/UC-PWC-NPPS-1516.pdf

11 Power and Water Corporation is contracted to maintain about 2,000 street lights in the NT, including the City of Darwin's street lights. Refer to: https://www.powerwater.com.au/customers/faqs2/streetlight_maintenance

12 *Street Lights – Power and Water Corporation – Deed of Agreement*, 1st Ordinary Council Meeting Agenda Item C28.2.1., 14 June 2016. Available at: http://www.darwin.nt.gov.au/sites/default/files/C28.2.1%20-%20STREET%20LIGHTS%20-%20POWER%20AND%20WATER%20CORPORATION%20-%20DEED%20OF%20AGREEMENT.pdf

13 Power and Water Corporation, 'LED streetlights on trial', Media Release dated 18 September 2012, accessed 16 February 2017. Available at: http://www.powerwater.com.au/news_and_publications/news/2012/led_streetlights_on_trial

Figure 12: Streetlights by type



Source: Marsden Jacob analysis of City of Darwin data

Historical data on changes in the number and type of streetlights installed within the City of Darwin is not currently available. However, evidence from other local council's suggests population growth within LGA's is the main driver for growth in public lighting stock and therefore energy use and emissions.[14]

Population growth in the City of Darwin, like that for the Northern Territory, fluctuates more highly than the population for Australia.

Figure 13: Historical population growth rates for City of Darwin, Norther Territory and Australia

Source: ABS, Cat. 3218.0: Regional Population Growth, Australia, released 30 March 2016

[14] For example City of Casey.

Figure 13 also shows the population growth of the City of Darwin tracks closely to the Northern Territory. The growth over the most recent five year period to 2015 was slightly higher than the average for NT (1.26 per cent compared to 1.24 per cent) and slightly lower than the average for NT over the most recent ten year period (1.63 per cent compared to 1.73 per cent).

Historical data on the number of residential dwellings in the Northern Territory is available on a quarterly basis. The quarter on quarter change in number of residential dwellings is shown in Figure 14. Given the correlation in population growth between the Northern Territory and the City of Darwin, it is likely that the number of dwellings in City of Darwin would have followed a similar growth pattern.

Figure 14: Quarter on quarter change in the number of residential dwellings, Northern Territory

Source: ABS, Cat. 6416.0 Residential Property Price Indexes: Eight Capital Cities, released 13 December 2016

Street lights – forecast energy use and emissions

Public lighting energy use and emissions are expected to continue to grow over the 5 year period but at a lower rate than historically (Table 4). The mean reasons for this are:

- a slowdown in population growth to about 1.8 per cent per annum in the next 5 years to 2021, compared to an annual growth rate of about 1.3 per cent from 2010 to 2015[15] resulting in a lower growth in dwellings;
- installation of energy efficient public lighting in all new developments (e.g. T5 2x14W, CFL 32W or CFL42W); and
- replacement of the existing MV stock with energy efficient options (i.e. LED) by 2020 assuming Australia ratifies the Minamata Convention on Mercury and therefore these type of lighting will no longer be able to be imported after 2020.

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15 ABS, *Cat. 3218.0: Regional Population Growth, Australia*, Table 7 Estimated Residential Population, Local Government Areas, Northern Territory, released 30 March 2016, accessed 24 Feb 2017.

Department of Treasury and Finance, *Northern Territory Population Projections (2014 Release)*. NTPOP Summary Main Update (2014) (xlsx), accessed 24 Feb 2017. Available at: http://www.treasury.nt.gov.au/Economy/populationprojections/Pages/default.aspx

Major drivers for growth in the number of public lighting assets and, as such, the emissions from public lighting, are population growth and resulting growth in dwelling numbers. Greenfield developments in particular require the installation of new public lighting assets. Therefore, the number of public lighting assets is assumed to increase in line with the growth in private dwellings; that is, the ratio of public lighting assets to private dwellings has been held constant for the five year period.

Traffic lights

City of Darwin owns and maintains a small number of traffic lights. All City of Darwin owned traffic lights are LEDs, with the exception of two 400 watt flood lights and associated 100 watt controllers installed at Cavenagh Pelican Xing (near L0032) and Progress Dr Zebra Xing (N-Cliff Mall).

Table 4 shows the breakdown of traffic lights by type, the total installed wattage and annual consumption based on utilisation rates.

Table 4: LED traffic lights owned by City of Darwin

Traffic light aspect	Number	Total installed wattage
3X300	12	132
3X200	189	1134
4X200	26	187.2
5X200	4	28.8
PED ASPECTS	140	840
2X200 (warning signs)	2	12
Flood lights (400W)	4	1,000
Total		**9,094**

2.6 Vehicle fleet

2.6.1 Current Transport Fleet and Usage

The City of Darwin had 140 vehicles in 2016. Most of vehicles are cars or light commercial vehicles that have Internal Combustion Engines (ICE) that use diesel or petrol. There are also 35 ICE Trucks that use diesel. The City of Darwin has also started to utilise hybrid light vehicles (both electric/petrol and electric/diesel) and hybrid trucks (electric diesel) (Table 5).

Based on distance data provided by the City of Darwin for each vehicle, Marsden have estimated the amount of petrol and diesel used on an annual basis (also shown in Table 5).

Table 5: City of Darwin Vehicle Fleet, fuel type and estimated fuel usage 2016

Vehicle Type	No. of Vehicles	Primary Fuel	Litres
Hybrid Light Vehicle	6	Unleaded	490
ICE Light Vehicle	83	Diesel	1,136
Truck - Hybrid	16	Diesel	2,246
ICE Truck	35	Diesel	2,706

Total	140		6,578

Using the mileage data for each vehicle type, the energy content and the emission intensity factor for each vehicle type, we have calculated the total emissions for the City of Darwin with the current fleet (Table 6). It is estimated to be 619 tonnes of CO_2^e in 2017.

Table 6: Energy Content and Emission Intensity of Vehicle Fuels

Fuel Type	Energy Content (GJ/kL)	Emission Intensity Factor (kg CO2e) per GJ
Unleaded Petrol	34.2	67.4
Diesel	38.6	69.9
Electricity	NA	51.4
Compressed Natural Gas	6.04	51.4

3. Energy Investment Framework in the NT

3.1 Introduction

The energy investment framework in the Territory is driven by international, national and jurisdictional policy settings and growth, market developments and technology changes.

The Chapter presents findings from our review of the investment framework and provides an analysis of the likely financial incentives for investment in new technologies, approaches and energy efficiency.

Each of the drivers for change to the energy investment framework is discussed in turn below.

3.2 International Factors

3.2.1 Oil and Gas Prices

The Territory has a high dependence on both natural gas and distillate for power generation. Natural gas prices are indirectly linked to international oil prices as producers can choose to export natural gas as LNG or supply into the domestic gas market. The link is direct between distillate and global oil prices.

Developing forecasts of both oil prices (Singapore Crude Oil) and natural gas is an important input to understanding the likely future price path of wholesale and retail electricity prices in the Territory, which, in turn, are also crucial in determining the financial return from energy-related investments (e.g. rooftop PV).

In the longer term, gas prices will usually reflect the opportunity cost of domestic gas. The opportunity cost of domestic gas being the achievable export price (given that gas can be exported offshore as LNG into Asia (e.g. Japan, China etc.). Data on future contracted gas prices is readily available for the Association of South East Asian Nations (ASEAN) region[16], and can be assumed to be reflective of international netback gas prices[17] going forwards.

In the ASEAN market, gas prices are oil linked through a formula (s curve):

Gas price = slope × oil price (USD/MMBtu) + constant.[18]

Where:

MMBTU is one million British Thermal Units (~1.055 PJ)

The domestic gas price is determined using the expected future coefficients in the above equation.

The domestic netback price is based on a financial equivalence of selling gas via export to selling gas domestically at specified locations. The short run netback price excludes sunk

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16 The Association of South East Asian Nations (ASEAN) was founded in 1967 and currently encompasses Burnei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

17 Netback gas price simply means the gross profit per unit price.

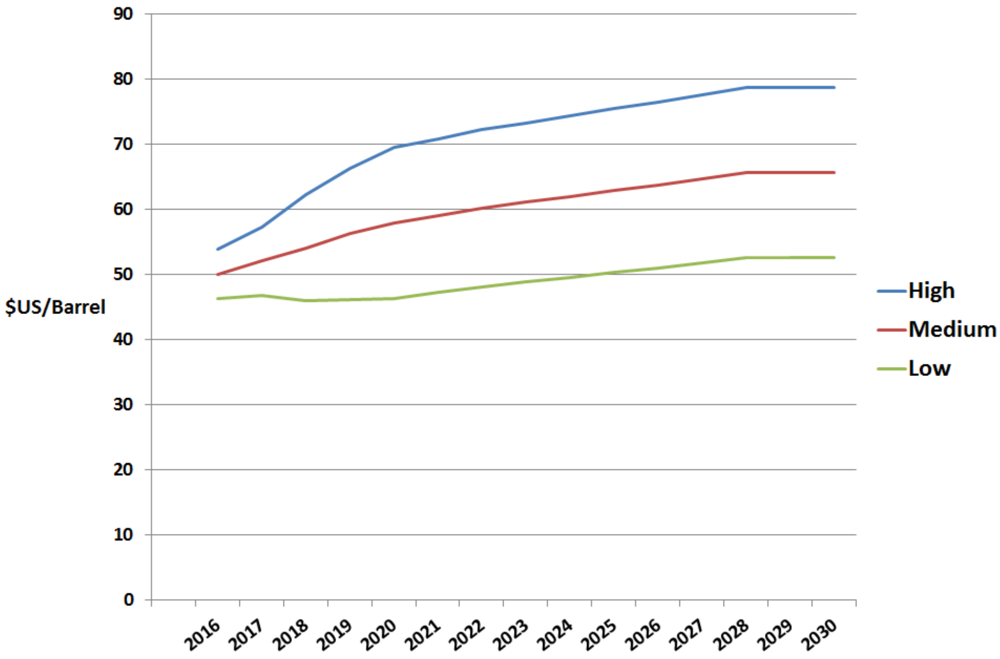
18 In our model, the slope = 0.13 and the constant = 0.

capital costs in the netback calculation. This is the accepted approach on the East Coast where LNG capital costs are also sunk.

The NT gas market will be connected to the East Coast Gas Market via the Northern Gas Pipeline from late 2018 (referred to as the NEGI pipeline). As a result, it is likely that domestic gas pricing in the Territory will begin to follow East Coast gas price trends (i.e. short run netback only) more closely.

Marsden Jacob has developed long run oil prices in order to calculate netback gas prices in recent assignments in both the National Electricity Market (NEM) and the Western Australian Electricity Market (WEM). In developing our forecasts we have used information from such sources as the IEA[19]. Marsden Jacob's oil price forecasts are provided below by scenario.

Figure 15: Oil Price Scenarios (USD/barrel 2016 dollars)



Source: MJA estimates

Using these oil prices, Marsden Jacob will develop forecasts of future gas domestic gas prices, which will then determine the future level of wholesale and retail electricity prices in the Darwin-Katherine (DK) Electricity System.

3.2.2 Emissions reduction and trading scheme (with international linkages)

Australia is a signatory to the Paris Climate Change Agreement which requires that Australia achieves a reduction in emissions by 26 to 28 per cent compared to 2005 levels by 2030. The current mechanism to achieve this target is the Conservative Government's "direct action" program which is insufficient to the meet the Paris target.[20]

19 International Energy Agency, *World Energy Outlook*, 2015.

20 https://www.theguardian.com/environment/2015/oct/01/emissions-target-will-require-major-changes-to-direct-action-say-experts

In order to achieve the target reduction in emissions, most experts assume that Australia will have to introduce an emission pricing mechanism, which prices carbon emissions explicitly.

The Climate Change Authority (CCA) and supporting reports[21] published in 2016 recommended the introduction of a baseline and trade system for the electricity sector and developed emission price trajectories for limiting temperature rises to 2 and 3 degree Celsius. Some of the analysis provided by the CCA is outlined in Box 1 below.

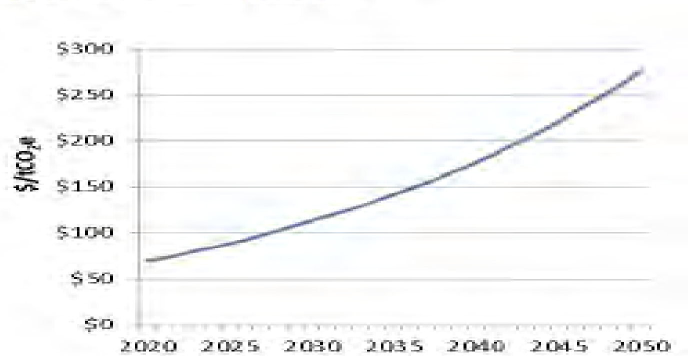
It should be noted that the electricity sector offers cost of abatement lower than most other sectors, which implies that efficient abatement mechanism would have the electricity sector undertaking abatement at least in proportion to its level of emissions.

Modelling undertaken by Jacob's for the 2016 CCA review used a scheduled electricity demand outlook that is significantly higher than the most recent AEMO projections in 2016. This would result in a higher carbon price than under a lower demand growth outlook.

BOX 1: Extracts from the CCA and Jacob's Modelling Reports 2016 [real prices]

R2	An emissions intensity scheme should be implemented in the electricity generation sector because, as a market mechanism, it will allow Australia to meet its emissions reduction goals and decarbonise the electricity sector at lower cost than would be possible otherwise.
C8	An emissions intensity scheme would increase electricity prices less than a cap and trade scheme. It could achieve significant emissions reductions and be scaled up to deliver further emissions reductions over time.
R3	An emissions intensity scheme covering the electricity generation sector should be introduced in 2018. The emissions intensity baseline for electricity should decline linearly over time and reach zero well before 2050, consistent with Australia's Paris Agreement obligations.

Figure 31: 2°C carbon price path

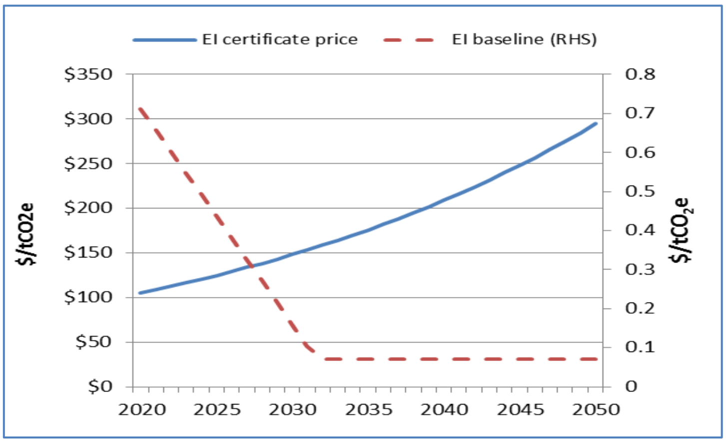
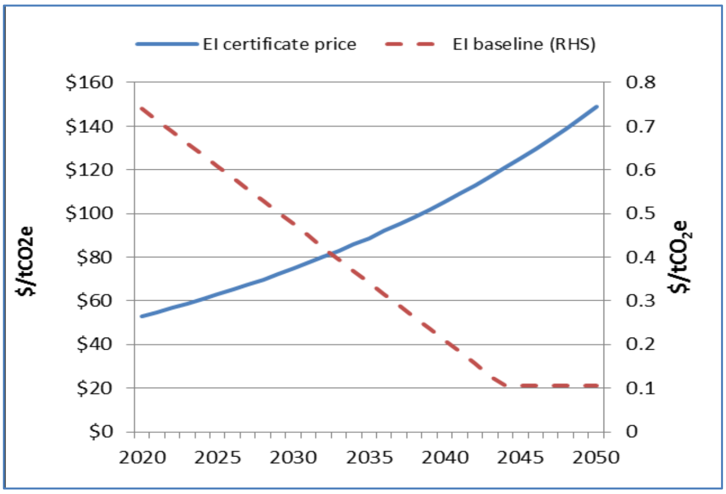


Carbon Price

The carbon price is calculated from median estimates consistent with a likely (67 per cent) chance of limiting warming to 2°C from the Intergovernmental Panel on Climate Change's Fifth Assessment Report

21 Climate Change Authority, *Towards a Climate Policy Toolkit*, Special Review on the Australian Climate Goals and Policies, 2016

Jacobs, *Modelling illustrative electricity sector emissions reduction policies for the Climate Change Authority*, Final Report, 25 August 2016

	**Emission intensity permit price and baseline, 2°C emissions constraint** The permit price is higher than the carbon price path. The emission intensity baseline commences from the emission intensity of the reference case in 2019/20, declines linearly and levels out in 2032.
	**Emission intensity permit price and baseline, 3°C emissions constraint** The emission intensity baseline commences from the emission intensity of the 3°C reference case in 2019/20, declines linearly and levels out at the average emission intensity of the grid from 2045 to 2050.

Each of these scenarios has carbon prices, at a minimum, exceeding $45/tonne commencing 2020, with prices rising to almost $80/tonne in the lowest case (3°C case) by 2030. Given the abandonment of the Carbon Tax in Australia in 2014, these prices are significantly above what is likely to be politically acceptable in Australia, especially given that current prices in the European Union (EU) are 4.5 EUR per tonne (or $6.5 AUD per tonne).

In our analysis it has been assumed that an emission trading system is introduced on 1 July 2020 and that prices commence at $20/tonne (nominal) and escalate at 5.5 per cent per annum. It should be made clear that this level of carbon pricing is unlikely to achieve the Paris Climate Agreement Targets, or may achieve the target, but that the scheme permits companies to purchase much of their requirements (i.e. carbon credits) from cheaper sources overseas.

The introduction of a carbon price in 2020 would have the effect of increasing wholesale electricity prices and improve the economics of renewable energy and energy efficiency.

3.3 National policy settings and Instruments

National policy settings that are driving investment in renewable energy technologies and energy efficiency investments include:

- the Large-Scale Renewable Energy Target (LRET);
- the Small-Scale Renewable Energy Scheme (SRES);
- Clean Energy Finance Corporation funding opportunities; and
- ARENA funding opportunities.

These national drivers and their implications for the Territory are discussed in turn.

3.3.1 Large-Scale Renewable Energy Target (LRET)

(a) Scheme Design and Framework

The LRET operates to have large renewable generators create Large-scale Generation Certificates (LGC's) and to require wholesale energy purchasers (mostly retailers) to purchase and surrender sufficient certificates to meet their annual target level of LGC's for that calendar year. This target is increased each calendar year and will reach 33,000 GWh in 2020 under the current scheme. Individual obligations are determined by prorating in proportion to energy purchase levels and the scheme currently allows certificates to be banked.

If a wholesale energy purchaser does not buy enough LGC's then that entity pays a penalty for each LGC that should have been purchased. The penalty per LGC is called the Shortfall Penalty Price, and is set at $65 per LGC, non-tax-deducible and constant in nominal terms over the life of the scheme.

If not enough renewable generation is developed and there are not enough LGC's, then the LGC price would be expected to be at the Shortfall Penalty Price (currently ~$92.80/MWh). However if there were more LGCs than required, the LGC price would be expected to be less than the Shortfall Penalty Price.

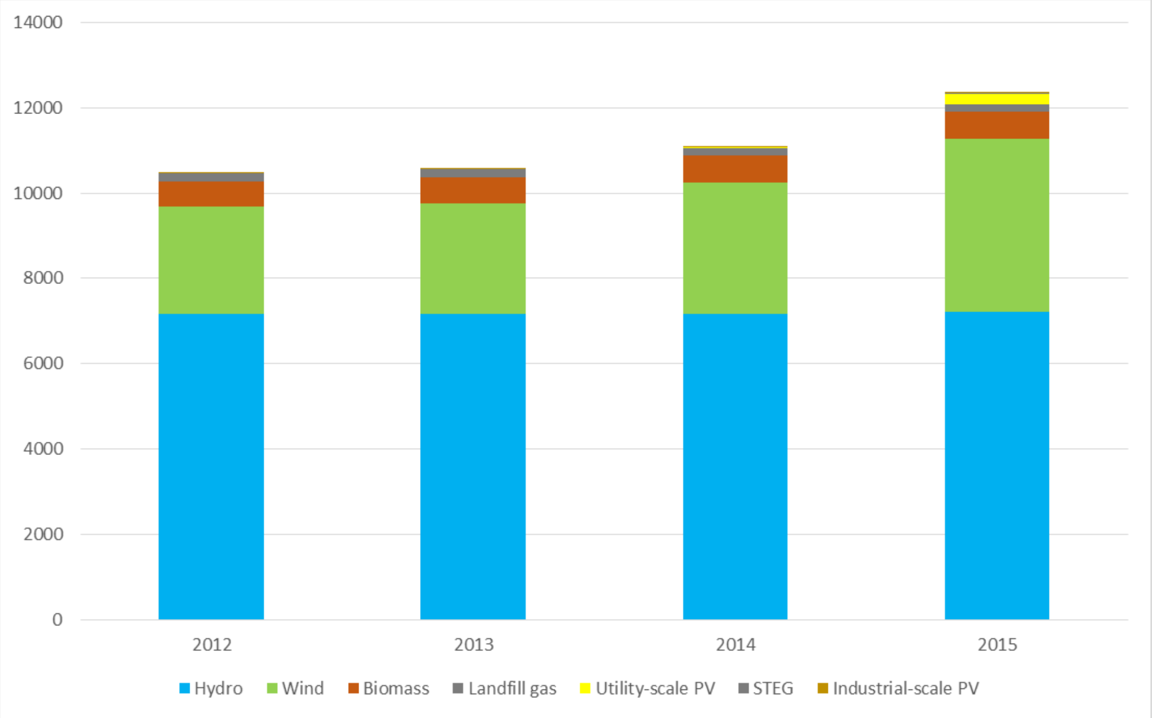
Eligible technologies that utilise the following resources can participate in the scheme: solar energy, wind, wave and tidal, geothermal-aquifers, wood waste, agricultural waste, bagasse (sugar cane waste), black liquor (a by-product of the paper-making process), or landfill gas. The minimum project size is dependent on technology type. For example, solar projects exceeding 100 kW can participate, while wind projects greater than 10 kW can participate. Projects under this size can qualify for the Small-scale Renewable Energy Scheme (SRES) (discussed later).

(b) Investment and LGC Pricing

The LRET scheme is driving considerable investment in renewable technologies across Australia (both large scale solar and wind farm). To reach the target of 33,000 GWh by 2020, around 6.7 GW of capacity will need to be installed in Australia, requiring around $12.4 b of new investment.[22] This implies that there will be around 19 GW of large-scale renewable energy capacity in Australia by 2020. The current composition of large-scale renewable capacity in Australia is shown below:

[22] Bloomberg, New Energy Finance, *Q1 2016 Australia REC Market Outlook*, 21 March 2016.

Figure 16: Renewable Energy Capacity in Australia (MW)



Source: Compiled by MJA from Clean Energy Regulator Data.

The history of LGC prices is shown below. Certificate prices have reflected the demand and supply balance and the uncertainty of potential policy changes. In particular:

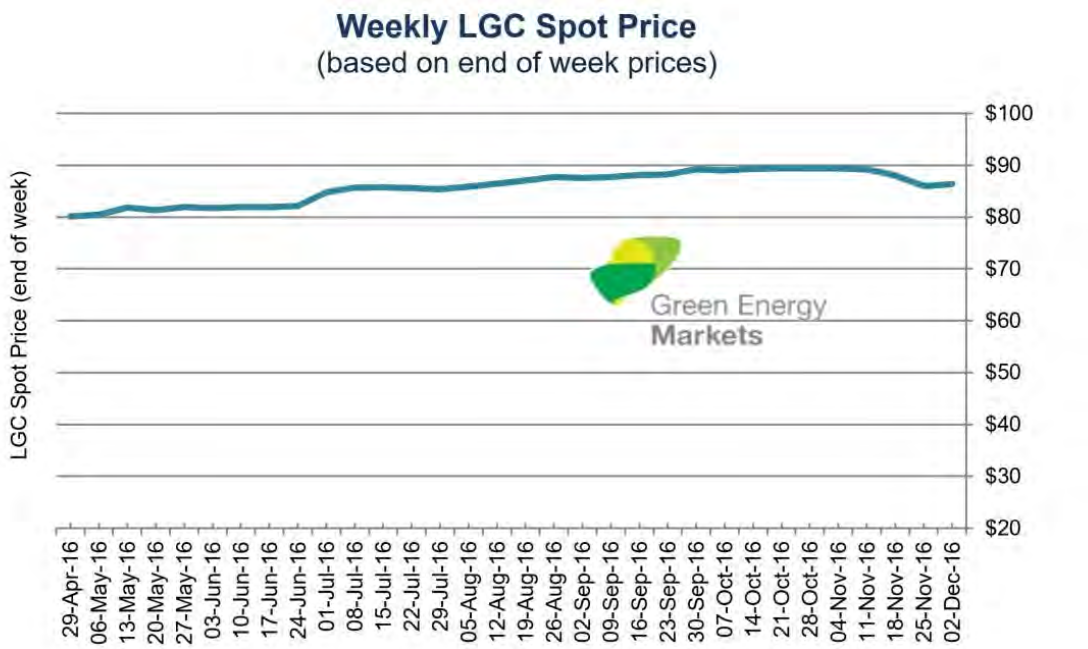
- The price increased in 2008 after the renewable target was increased to 45,000 GWh by 2020;
- The price decreased in 2009 due to an oversupply of certificates associated with solar hot water systems receiving multiples of certificates (to assist their economics). This led to the separation of the RET into the LRET and SRES;
- From 2010 to late 2014, the oversupply of RECs plus a significant level of uncertainty (that the scheme may be scaled back – as recommended in the Warburton report) resulted in the price for LGCs decreasing;
- There was considerable regulatory and associated investment uncertainty on what the scheme may look like until bipartisan agreement was reached in mid-2015 on the 33,000 GWh target. The perceived difficulty with achieving the target has resulted in LGC prices increasing to near the Shortfall Penalty Price.

Figure 17: LGC prices (nominal)

Source *http://reneweconomy.com.au/2016/ret-wont-be-met-in-2018*

Currently, LGC prices are just below $90/MWh (close to the Penalty Price of $92/MWh) as shown below.

Figure 18: Spot LGC prices (2016)



Source: http://greenmarkets.com.au/resources/lgc-market-prices

There is considerable uncertainty as to the actual LGC prices that will prevail in the period 2020 to 2030 (current scheme closes at the end of calendar year 2030). If new build occurs immediately and the target is met in the early 2020's, then LGC prices may average around $60/MWh over the period 2017 to 2030. However, if new build occurs slowly, prices may remain at the cap until the mid-2020s, causing the price to average more than $80/MWh over the same period (Marden Jacob assessment).

The expected asset lives of large scale renewable projects (e.g. wind and solar) are typically around 20 to 25 years, which implies that project developers will require offtake agreements for similar terms to obtain (debt) finance. Because of the risk of high prices prevailing over the period 2017 to 2030, retailers are likely to enter into long term power purchase agreements (PPA's). However, it is likely that project developers may face some level of market exposure given that retailers are unlikely to contract beyond the end of the LRET scheme (December 2030); implying terms of 12 to 13 years.

Project developers are factoring in an emissions trading scheme (see later discussion), or other renewable schemes (e.g. state based renewable targets), post 2020-2030 to help make their projects viable (e.g. VRET scheme).

(c) Implications for the Territory

There are three major solar projects operating in the Northern Territory.

Thirty solar concentrator dishes were installed at the remote communities of Hermannsburg, Yuendumu and Lajamanu. The solar concentrator dish power stations together generate 720 kW and 1.5 GWh per year. The project received NT and Federal Government assistance under their Renewable Remote Power Generation Program.[23]

The other major project is the Uterne 4.1 MW solar project operating at Alice Springs. It was initially a 1 MW plant, but Phase 2 (3 MW) was completed in 2015. Epuron owns and operates the facility, with the power sold to the Northern Territory government's energy utility Territory Generation under a long term power purchase agreement. Uterne II was built with assistance from the Clean Energy Finance Corporation (CEFC) (discussed later).

Epuron and Voyages Indigenous Tourism Australia have completed a 2 MW solar power station (PV) at the Ayers Rock Resort. The development and financing of the project is supported by ARENA and the CEFC.

The economics of large-scale solar technologies can be determined by calculating levelised cost of energy (LCOE). That is the unit cost over the project lifetime that is necessary to pay capital (e.g. including the required return on investment) and operating costs. It is estimated that the LCOE of large scale PV is currently around $105-120/MWh and is forecast to decrease to a range of $90-$95/MWh by 2020 (without financial assistance).

In the Darwin-Katherine System (DK), wholesale prices exceed $140/MWh and are forecast to increase over time (assuming no significant penetration of large-scale solar systems in Darwin). At this price, developers of solar projects do not need LGC payments to be viable. In fact today, by comparing current wholesale prices in Darwin with the levelised cost of production, the project developer would generate a surplus of $35/MWh (based on a levelised cost of $105/MWh).

The current economics would suggest we should see numerous large scale projects being constructed in the Darwin-Katherine System over the next 5 years. It is our understanding that there is likely to be over 100 MW of large-scale solar projects planned for the DK system.[24] Given that peak demand of the DK System is around 300 MW, this has the potential to significantly alter the generation mix in the region around Darwin. In effect, this will lower unit prices and the emission intensity of major users – such as the City of Darwin.

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23 http://www.smh.com.au/news/national/sun-rises-on-renewable-power-for-outback/2006/09/18/1158431644208.html

24 Based on informal conversations with System Control (PWC).

3.3.2 Small-Scale Renewable Energy Scheme (SRES)

(a) Scheme Design and Framework

The SRES places an obligation on retailers to purchase Small-scale Technology Certificates (STCs) based on a projection of the growth in small-scale technology generators the year before. A cap on STC price is set at $40/MWh (tax deductable). STCs are surrendered to the Clean Energy Regulator (CER).

The intention is to support the development of small scale technology generation such as rooftop PV, solar water heaters and heat pumps.

Currently the price of STC's are trading at near the cap price of $40.

The Scheme provides a capital subsidy to residential and commercial customers installing rooftop PV systems that meet the following criteria:

- solar panel system that has a capacity of no more than 100kW, and a total annual electricity output less than 250MWh
- wind system that has a capacity of no more than 10kW, and a total annual electricity output of less than 25MWh, or
- hydro system that has a capacity of no more than 6.4kW, and a total annual electricity output of less than 25MWh.

The scheme finishes in December 2030.

(b) Implications for the Territory

Retail electricity prices are subsidised in the Territory. The energy rate in the domestic tariff is around 25 cents/kWh (inc. GST), which is similar to other capital cities in Australia.[25]

In addition to the avoided retail tariff rate, the economics of small scale solar is also a function of the capital subsidy provided under the SRES scheme and generous rebates for solar exports in the Territory. The current 1:1 Feed-in-Tariff (FiT) was implemented in 2001 by PWC and has been inherited by Jacana Energy. The ongoing level of the FiT (equals the retail electricity price offered by Jacana Energy) is determined by Jacana Energy in consultation with its shareholding Minister. It is our understanding that the current NT Government is committed to maintaining the 1:1 Feed-in-Tariff, but that it could be reviewed in light of the need to achieve the 50 per cent renewable energy target by 2030 (see discussion in Section 3.4.1 "*Roadmap to Renewables*")

As a result of subsidies (SRES and FiT) and modest retail electricity prices in the Territory, the payback on investment in small-scale PV systems is currently 5.6 years and is forecast to reduce to just over 5 years in the mid-2020's.

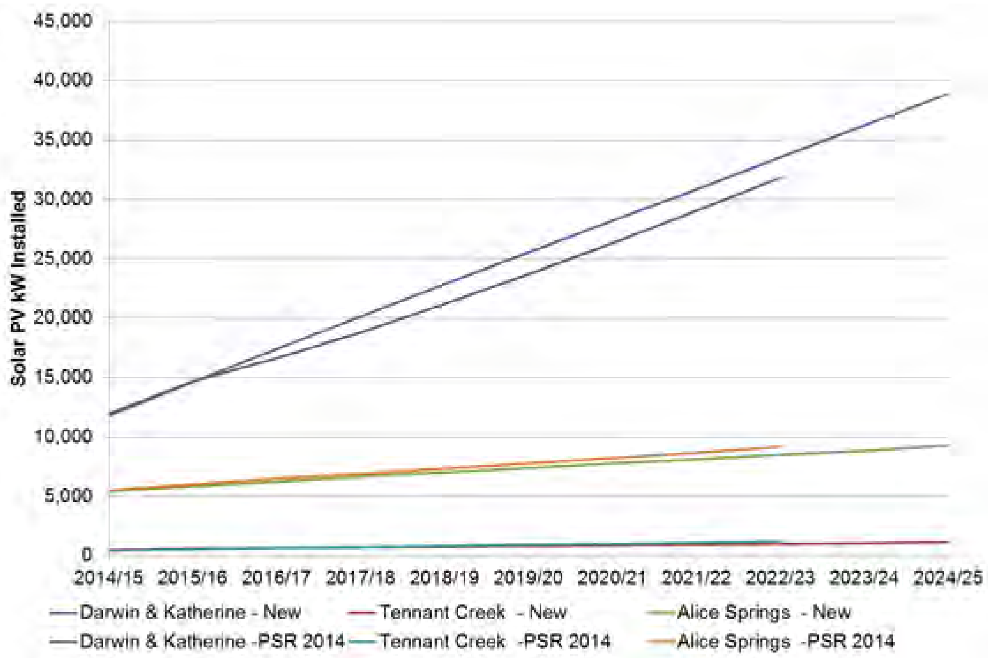
Figure 19: Rooftop PV Costs (Installed) and Economic Payback Period

[25] Business energy tariff rates are around 29 c/unit, but remain significantly below cost.

Source: Utilities Commission Power System Review 2014-15

The Utilities Commission provided projections for the uptake of rooftop PV in the Darwin-Katherine System.[26] They expect the percentage of dwellings with rooftop PV to increase from 11 per cent to 29 per cent over the period 2016 to 2024.

Figure 20: Projected Rooftop PV Installation (kW Installed)

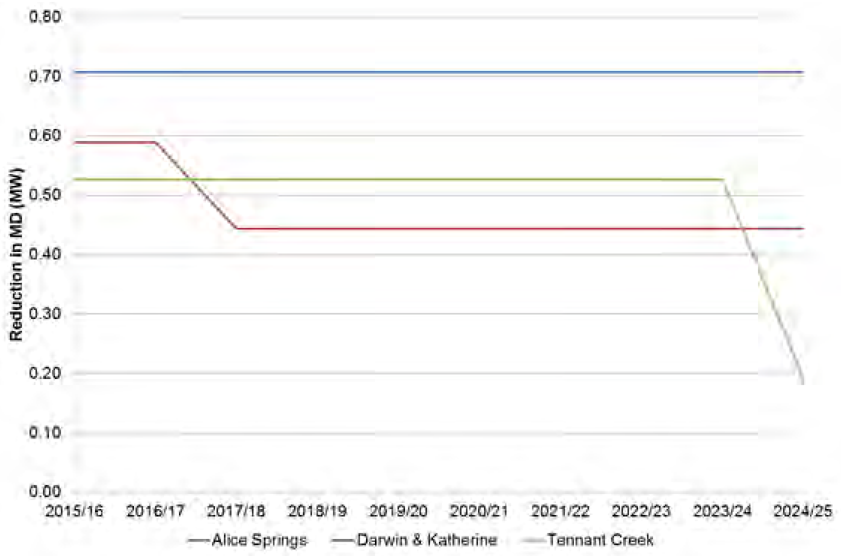


Source: Utilities Commission Power System Review 2014-15

The implications of the increasing penetration in rooftop PV is that both peak demand and wholesale energy consumption will decline. This should reduce future investment in both the network and power stations, which should in turn reduce future retail prices in the Territory.

26 Utilities Commission, *Power System Review 2014-15,* pp. 26-27.

Figure 21: Reduction in Maximum Demand due to 1 MW Rooftop PV



Source: Utilities Commission, Power System Review 2014-15

The other major implication of the current economics of solar PV, is that there is a strong likelihood that it will be economic for the City of Darwin to invest in rooftop and ground mounted solar systems on City of Darwin owned buildings and sites. Options for this will be covered in a later Chapter.

3.3.3 Clean Energy Finance Corporation

The Clean Energy Finance Corporation (CEFC) co-finances or co-invests with renewable energy companies in low emissions and energy efficient technologies.

Uterne II (at Alice Springs) received funding from the CEFC for its 3.1 MW expansion of the Uterne PV farm (Uterne I – 1 MW).

The types of funding provided by the CEFC include the following:

- Project finance - used to finance a project where debt and equity are repaid solely from a project's cash flow (limited recourse financing). Project financing is most appropriate for large-scale capital investments in energy infrastructure and is focused on projects at a later stage of development.
- Corporate loans – provided to a company that has a portfolio of smaller projects which can be financed on a consolidated basis.
- Aggregation finance – designed to overcome difficulties in obtaining upfront finance. Can include utilities and government agencies.

Relevant funding opportunities for the City of Darwin include the following funds:

- Large-Scale Solar Program
- Local Government Finance Program[27]
- Clean Energy Innovation Fund

[27] https://www.cleanenergyfinancecorp.com.au/media/158209/cefc-local-government-finance-program-faqs_160314.pdf

(a) Large-Scale Solar Program

The CEFC's $250 million Large-Scale Solar program was launched in 2015 and provided support to the development of solar PV projects of more than 10MW, with loan requirements of $15 million or more.

Funds from this program are funding about 1/3 of the cost of solar projects installed or under construction in Australia (300 MW).[28]

This program awarded funding in December 2016, but is no longer accessible by project proponents.

(b) CEFC Local Government Finance Program[29]

The CEFC Local Government Finance Program is designed to provide fixed rate, long-term finance to help reduce a council's energy consumption. Key elements of the Program include:

- Finance for eligible projects (i.e. renewable energy, energy efficiency and low emissions technologies);
- Finance can be drawn over three years
- Ability for multiple councils to enter into joint financing agreements for eligible projects
- Access to competitive fixed rate longer dated senior debt, up to 10 years
- A straightforward approval process with simple loan documentation.

Particular projects that could be implemented under this program include the following:

- Energy from municipal waste
- Street lighting upgrades (e.g. LED lights)
- HVAC upgrades for leisure and aquatic centres
- Rooftop solar PV on council buildings
- Building upgrades
- Electric and Low emissions vehicles.

(c) Clean Energy Innovation Fund

The Innovation Fund is a part of the CEFC and is operated in consultation with ARENA. The Innovation Fund targets a broad range of long term energy investments in Australia. The CEFC also provides opportunities for both private and institutional financiers to also support innovative clean energy investments through co-investment opportunities.

Up to $100 million of finance (equity or debt) is available each year.

Eligible investments include the following:

- Renewable energy technologies - bioenergy, geothermal, hydro, ocean, solar, waste-to-energy, wind);

28 http://www.cleanenergyfinancecorp.com.au/where-we-invest/cleaner-power-solutions/large-scale-solar.aspx

29 http://www.cleanenergyfinancecorp.com.au/media/158207/cefc-factsheet_local-govt-finance-program_lr_20160607.pdf

- Hybrids of renewables with other technologies
- Energy efficiency (including energy conservation and demand management)
- Technologies that reduce emissions that are not renewables or energy efficiency (including supply) e.g. smart grid technologies.

3.3.4 ARENA Funding

Australian Renewable Energy Agency (ARENA) provides funding to innovative renewable energy (including storage) projects in Australia. ARENA has approximately $2 billion in funding, which is legislated and extends until 2022. ARENA funds activities that are expected to advance renewable energy technologies towards commercial readiness, improve business models or reduce overall industry costs. This is a potential source of funds for the City of Darwin to fund innovative renewable projects in its jurisdiction.

ARENA provided funding of $100 million to large scale solar projects on the NEM and WEM but excluded the NT.

Of most relevance to the NT is the Community and Regional Renewable Fund, which provides funding to remote communities in Australia. PWC obtained $27.5 M in funding (50 per cent of project costs) for the deployment of solar PV systems in more than 30 remote communities in the Northern Territory.

The projects will integrate 10 MW of solar PV into remote locations with existing diesel power stations. The largest project is at Nauiyu (Daly River), where a 1 MW system will reduce diesel fuel consumption by 50 per cent.

3.4 NT policy developments

3.4.1 Roadmap to Renewables

The newly formed NT Labor Government has committed to a renewable energy target of 50 per cent by 2030.

Labor set out the policy prior to the August 2016 election in the *Roadmap to Renewables: Labor's Plan to Transition to Renewable Energy in the Northern Territory* document[30]. Since forming government, the team of experts tasked with setting out options on how to achieve the target of 50 per cent renewables by 2030, led by Alan Langworthy, has been engaged.

The team of experts is expected to deliver a report in 2017 that will:

- Refresh the findings and advice from the first two Green Energy Taskforce reports with regard to advances in technology and the regulatory and commercial environments over the last six years;
- Provide advice on the technology, regulatory and financial issues and options to meet the future energy needs of the Territory whilst reaching the 50% renewables target;
- Explore options to ensure low income, remote and renting households can participate in the transition to renewables;

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[30] Available at: http://www.territorystories.nt.gov.au/bitstream/10070/262935/2/Gunner-140816-Territory_labors_roadmap_to_renewables_attachment.pdf

- Provide advice on the best way to attract investment in and job creation from, the transition to renewables; and
- Be informed by wide consultation with Territorians.[31]

Marsden Jacob understands initial work has focused on defining the target. Discussions with the Chief Minister's Office suggest:

- the target will likely only apply to stationary sources of energy – so transport energy use and emissions will be out of scope;
- stationary sources of energy located behind the meter – such as rooftop PV – will be included towards the target;
- the target adopted will apply to energy generated rather than energy consumed (however this point is still being considered).

The NT government are planning on achieving the target through a mix of policy responses, including legislative, technical and incentive based approaches.

Solar is expected to continue as a featured policy. The *Roadmap to Renewables* outlines $5 million will go to fund the installation of roof top solar to a wide range of school buildings across the Territory, with this funding being tied to educational programs teaching children about the new solar technology[32].

The current 1:1 feed-in tariff for solar is also expected to continue at least until the expert panel's report is delivered at the end of 2017. The continuation of this scheme recognises the need for additional incentives in the NT to counteract the effect of subsidised residential retail tariffs which otherwise lower the incentive to invest in rooftop PV and recognise the fluctuating nature of the Territory's population means the tendency to invest in property enhancements may be lower than elsewhere in Australia.

Large scale renewable energy solutions (macro solutions) are also likely to be considered including the further the development of Alice Springs as *"the Centre for Excellence for Solar Energy"*. Labor's Roadmap to Renewables will look to invest $5 million into the Centre and use this investment to leverage a further $15 million of private sector and Commonwealth funding[33].

3.5 NT electricity market developments

3.5.1 Market Reforms

The Northern Territory Government is undertaking reform of the electricity sector in the Territory. To date the reforms have resulted in the structural separation of the Power and Water Corporation into a generation business (Territory Generation), a retailing business (Jacana Energy) and a combined electricity network, system operations market operator and original water and sewerage business which retained the name Power and Water Corporation.

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[31] Labor, *Roadmap to Renewables: Labor's Plan to Transition to Renewable Energy in the Northern Territory,* page 3

[32] Labor, *Roadmap to Renewables: Labor's Plan to Transition to Renewable Energy in the Northern Territory,* page 5

[33] Roadmap to Renewables, page 5

Territory Generation and Jacana Energy continue to be subject to the Government Owned Corporations Act but are competitive businesses able to compete with private suppliers.

Regulation of the Territory's prescribed electricity networks was transferred to the Australian Energy Regulator on 1 July 2015.

Competitive trading of electricity in a Northern Territory Electricity Market (NTEM) will occur through an energy and capacity market structure. An initial form of the NTEM commenced operating in May 2015: the Interim NTEM or I-NTEM. The final market design is likely to be implemented in 2017 or 2018.

3.5.2 Implications for City of Darwin

Opportunities are created for the City of Darwin by having access to competitive energy offers from multiple retailers. However, it is also likely that retailers will attempt to transfer both wholesale and network risks to customers via contract pricing and terms. This would include peak and off peak energy prices, allocation of capacity charges (based on peak demand) and potentially increasing gas prices.

(1) Large-Scale Solar Entry

Given the economics of large scale solar in the NEM, it is likely that around 100 MW of capacity could be installed in the DK system in the next few years. This will significantly change the generation mix in that system. Projects proponents will attempt to enter into long term PPA contracts with major energy retailers (e.g. Jacana Energy) and a retailer's wholesale portfolio will reflect a mix of renewable and conventional electricity supplies from Territory Generation (mainly gas fired).

(2) Capacity Prices

A retailer will likely purchase short term from Territory Generation (i.e. 6 months to 3 years) since Territory Generation has an existing generation fleet and is likely to offer a mix of products in the deregulated market place. This would include peak and off peak energy blocks, as well as a capacity product if a capacity market is introduced.

A capacity market was introduced in Western Australia (known as the Reserve Capacity Mechanism), which required retailers to purchase sufficient capacity credits (in effect generation capacity or Demand Side Management facilities) to meet a 1 in 10 year peak demand plus capacity required for loss of the largest generator and to provide ancillary services. The price cap in the market was based on the cost of an Open Cycle Gas Unit (OCGT), which was around $150,000/MW/annum on average.

The capacity price created a strong signal to retailers and customers to reduce their peak demand in order to reduce their liability to purchase capacity credits. The liability for capacity credits was based on a customer's demand (known as in the individual reserve capacity requirement) in 12 half hour intervals measured in the previous year. By reducing demand in those critical 12 half hour intervals, customers were able to significantly reduce their electricity bill. For example, a customer able to reduce peak demand by 1 MW was able to save around $210,000/annum.[34]

[34] If a customer reduces demand in those 12 half hour trading intervals by 1 MW on average, then they save 1.4 (uplift factor to cover 1 in 10 year event) multiplied by the capacity price of $150,000/MW/annum.

In addition, DSM facilities were also able to participate directly in the Reserve Capacity Mechanism. That is a retailer or DSM aggregator would put in place agreements with customers (e.g. loads) to reduce demand when called upon by System Management (known as System Control in the NT). DSM facilities were rarely called upon to provide a capacity reduction, but were able to receive the payment of $150,000/MW/annum for every MW provided. Retailers and customers shared the benefit typically on a 40/60 basis (i.e. 60 per cent of the benefit went to the retailer).

Under market reforms in Western Australia, the payment mechanism for DSM has changed, with the result that DSM providers only obtain payments of around $17,000/MW/annum. As a result, many DSM resources have exited the formal RCM and are looking at ways to reduce their peak demand as outlined earlier to receive the full benefit of the capacity price.

In short, the introduction of a capacity market in the DK system could provide substantial benefits to the City of Darwin if the City can reduce its power demand at peak times in the wholesale electricity market.

(3) Energy Prices[35]

Peak and off peak energy prices in the DK system are fundamentally driven by gas prices. Territory Generation's gas consumption for 2014-15 was 22.15 PJ and 85 per cent of all gas consumed in the three main Territory power systems (i.e. Alice Springs, DK and Tennant Creek) was in the Darwin-Katherine system.

PWC and Territory Generation have entered into a short-term two-year supply agreement post structural separation and are currently in negotiations to finalise a long-term gas supply agreement to commence in 2018 (includes both gas commodity and transport).

PWC sources its gas on a long term supply agreement from ENI's offshore Blacktip gas field in the Bonaparte Basin. The gas is brought onshore for processing at the Wadeye onshore processing plant.

PWC and ENI have entered into a 25-year gas supply arrangement, which commenced in 2009 for the supply of up to 740 PJ of gas, with an initial annual quantity of 22.5 PJ/a and increasing to 37 PJ/a in the last contract year[36]. The maximum gas processing capacity of the Wadeye plant is approximately 110 to 120 TJ/d[37].

The transportation capacity of the Bonaparte Pipeline and the Ban Ban Springs to Darwin section of the Amadeus pipeline is approximately 107 TJ. PWC has entered into long-term transportation agreements with the owners of the Bonaparte and Amadeus gas pipelines sufficient to transport Blacktip gas to its various power station delivery points in the Territory.

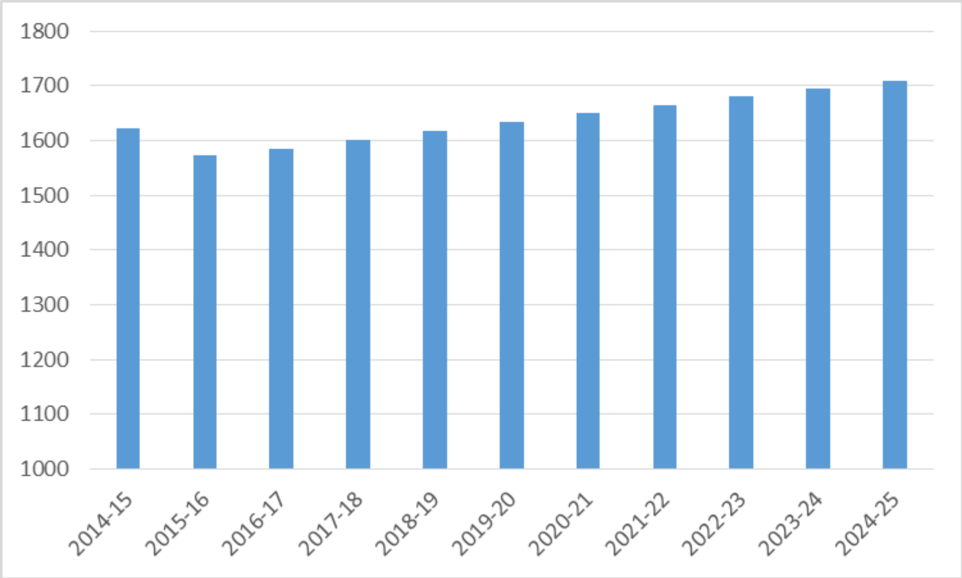
Given that Territory Generation's annual electricity sales are rising modestly at 0.93 per cent per annum due to the impact of increased solar penetration in the future (see figure below), PWC's annual contract quantity from Blacktip in future years will be substantially in excess of its actual gas requirements. It is hoped that the commencement of the Northern Gas Pipeline into QLD from late 2018 (referred to as the NEGI pipeline) will help eliminate PWC's current long supply position from Blacktip overtime.

35 Utilities Commission, *Power System Review* 2014-15

36 Eni press release, *'Eni starts development of Blacktip gas field offshore Australia'*, 30 June 2006

37 Eni press release, *'Eni starts development of Blacktip gas field offshore Australia'*, 30 June 2006

Figure 22: Future Energy Demand in the DK System (GWh delivered)



Source: Utilities Commission, Power System Review 2014-15

The commencement of NEGI pipeline from 4Q 2018 is likely to transform the Northern Territory gas market from one of excess conventional gas supply capability to limited quantities of uncontracted conventional gas reserves from Blacktip and the Amadeus Basin.

Given the tightening gas supply and demand position, it is likely that PWC will seek to obtain a higher delivered cost of gas in future years. MJA estimates that current gas prices are around $6.50/GJ (2016 dollars) and are likely to increase to more than $8.00/GJ (in real terms) overtime reflecting the higher value of gas for both export and sales in the QLD market.

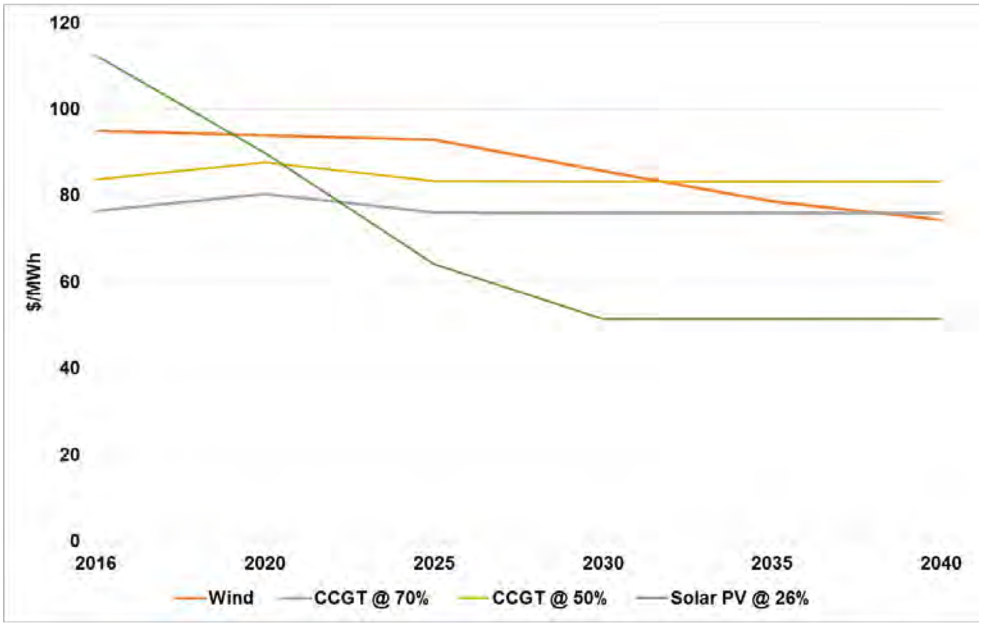
An increase of $1.50/GJ (in real dollars) in gas prices could see electricity tariffs increasing by over 11 per cent in real terms in 2018/19 over current tariff levels.

3.6 Technology Changes

Decreasing costs and increasing reliability of new energy technologies is changing the energy mix in Australia.

Cost reductions in the deployment of large scale renewable generation is highlighted below. The learning curve effects on decreasing capital costs of both large-scale solar and wind are appreciable over the next two decades. Similar reductions can be expected for small-scale solar technologies as well.

Figure 23: Levelised Cost of Large-Scale Generation Technologies



Source: Marsden Jacob analysis

Notes: *The percentages next to Combined Cycle Gas Turbines (CCGT) and Solar PV refer to the capacity factor of the plant (i.e. proportion of hours in a year that the plant is operating at its maximum capacity).*

Apart from renewable generation technologies, there are also likely to be significant technological advances which could be utilised by the City of Darwin.

Advances in energy storage opportunities, including electric vehicles are outlined below. A short discussion on community scale renewable energy projects is also provided.

3.6.1 Energy Storage

(1) Generic Services

Energy storage systems can provide a range of services to different parties in the electricity value chain. To better understand the services that they can provide, we have categorised them into three service categories:

- ***End User Services*** – typically used by customers to reduce reliance on the grid. Can be ‘behind the meter’ or integrated into the network (i.e. community storage);
- ***Network Services*** – typically used by network operators to avoid capital upgrades of the network or provide ancillary services (e.g. voltage control);
- ***Wholesale Market Services***: typically used by intermittent large-scale generators (e.g. solar) to time-shift generation from low to high value periods (i.e. energy arbitrage) and/or provide ancillary services (e.g. regulation and contingency services)

Some examples of ***End User Services*** include the following:

- Grid connected customers can use energy storage (*behind the meter*) to reduce the peak demand for customers on time of use demand tariffs;
- Grid connected customers can minimise the export of electricity generated from behind the meter generation (e.g. PV) to maximise the financial benefit of solar PV in regions with low feed-in tariffs.

- Remote, non-grid connected commercial customers can use energy storage to store surplus energy produced by intermittent generation (e.g. PV or wind) and minimise the requirement for running diesel generation in remote areas of Australia (e.g. communities and mine sites).

Rather than each customer installing energy storage behind the meter, customers could embed energy storage in the distribution network so that it can be used to provide services to more than one customer. This may enable customers to benefit from economies of scale in the sizing of the energy storage system (decreased capital costs) and may also facilitate increased utilisation of the energy storage system (e.g. higher capacity factor). We term distribution embedded energy storage as community energy storage and could be facilitated by an aggregator (i.e. retailer, network operator or other). One such project is underway in a northern Perth suburb (e.g. Alkimos Energy Storage Project) and is being facilitated by the local electricity retailer (Synergy).

In the event of network failures, energy storage in combination with a local generator can provide backup power to both residential and business customers.

Some examples of ***Network Services*** that can be delivered by energy storage:

- Network capital deferment entails use of battery storage solutions to defer upgrades or new investment in network assets (e.g. sub-stations, transformers etc.). Ergon Energy (network operator in Northern Queensland) has installed twenty 100 kilowatt hour lithium-ion batteries to help meet peak demand and maintain voltage in sparsely populated parts of the network.[38] It has been estimated that installing batteries will deliver a 35 per cent cost saving on traditional network solutions for these remote parts of the network.[39]

  With the increased amount of intermittent generation in distribution networks, voltage fluctuations can occur due to sudden changes in weather patterns (e.g. increased cloud cover reducing solar radiation, wind speeds etc.). Battery storage can be used to stabilise voltage fluctuations and reduce the need for costly network solutions (e.g. Static VAR compensators).

- Energy storage in combination with local generation can provide power in a region that is effectively islanded by major network failures (e.g. HV, sub-transmission or transmission asset failures). A good example of this would be the effective islanding of generation in the Ravensthorpe region of WA.

Some examples of ***Wholesale Market Services*** that can be delivered by energy storage:

- Intermittent large-scale generators (e.g. wind and solar) can time-shift generation from low to high value periods (i.e. energy arbitrage) and/or provide ancilliary services (e.g. regulation and contingency services).

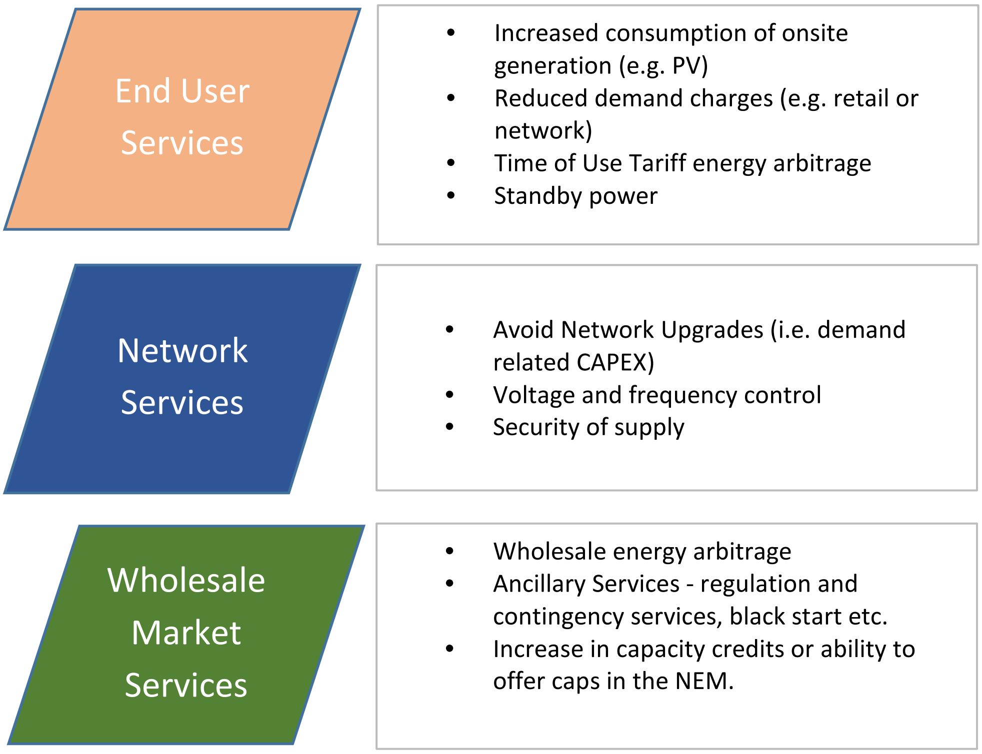
- Intermittent large-scale generators can use energy storage to increase output at peak times on the network. For example, in the Wholesale Electricity Market (WEM) in WA, increases in the potential output of intermittent generation can increase their capacity credit quantity (MW). In the National Electricity Market, intermittent generators using battery storage can offer caps (i.e. peak capacity hedges) to market participants to achieve a higher PPA price (effectively offering firm supply).

38 http://reneweconomy.com.au/2014/ergon-seals-deal-for-2mwh-of-battery-storage-27606

39 https://www.ergon.com.au/about-us/news-hub/talking-energy/technology/ergon-battery-energy-storage-systems-roll-out

Figure 24 below provides a summary of the benefits that Energy Storage can provide at different parts of the electricity value chain.

Figure 24: Potential Benefits of Energy Storage



Source: MJA

The extent of these benefits will vary with where the battery is installed in the electricity value chain and the geographic location in the network. When the energy storage system is deployed behind-the-meter, technically the system can provide all of the above listed services in . At the distribution level, the energy storage system loses the ability to provide end user benefits. At the transmission level, the energy storage system loses the ability to provide both end user and distribution level benefits.

(2) Applicable Technologies

There are a range of battery technologies that could be used to provide energy storage in the Territory.

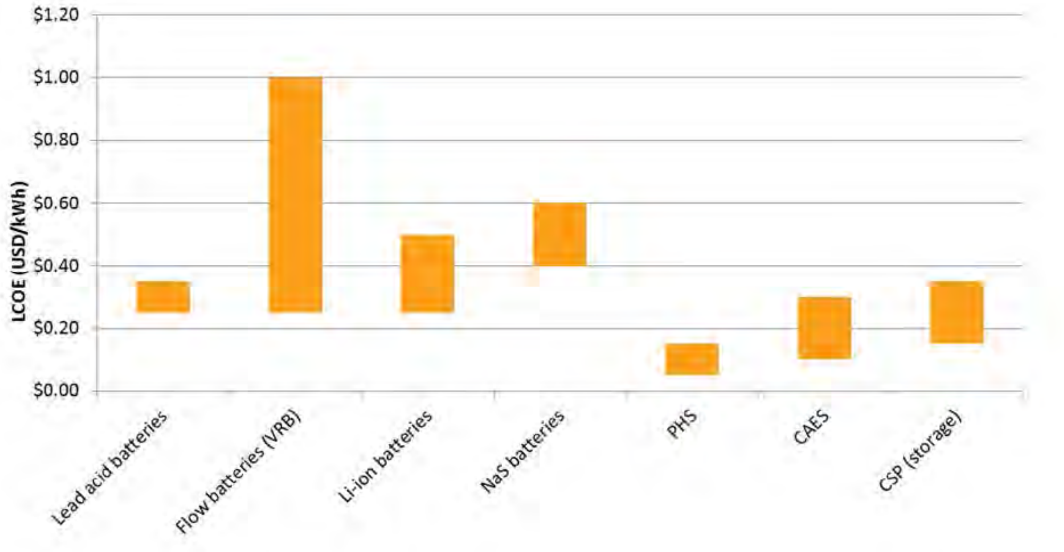
Lead-acid batteries are the most commonly used type of rechargeable battery. They are low cost and are used in numerous applications including vehicles, off-grid power systems and uninterruptible power supplies. Typical lead-acid batteries have efficiencies of around 70 - 90 percent with an expected lifetime of 5-15 years. They typically have lower cycle lifetimes and depths of discharge than other battery types.

Lead-acid batteries have been coupled with numerous solar, wind and off-grid power systems. However, the declining costs of lithium-ion batteries and better operating performance (i.e. depth of discharge and efficiency) when compared to lead-acid batteries has resulted in lithium-ion batteries displace lead-acid batteries in many applications.

Flow batteries (Zinc Bromine and Vanadium Redox) are scalable batteries that are also useful for large-scale intermittent plant. Flow batteries are usually between 65 and 80 percent efficient, permit up to 10,000 cycles, allow operational flexibility in terms of depth-of-discharge, and have a short response time.

On a levelised cost basis, lithium ion batteries are significantly lower cost than flow batteries.

Figure 25: Levelised costs of battery technologies



Source: AECOM, Energy Storage Study, Funding and Knowledge Sharing Priorities, Prepared for ARENA, July 2015

Based on the current costs and scalability of lithium ion batteries, this study shall consider the feasibility of deploying lithium ion batteries in combination with either rooftop or ground mounted solar systems on City of Darwin facilities and/or land.

3.6.2 Electric Vehicles (EV)

While the EV market in Australia is currently very small, the uptake of EV in some countries has passed 5 per cent (in 2013).[40] If EV market share continues to grow worldwide and the technology develops, it is likely that EV penetration will start to increase in Australia.

The fuel cost of EVs is significantly less than for Internal Combustion Engines (ICE) cars using either petrol or diesel. It has been calculated to be 50 per cent of the cost of running an equivalent petrol car.[41] Key challenges in the development of EV's will be access to standardised charging infrastructure and allowing vehicles to connect to the grid.

A summary of electric vehicle adoption projections is presented below in Figure 26. This demonstrates a wide variance in projections. Many of the forecasts utilise the CSIRO Energy Sector Model, which includes a model of Australian road fleet (both trucks and passenger vehicles) and assumes investment choices are based primarily on economic merit.

On average, the estimates suggests that the 5 per cent of the vehicle fleet in Australia will be EV's by 2020, rising to around 12 per cent in 2025. This suggests that the City of Darwin should continue to invest in the changeover of vehicles at the end of their useful life if the economics of EV's stack up.

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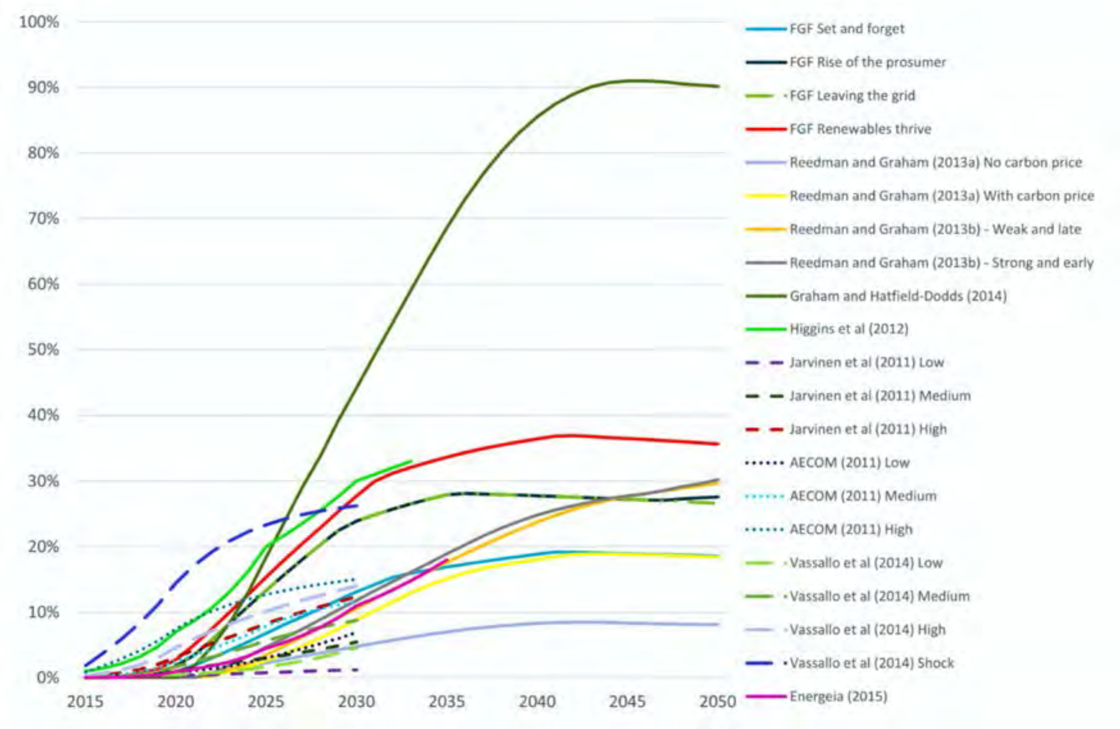
40 AECOM, *Energy Storage Study, Funding and Knowledge Sharing Priorities*, Prepared for ARENA, July 2015, p. 68-69

41 Ibid, p. 69.

Figure 26: Projections of Electric Vehicle Fleet Uptake



Source: Energy Network Association and CSIRO. 2015. Electricity Network Transformation Roadmap: Future Grid Forum, 2015 Refresh - Technical Report

The value of EV's increases where they can be charged from very low cost electricity, which can occur when solar PV penetration reaches high levels, and there is excess energy available in the middle of the day (i.e. installed solar PV is capable of generating more than the grid can absorb the time). EV's value also improves where they can feed electricity back into the grid on command, to provide effective peaking generation or other network services. Both of these applications requires planning and analysis of vehicle use patterns, and smart grid technology, and suitable conditions will take some time to develop. Hence this is considered an important long term strategy.

3.6.3 Community Scale Renewable Energy Projects

One of the significant barriers to the uptake of rooftop PV is the availability of appropriate roof space. For example, households that live in apartments, duplexes and other high density housing may have no access to rooftop space for the purpose of PV or need to jointly negotiate the use of the rooftop with multiple parties.

One way to overcome this barrier is to develop community scale renewable energy projects on commercial sites / buildings and to provide the energy produced by the project to the customer (e.g. virtual renewable energy supply). The household would pay the project developer an upfront and/or ongoing payments for the right to utilise the renewable energy.

In essence, households can help to fund the investment in solar PV systems and receive cheap energy from the sun, while the developer is able to obtain capital funds to undertake the project.

Issues that will need to be addressed include the following:

- Network charges for wheeling energy from the renewable generator to the customer;

- Limiting supply to customers within a substation zone of the network, so that upstream transmission charges are avoided.
- Utilisation of community storage to avoid low energy buyback rates – which is not a problem in the NT given the 1 to 1 buyback tariff currently offered.
- Access to suitable sites – City of Darwin has a number of sites which could be used for community storage projects.
- Management fees, and possible smart metering requirements, to administer the system.

3.7 Summary and Conclusions

This Chapter covered the investment energy framework as influenced by international, national and state policy as well as changing technology and relative costs.

In summary, our review suggests the following:

- International politics will influence Australia's and consequently, the Territory's, adoption of energy efficiency and greenhouse gas emissions targets. As outlined in Section 3.4, the NT Government (Labor) has committed to a renewable energy target of 50 per cent by 2030. Such a target will have a major impact on the generation mix in the DKIS, which will impact the City of Darwin's emissions even if no direct action is taken by the City of Darwin to reduce emissions (i.e. the base case is altered).
- International oil prices play a significant role in determining the domestic gas price and subsequently the electricity generation price in the Territory (i.e. high proportion of generation is gas fired). MJA is forecasting rising oil prices and hence rising gas prices which will drive up wholesale and retail electricity prices and improve the economics of investments in renewable and energy efficiency projects.
- The current electricity market reforms in the Territory are noted as presenting both opportunities and challenges for future electricity supply negotiations. A complexity in the assessment of renewable energy projects for the City of Darwin is to understand the extent to which Territory reform will move retail tariffs towards a competitive and non-subsided landscape – an outcome which is also noted as impacting the relative attractiveness of solar PV, for example.
- A number of opportunities are emerging beyond renewable energy generation (wind, solar, hydro) as technology changes. Energy storage benefits, including behind the meter options, electric vehicles and advantages of community scale renewable energy projects were canvassed for further consideration. Matching of these projects to CEFC and ARENA funding opportunities (background for which has been provided) will enable City of Darwin to more easily realise carbon abatement opportunities. Further, project specific opportunities are outlined in a later Chapter.

4. Options for the Development of Emission Reduction Targets

4.1 Background

In this chapter we have developed a baseline scenario for the future energy consumption of the City of Darwin and the consequent carbon emissions. We also discuss the challenge of setting an energy use and emission reduction target for the City of City of Darwin and outline our recommended approach to establishing a target.

4.2 Energy Consumption and Emission Reduction Forecasts

To develop future energy demand and emission reduction scenarios, Marsden Jacob have developed a model to forecast future electricity demand and the consequent emissions for the period 2017 to 2030.

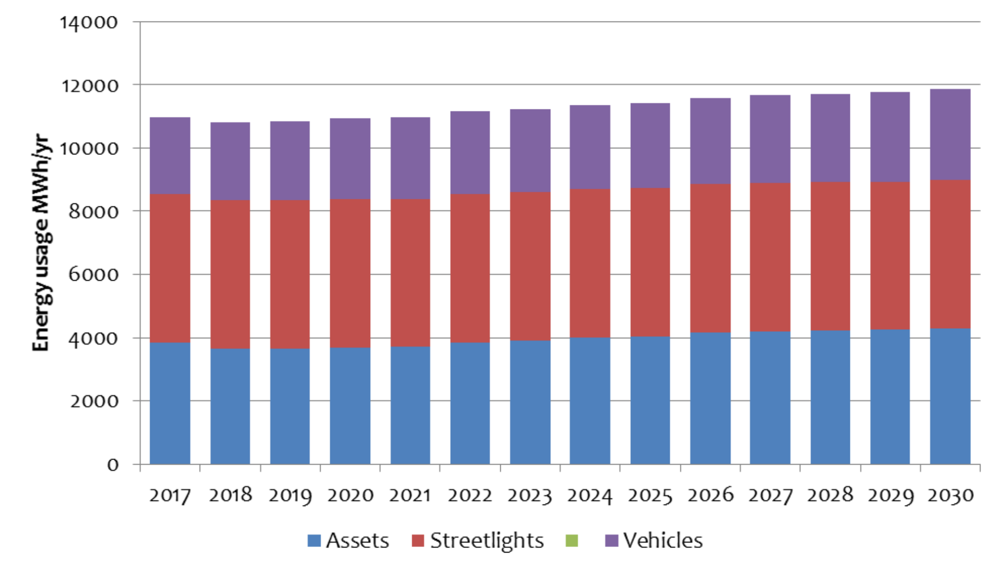
Energy consumption is divided into the following segments:

- Asset electricity demand – the net demand for electricity by the City of Darwin building's and facilities, taking into electricity supply from onsite PV systems that have already been installed.
- Streetlight electricity demand – the demand for electricity to power streetlights and traffic lights.
- Vehicle energy demand – Currently, all of the City of Darwin's fleet is powered by liquid fuels (e.g. Petrol and Diesel). However, in the future, vehicles may also require electricity demand to power plug-in hybrid or battery electric vehicles. In the base case, we assume no electric vehicles are purchased by the City of Darwin. To compare energy demand with both asset and streetlight electricity demand, we have converted liquid fuel used by the City of Darwin fleet from litres used per year to annual electricity demand.

Future demand for all of the above services increases in line with forecast increases in the population of Darwin.

The forecast demand for energy (measured in MWh) by the City of Darwin, assuming no active initiatives to reduce electricity use and emissions is outlined below. The decline in energy use in the initial years is due to committed facility upgrades that improve energy efficiency. Overtime, the demand for services increases overall energy use.

Figure 27: City of Darwin Electricity Demand – Base Case (MWh)



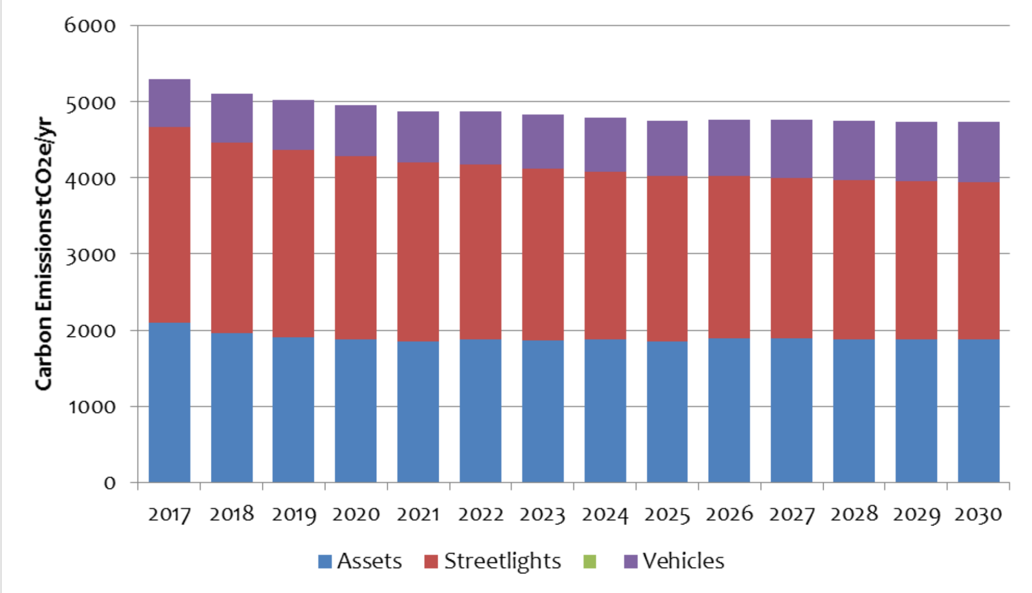
Source: Marsden Jacob analysis

The emissions profile for the City of Darwin does not track the energy demand profile since we have assumed that significant investment in large-scale renewable energy is made over the forecast period to align with the NT Government's renewable energy target that 50 per cent of electricity produced must come from a renewable energy source. In our analysis, we have assumed that 260 MW of investment is made in large-scale solar projects by 2030 in the DKIS, with the result that 22 per cent of electricity generated in the wholesale market is produced from renewable energy.

This is significantly less than the target set by the NT Government, but in Marsden Jacob's view, this is the maximum amount of large-scale solar PV (with and without battery storage) that can be connected to the grid without breaching system reliability standards, while being the least cost generation portfolio. To achieve the target of 50 per cent renewable generation, more '*scheduled*' renewable generation would have to be built, such as tidal power.[42] As a result of the investment in large-scale solar (260 MW), the emission intensity of electricity from the DKIS falls from 0.55 (tonnes CO_2^e per MWh) in 2017 to 0.44 in 2030. As a consequence, the overall City of Darwin emissions are forecast to fall from 5301 tonnes of CO_2^e in 2017 to 4742 tonnes of CO_2^e in 2030 in the base case (e.g. direct emissions only).

[42] Examples include the proposed Derby Tidal Power Station. See http://www.aie.org.au/AIE/Documents/FS10_TIDAL_ENERGY.pdf

Figure 28: City of Darwin Emissions (tonnes CO_2^e)



Source: Marsden Jacob analysis

4.3 Establishing Future Electricity Use and Emission Reduction Targets

There are a range of targets that the City of Darwin could achieve for reducing energy use and consequent emissions. The Commonwealth Government is a signatory to Australia is a signatory to the Paris Climate Change Agreement (December 2015), which requires that Australia achieves a reduction in emissions by 26 to 28 per cent compared to 2005 levels by 2030. Alternatively, the Federal Labour party has proposed a carbon reduction target of 45 per cent by 2030.

Many councils and other organisations are setting ambitious emissions reductions strategies including zero net emissions, 100 per cent renewable, carbon neutral and even carbon positive.

The ACT has an emissions reduction target of 40 per cent below 1990 levels by 2020. This is one of the most ambitious targets in Australia and compares favourably with the targets of many cities internationally.

While many of these targets are admirable, they fail to take into account the technological changes that may make achievement of these targets feasible. In addition, achieving reductions in energy use and emissions typically requires large investment in equipment, vehicles and facilities. Organisations are usually capital constrained which implies that an organisation can really only achieve the level of emissions reductions its capital budget allows.

4.4 Preferred Approach to establishing the target

Our preferred approach to establishing the future energy use and emission reduction target for the City of Darwin is to develop a range of options or initiatives that could be considered by the City of Darwin and then determine whether those options are economically feasible or not (see levelised cost analysis in Chapter 5). We would then calculate the cost of carbon abatement per initiative, rank them in terms of both cost effectiveness and magnitude (i.e. which options deliver emissions reductions at the lowest possible cost, or has the highest net benefit if the option delivers cost reductions).

The above analysis would provide us with an abatement cost curve which would help to determine the relative priority of each investment (see Section 5.2).

We would then review the capital costs of each proposal to consider what proposals can be included in the capital budget of the City of Darwin given its other organisational priorities.

Chapter 6 of this report compares the energy use and emission reduction scenarios under the Business-As-Usual Approach with the outcomes that could be achieved if the costed options developed in Chapter 5 are implemented. Chapter 6 will also propose a recommended approach if only those options that are feasible are implemented.

5. Costed Options to Reduce Energy Use and GHG Emissions

5.1 Methodology

Based on our understanding of energy use by the City of Darwin, the various technologies available, and the upfront and ongoing costs of deploying those technologies, MJA and Entura have evaluated the financial benefits of different options to reduce both energy use and greenhouse gas emissions.

The methodology that we have employed involves the following:

a) Calculate the annualised reduction in energy use per technology or initiative (e.g. MWh or GJ);

b) Calculated the associated annualised reduction in CO_2^e for each technology and initiative;

c) Calculate the annualised net benefits (financial benefit minus cost) of each technology or initiative ($/MWh). This includes taking into account any capital subsidies (ARENA) that are available or access to capital (e.g. CEFC) that is below market rates;

d) Divide (c) by (b) to calculate the levelised cost of abatement ($ per tonne of CO_2^e abated):

- If (d) is > 0, the initiative or technology delivers a positive net benefit to the City of Darwin and should be implemented;
- If (d) is <0, the initiative or technology has a net cost. In this case, the initiative should only be undertaken if the cost is lower than the benchmark (or 'shadow') price of carbon. The benchmark price of carbon could be international price of carbon or buying carbon offsets in Australia.

Provided in the box below is a description of how Marsden Jacob and Entura have calculated the levelised (or marginal) cost of abatement for each option.

Marginal Abatement Cost

Renewable electricity and energy efficiency technologies abate greenhouse gas emissions by reducing the use of emissions intensive fossil fuel powered generators. The cost from renewable electricity technologies are becoming competitive with gas generators (which are used extensively in Darwin).

Any difference between the cost of generating electricity using gas generators and a particular renewable technology can be considered the cost of abating greenhouse gas emissions. When this cost is divided by the amount of greenhouse gas emissions avoided (measured in tonnes of CO2 equivalents, or CO2e), this provides the cost of abatement on a dollars per tonne CO2e ($/CO2e) basis.

Each of the renewable electricity and energy efficiency investments to be assessed reduces emissions at a different cost. The lowest cost technology should be used to replace emission intensive fossil fuel based electricity generators, such as the Open or Combined Cycle Generation Technologies.

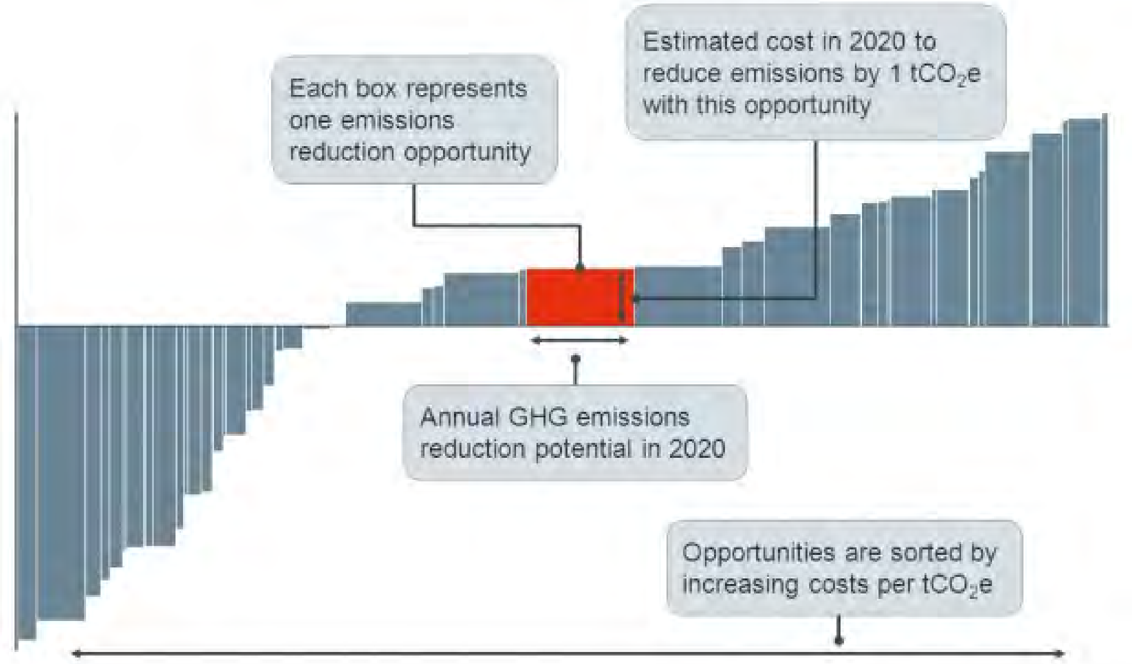
However, there may be constraints to how much electricity each renewable technology types can produce or energy efficiency investments can reduce for the city. These constraints may stem from need to balance between different technologies to ensure supply reliability, or natural physical limits, such as land or site availability, the amount of sunlight hours available at different points for solar technologies etc.

As such, each technology type is capable of providing only a certain amount of low emissions electricity. In other words, at each cost level, a certain renewable electricity technology can provide a limited amount of emissions abatement potential. If additional abatement is required, the deployment of the next cost-effective technology is required.

The marginal abatement cost curve is a curve that plots out the amount of emissions abatement that is available at each cost level through different technologies. It is marginal in that it provides an indication of the additional cost that is required to achieve additional quantities of emissions abatement.

The marginal social cost of abatement curve takes into account both private and social costs of abatement, that is the cost to those directly involved in producing electricity or reducing electricity use, as well as any additional costs imposed on society, such as increased council rates to subsidise the technology deployment.

Figure 29: Marginal Abatement Curve - $ tonne CO2e reduction (by project)



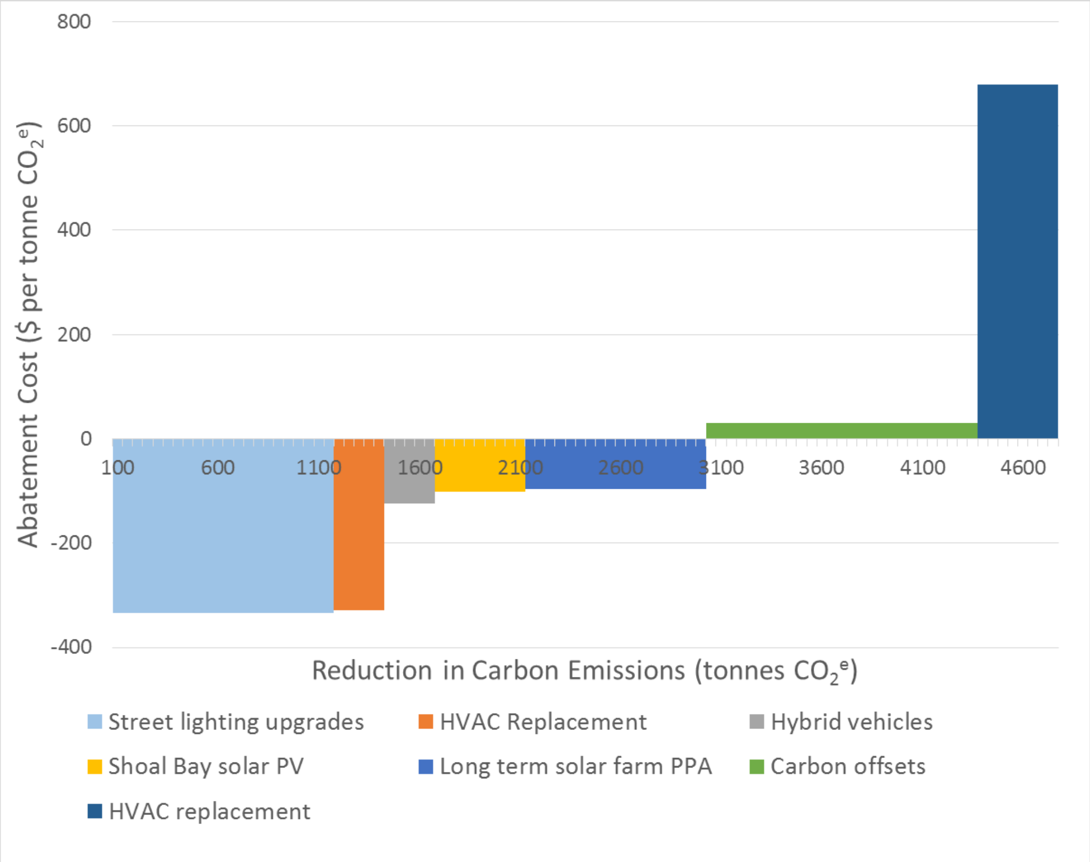
5.2 Costed Options

Marsden Jacob and Entura have focused on the following options to reduce energy used and emissions:

- Installation of a solar PV system at the Shoal Bay Waste Management Centre;
- Installation of rooftop solar at the Civic Centre (which is dependent on the timing of roof replacement);
- Put in place a power purchase agreement with a large-scale solar farm developer to help underwrite the project;
- Utilisation of waste streams at the Shoal Bay Waste Management Centre to produce electricity;
- Installation of energy efficient public lighting;
- Replacement of existing HVAC systems with more energy efficient systems (i.e. accelerated replacement);
- Putting in place electricity procurement arrangements (i.e. reverse auction) to reduce energy costs;
- Upgrading electricity metering at selected sites to enable retailers to offer innovative products (e.g. time of use tariffs) that could reduce electricity costs;
- Replace conventional vehicles using either petrol or diesel with hybrid (e.g. electric/petrol), battery electric vehicles and/or compressed natural gas vehicles;
- Purchase of green energy offsets.

For the projects assessed by Marsden Jacob and Entura we have calculated the Abatement Cost Curve for a range of projects if the project results in a net reduction of emissions. This is shown in the following figure and indicates that a number of projects are financially viable and deliver substantial emission reductions for the City of Darwin. Many of these projects are not dependent on the introduction of a carbon price, except for the purchase of carbon offsets and accelerated HVAC replacement. In the latter case, it is only viable to replace existing HVAC systems at the end of their useful life.

Figure 30: Abatement Cost Curve for City of Darwin - $000's per annum (by project)



Each of these initiatives is discussed in more detail in subsequent sections of this chapter.

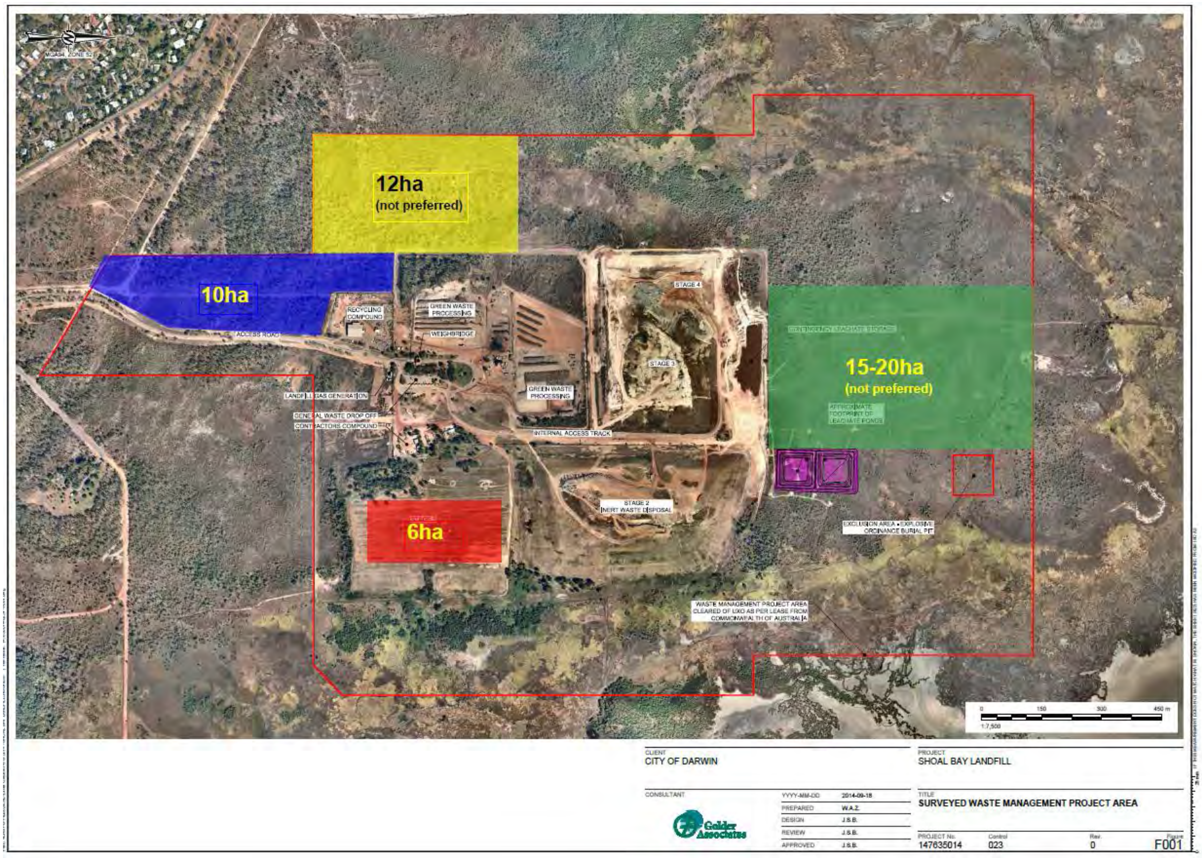
5.3 Shoal Bay Ground Mounted Solar Installation

5.3.1 Site description

The Shoal Bay Waste Management Centre, located north-east of Darwin CBD and east of residential areas, operates waste management services, utilises existing landfill for methane capture and energy generation (private operator), and has significant additional land available for the installation of ground mounted solar PV arrays. The facility has an electrical load of 120 MWh per annum (recently increased due to the installation of electrical air compressors at the facility). While there is other equipment on site that is currently diesel powered and may be converted to electric power (therefore increasing the electrical load further), the future facility load will be substantially less that the amount of generation that can be installed at the site.

Data provided indicated that land available for ground mounted solar PV installation could be installed to in the blue and red areas in the figure below. That is, relatively flat land with minimal shading and sufficient area to accommodate approximately 5 MW of flat-plate, fixed tilt solar PV. This site has the potential to provide more generation capacity to meet the entire City of Darwin load.

Figure 31: Shoal Bay site.



Source: City of Darwin

There is a 66 kV transmission line running adjacent to the site, along the western boundary, which connects direct to PWC generation. This represents an ideal network connection point for the solar PV plant.

5.3.2 Project description

The project involves the installation of a standard fixed-tilt ground mounted solar PV system and connection to the 66 kV transmission system. While the site could accommodate 5 MW, we have sized the system at 1 MW (AC) in order to approximately cover the City of Darwin load over 12 months.

While the assessment is based on a nominal 1 MW system, the site could accommodate up to about 5 MW, which would generate over twice the electrical load of the City of Darwin.

The site also appears suitable for a single axis tracking system. Single axis tracking systems require more area, which implies that the maximum wattage that can be installed at the site is approximately 2-3 MW in the preferred zones (blue and red). While the single axis tracking system would have less generation potential, the actual output of the system would be the same as a fixed tilt system as it is able to produce power more evenly over the day.

5.3.3 Project net benefits

The Table below provides a summary of the project, including costs and the annualised net benefit of the project. As indicated, the project has a positive net financial benefit which implies the project is commercially viable for the City of Darwin.

Table 7: Summary of Shoal Bay Solar Project

Project title:	Shoal Bay ground mounted solar PV system
Technology:	Solar photovoltaics (PV), fixed tilt
Capacity:	1.2 MW (DC) / 900 kW (AC) (scalable to 5 MW)
Resource:	Solar irradiance (global horizontal) 5.6 kWh/m^2
Energy yield:	1,966 MWh/y
Carbon dioxide (equivalent) savings:	458 t/y
Capital cost estimate:	$2,000,000
Project life:	20 years
Operational and maintenance cost estimate:	$30,000/year + $100,000 for inverter replacement at year 10
Connection point:	Direct connection to 66 kV transmission network (subject to connection application)
Savings on existing electricity costs / new electricity sales:	$245,500 (year 1)
Annualised pre-tax net benefit:	$46,933
Annualised benefit of carbon dioxide abatement:	$102/tonne
Indicative uncertainty on above estimates:	12%
Recommendation:	Proceed with full feasibility study and plant specifications for procurement. Selection of final capacity to suit investment profile.

5.3.4 Other opportunities and/or constraints

There is potential for part of the project to be sectioned off as ‘behind-the-meter’ generation for offsetting the electrical load at the waste management facility. By offsetting commercial tariffs rather than generating at wholesale prices, this arrangement will provide a slightly higher benefit. However, it adds to the complexity of the project and may be avoided through PPA negotiations with a retailer.

The connection of this project must meet the requirements of PWC. The capacity of the 66 kV transmission line should be assessed through consultation with PWC, however, capacity is expected to be ample to accommodate 5 MW of new generation.

If the City of Darwin is capital constrained, it could sell the rights to a separate party (e.g. retailer) to develop the site for power generation, with the City of Darwin putting in place a PPA (operating expense) for the off take from the solar plant.

5.4 Rooftop Solar at the Civic Centre

5.4.1 Site description

The City of Darwin Civic Centre, located in the Darwin CBD, currently uses approximately 1 GWh of electrical energy per year. The Civic Centre is a multi-use centre, with predominantly daytime loads. Its usage and electricity load are relatively stable, and usage patterns are not likely to change overtime.

The Civic Centre building has a substantial open roof area with a low slope (~10 degrees). There is some shading of the roof due to a tree in the courtyard, however, this will mostly affect early morning and late afternoon solar generation. The building is expected to have a life time in-excess of 20 years.

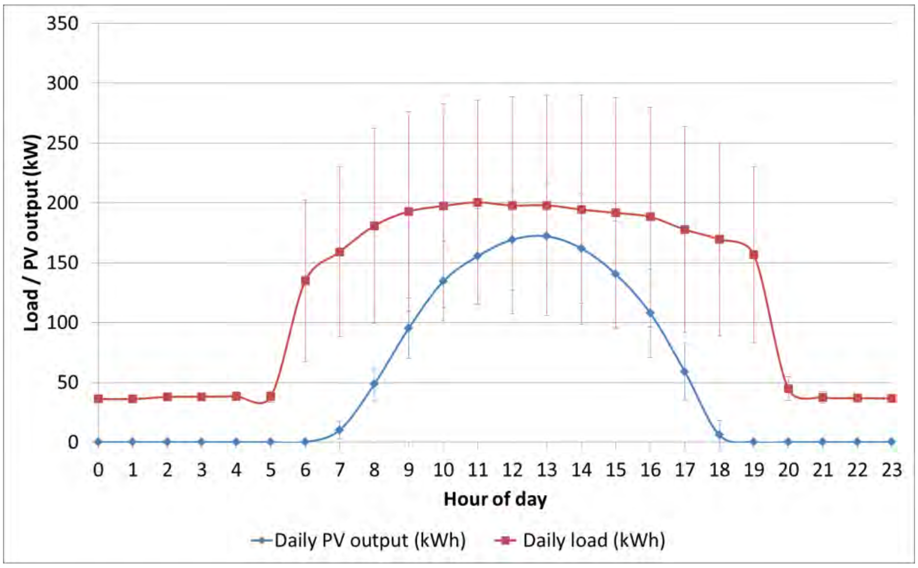
Figure 32: Civic centre building.

5.4.2 Project description

The project assessed here is a standard behind-the-meter style rooftop PV system. The majority of energy generated will directly offset existing load, with any surplus being exported to the grid.

The size of the proposed project is designed to take up all available roof area (with allowance for existing facilities). This sizing is below that which would provide optimal benefits from the project, but is limited by the available roof area. The following figure shows the daily generation from the project compared to load. Error bars are included to provide an indication of the variability in load and generation (also indicating times when export may occur).

Figure 33: Civic centre load and solar PV generation profile.



Source: City of Darwin, Entura Analysis

5.4.3 Project net benefits

The Table below provides a summary of the project, including costs and the annualised net benefit of the project. As indicated, the project has a positive net financial benefit which implies the project is commercially viable for the City of Darwin.

Table 8: Summary of City of Darwin Civic Centre Project

Project title:	Civic Centre roof mounted solar PV system
Technology:	Solar photovoltaics (PV)
Capacity:	288 kW (DC) / 255 kW (AC)
Resource:	Solar irradiance (global horizontal) 5.6 kWh/m2
Energy yield:	460 MWh/y
Carbon dioxide (equivalent) savings:	121 t/y
Capital cost estimate:	$489,600
Project life:	20 years
Operational and maintenance cost estimate:	$8,460/year + $24,480 for inverter replacement at year 10
Connection point:	Behind the meter at existing Civic Centre meter (subject to connection application)
Savings on existing electricity costs / new electricity sales:	$102,791 (year 1)
Annualised pre-tax net benefit:	$39,804
Annualised benefit of carbon dioxide abatement:	$329/tonne
Indicative uncertainty on above estimates:	15%
Recommendation:	Proceed with project

5.4.4 Other opportunities and/or constraints

The roof area constrains the size of the plant. A site inspection may indicate some variation in the maximum allowable size.

The connection of this project must meet the requirements of PWC.

Load growth at this site is assumed flat on the basis that the use of the site may be near capacity. Any load growth that does occur will likely improve the business case for the project.

The roof may need to replaced, which will require the rooftop system to be installed after the roof restoration or replacement.

5.5 Long term PPA with a large-scale solar project

As outlined in Section 3.5.2(1) and above, larges-scale solar is viable in the NT. Rather than the City of Darwin funding solar projects itself on City of Darwin land, the council could simply enter into a long term power purchase agreement with a solar project developer. It is likely that the solar project developer would require a contract term aligned to the end of the LRET scheme (December 2030) – around 12 to 13 years.

The advantage of a PPA is two-fold:

- A project developer may be able to build a large solar-farm (10 MW) than what can be built at either Shoal Bay (1 MW) or at the Civic Centre (255 kW) and achieve a lower unit cost due to realisation of scale economies.
- Due to the benefit of lower installed unit costs, our analysis indicated that a 10 MW solar farm provide benefits of $98 per tonne of carbon emissions, while the 1 MW solar farm at Shoal Bay would provide a benefit of the same order ($102 per tonne).

This suggests that if the City of Darwin is subject to capital constraints, a PPA contract may be an alternative mechanism by which to reduce overall council emissions.

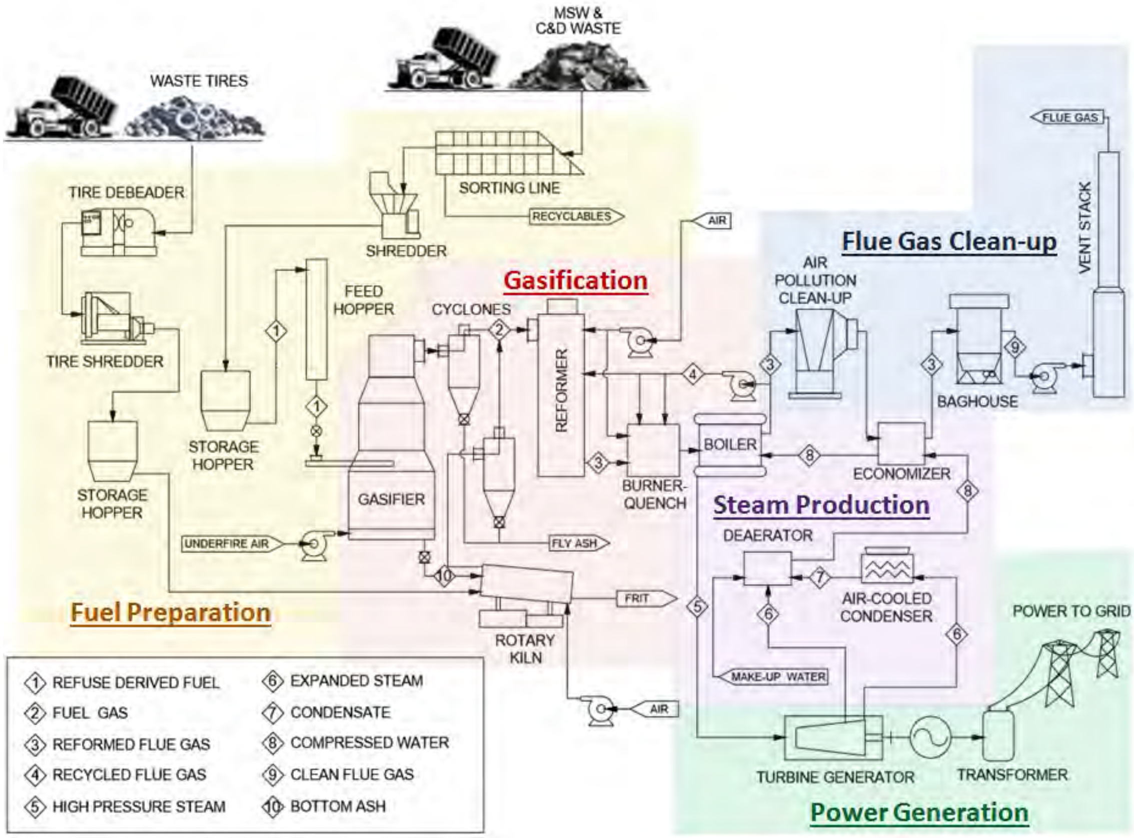
5.6 Shoal Bay Waste to Energy

5.6.1 Site description

The location of the Shoal Bay Waste Management Centre and proximity to the 66 kV transmission line was outlined in 5.3.1.

Data provided indicated that the Municipal Waste Stream (MWS) is approximately 188 kt (combined commercial and domestic). A detailed breakdown / sampling composition was not provided, so a typical breakdown was assumed for this facility.

Figure 34: Conventional waste to energy plant



Source: *http://www.eprenewable.com/atec-process-diagram*

5.6.2 Project description

The project assessed here is a conventional thermal treatment of MWS. There is substantial uncertainty in the final estimate relative to the solar PV projects assessed because construction, operations and maintenance costs are more site specific, and a detailed breakdown of the constituents of the MWS were not available.

Waste to energy plants of this nature typically release carbon dioxide during the combustion. This is of an equivalent magnitude to the emissions of the waste in landfill over its life, however, it occurs at the outset. The main potential benefit of waste to energy is in the energy generated and the carbon dioxide offset from this.

5.6.3 Project net benefits

Our assessment indicated that the value of the energy generated is insufficient to justify the cost of the plant. Furthermore, the carbon dioxide offset from the energy generation is insufficient to make up for the fact that incineration brings forward the carbon dioxide emissions of the waste. As a result, the plant actually increases net emissions.

The reduced cost of land use for landfill was not included in this assessment, as there appears ample land within the current site to accommodate future waste streams. Also, the opportunity cost of methane capture from the waste were it deposited in landfill are not captured, nor are changes in operations and maintenance that may result.

Table 9: Summary of Shoal Bay Waste to Energy project

Project title:	Shoal Bay waste to energy
Technology:	Thermal treatment (conventional)
Capacity:	10,000 t/y
Resource:	Municipal Waste Stream (MWS) 188,000 t/y: Maximum plant input estimated as 68,620 t/y; Actual plant size selected for 10,000 t/y (minimum)
Energy yield:	6,500 MWh/y
Carbon dioxide (equivalent) savings:	Net on discounted basis: -124 t/y
Capital cost estimate:	$10,500,000
Project life:	25 years
Operational and maintenance cost estimate:	$871,000
Connection point:	Direct connection to 66 kV transmission network (subject to connection application)
Savings on existing electricity costs / new electricity sales:	$275,234 (year 1)
Annualised pre-tax net benefit:	-$394,221
Annualised benefit of carbon dioxide abatement:	N/A
Indicative uncertainty on above estimates:	30%
Recommendation:	Subject to abatement needs being met through other projects – do not proceed. Consideration to private operator proposals to develop and manage waste to energy facility on case by case basis.

5.6.4 Other opportunities and constraints

There is also potential for a bio-digester to process green waste streams of approximately 11,000 tonnes per year. This option was not examined in detail, as it was apparent that a mulching program was in place and the green waste was assumed to contribute to this. Mulching and composting programs typically offer better value than bio-digesters, where there is a ready market for the product.

As noted earlier, there is a high degree of uncertainty in the assessment. Some scenarios do make for a positive net benefit with some abatement potential. However, even these scenarios are less attractive than solar PV type projects, and would entail greater risk. Nevertheless, there is potential for private developers to propose waste to energy systems, and these can be considered on a case-by-case basis.

The connection of this project must meet the requirements of PWC. The capacity of the 66 kV transmission line should be assessed through consultation with PWC, however, capacity is expected to be able to accommodate the waste to energy plant.

5.7 Civic Centre HVAC

5.7.1 Site description

The City of Darwin operates a number of sites with buildings containing HVAC. HVAC is typically a large energy consumer (around 40% or more of electricity bill). Improvements to HVAC can be achieved via simple adaptations or controls, or by complete revamp using higher energy efficiency technology (where applicable).

5.7.2 Project description

A 2012-13 audit report[43] established a range of measures that could be implemented to improve HVAC systems at City of Darwin buildings, including estimates of energy savings and capital cost. These estimates are considered reliable (except where changes to the buildings have already been implemented) and form the basis of the assessment herein.

The main existing air conditioners at the Civic Centre, Casuarina Library and West Lane Car Park are chilled water systems with multiple air handling units servicing different areas. There are also additional air conditioning units (e.g. split systems) used to serve specific buildings (administration area at the Casuarina Library) and areas (West Lane Car Park).

The audit report assessed the replacement of chilled water systems (and other units) with Variable Refrigerant Flow (VRF) air conditioning systems. VRF consist of outdoor units connected to internal fan coil units of varying capacities and types.

The initial costs for VRF systems are an additional 5 to 20 percent over those for chilled water systems. However, they are 30 percent more efficient than comparable HVAC systems. Although the equipment cost is higher, the installation cost is lower because all the evaporators use a two-pipe distribution system.[44]

The 2012-13 Audit Report recommended replacement of the existing units before the end of the useful life of the existing HVAC systems. Given the relatively high capital cost of these units, it is unlikely that this would be feasible. The simple payback on investment for this option (calculated from the Audit Report) are shown below. This highlights that paybacks are typically higher than 30 years (not feasible).

Table 10: Net Benefits of Improving HVAC Systems

Facilities	Estimate energy savings (kWh/year)	Estimated financial savings ($/Year)	Estimated installation Costs ($)	Simple payback (years)	Benefit (Cost) of CO2 abatement ($/t)
Casuarina Library					
Replacement of air	89,641	$34,090	$1,130,500	33.2	-978

[43] OPUS, City of Darwin Audit Report, 2013

[44] http://www.buildings.com/article-details/articleid/9248/title/is-a-variable-refrigerant-flow-system-right-for-your-building-

conditioning system [vrf] & roof insulation					
Civic Centre					
Air handling units replacement	87,312	$19,025	$613,050	32.2	-489
Replacement of Air Conditioning [VRF] & Roof Insulation	312,595	$68,114	$2,457,000	36.1	-622
West Lane Car Park					
Replacement of existing air conditioning system – variable refrigerant flow	109,519	$41,650	$1,150,000	27.6	-665
Replacement of existing fan coil units	20,928	$7,959	$282,700	35.5	-1111
Total	**619,995**	**$170,838**	**$5,633,250**		**-679**
Carbon savings (t)	**347**				

5.7.3 Project Net Benefits (and recommendation)

The following table provides a summary of the net benefits and emission reductions associated with the HVAC upgrades assessed in the Audit Report.

Table 11: Project Net Benefits - HVAC System Replacement (Audit Report)

Project title:	HVAC – Multiple sites
Technology:	Centralised Heating, Ventilation and Air-conditioning (HVAC), including variable refrigerant flow technology
Energy yield:	620 MWh/y
Carbon dioxide (equivalent) savings:	347 t/y
Capital cost estimate:	$5,563,250
Project life:	Varies
Operational and maintenance cost estimate:	$0 (assumed no different to existing O&M costs)
Connection point:	Behind the meter within each building
Savings on existing electricity costs / new electricity sales:	$170,000
Annualised pre-tax net benefit:	-$235,761
Annualised benefit of carbon dioxide	$679/tonne

abatement:	
Indicative uncertainty on above estimates:	20%
Recommendation:	Do not proceed with replacement of existing HVAC systems

5.7.4 Project Net Benefits (Replace at End of Useful Life)

An alternatively strategy is to only replace the HVAC systems with VRF at the end of the life of existing systems. For this project, we have assumed that the existing HVAC systems are replaced in the following years for each facility:

- Casuarina Library – 2019
- Civic Centre – 2021
- West Lane Car Park – 2024

In this case, the capital costs considered in the assessment are only the incremental capital costs of the more expensive VRF systems (assumed to be 20 per cent higher cost than Chilled Water Systems). As shown in the following table, the project is viable and delivers carbon abatement of benefits of $297/tonne.

Table 12: Project Net Benefits - HVAC System Replacement (End of Useful Life)

Project title:	HVAC – Multiple sites
Technology:	Centralised Heating, Ventilation and Air-conditioning (HVAC), including variable refrigerant flow technology
Energy yield:	620 MWh/y
Carbon dioxide (equivalent) savings:	347 t/y
Incremental capital cost estimate:	$938,875
Project life:	Varies
Operational and maintenance cost estimate:	$0 (assumed no different to existing O&M costs)
Connection point:	Behind the meter within each building
Savings on existing electricity costs / new electricity sales:	$170,000
Annualised pre-tax net benefit:	$103,071
Annualised benefit of carbon dioxide abatement:	$297/tonne
Indicative uncertainty on above estimates:	20%
Recommendation:	When major capital works are required (end of life of existing HVAC equipment), the business case should be revisited and would typically support replacement with the most energy efficient HVAC available.

5.8 Public Lighting

Replacement of existing public street lighting assets has the potential to reduce City of Darwin's energy costs and the emissions from this source. Limited information on the age of the assets is available at this time, hence, potential upgrade projects should be reviewed once this data is available.

5.8.1 Background

As highlighted in 2.2.9 of Chapter 2, the City of Darwin has approximately 8,691 streetlights installed 55.3 per cent of which are MV and a further 34.5 per cent of which are HPS.

Assuming streetlights are scheduled to turn on at sunset and off at sunrise each day and the DK Emissions Intensity is 0.56 (as per the National Greenhouse Reporting Accounts), the estimated electricity usage from streetlights is 4,607 MWh and account for approximately 2,580 tonnes of CO2 emissions (Table 13).

Table 13: Estimated electricity and CO2 emissions by street light for 2015-16

Street light type	Annual consumption (kWh)	Tonnes of CO2e	Annual cost of electricity [(a)]
FLU	10,893	6	$3,723
HPS	2,263,959	1,268	$729,640
LPS	1,644	1	$465
MH	5,024	3	$1,629
MV	1,794,132	1,005	$635,469
LED	210,633	118	$29,956
Other	320,646	180	$104,525
Total	**4,606,931**	**2,580**	**$1,505,406**

Source: Marsden Jacob analysis of City of Darwin data.

Notes: (a) Assuming City of Darwin is being charged in accordance with the current Electricity Pricing Order

Unmetered street lights in NT are subject to an Electricity Pricing Order. Annual charges are based on ranges of light wattages.[45]

The annual charges as set out in the current Electricity Pricing Order, the number of lights in City of Darwin that fall into each range and the estimated total annual cost for 2015/16 is provided in Table 14 (below).

Table 14: Current unmetered street light charges and estimated cost to City of Darwin

Light wattage range	Annual charge ($)	Number of lights (2015/16)	Annual cost ($)
1 to 50	$58.167	69	$4,014

[45] NT Government (2016) *Electricity Pricing Order (prescribed class of contestable customers using less than 750 MWh of electricity each year – 1 January 2017 to 30 June 2017*, 22 December 2016, available at: http://www.utilicom.nt.gov.au/PMS/Publications/UC-PO-E-1701.pdf

51 to 100	$116.333	5,519	$642,042
101 to 200	$232.666	1,950	$453,699
201 to 300	$348.998	1,093	$381,455
301 to 400	$465.331	42	$19,544
401 and above	$1,163.328	4	$4,653
Total		**8,677**	**$1,505,406**

5.8.2 Project description

New technology LED street lights are widely recognised as offering increased energy efficiency, reduced maintenance costs and longer lifetimes over traditional street lighting technology. Upgrades of luminaire technology used in street lights has the potential to offer City of Darwin both energy cost savings and reduce emissions attributable to the Council.

Marsden Jacob understand an in principle agreement for the ownership of street lighting assets to transfer on 1 January 2018 from PWC to the City of Darwin[46] and that the Council will be investigating options to replace existing street lights, include energy efficient upgrade options after this time.

While Marsden Jacob has provided indicative benefit estimates, this project should be developed in greater detail with reference to age and state of current assets to enable optimisation of replacement cycles. Analysis is limited to energy efficient luminaires and does not consider smart street lighting technology (such as sensors, dimmers, and data collection and communication technology).

Marsden Jacob notes the following:

- Energy efficient luminaries are generally selected which maintain or improve the light emitted from the globe (as measured in lumens) but that require lower electricity to maintain this light output.
- Electricity charges for unmetered streetlights are currently set based on ranges of light wattages in NT (in accordance with the current Electricity Pricing Order). Any upgrade result in a fall in wattage to a lower bracket will result in lower costs to the City of Darwin (without loss in service if lumens / light quality is selected to be maintained).

For the purposes of demonstrating benefits from upgraded streetlights, Marsden Jacob has assumed current MVs and HPS are replaced only with LED options. In making this assumption consideration has not been given to other characteristics of lighting such as the colour quality and temperature of the lights. These and other factors (besides electricity consumption) may alter the choice of luminaire when City of Darwin undertakes more detailed analysis.

46 *Street Lights – Power and Water Corporation – Deed of Agreement*, 1st Ordinary Council Meeting Agenda Item C28.2.1., 14 June 2016. Available at: http://www.darwin.nt.gov.au/sites/default/files/C28.2.1%20-%20STREET%20LIGHTS%20-%20POWER%20AND%20WATER%20CORPORATION%20-%20DEED%20OF%20AGREEMENT.pdf

5.8.3 Project net benefits

Based on the conversion of existing lights to LED, we have estimated the following net benefits of the project. Despite a modest increase in capital costs, the lower energy and maintenance costs result in an overall net cost reduction. In addition, installing LED lights results in a substantial reduction in emissions (1,143 tonnes) once all lights are converted. As a result, the cost of abatement is negative (-$335 per tonne) and the project should proceed.

Table 15: Efficient Public lighting Project, Net Benefits (2017 dollars)

Component	Estimate
Annualised (incremental) Capital Cost Increase $/annum	-$48,410
Maintenance Cost Reduction $/annum	$206,661
Energy Cost Reduction $/annum	$224,525
Net Cost Reduction $/annum	$382,775
Annual Energy Reduction (kWh)	2,041,135
Annual Emissions Reduction (tonnes)	1,143
Abatement Cost ($/tonne)	(334.9)

5.8.4 Other opportunities and constraints

MVs will likely have to be replaced with alternative technology options regardless of the City\s energy strategy as Australia look likely to ratify the Minamata Convention on Mercury and this will restructure replacement globe supply from 2020.

5.9 Electricity retail contracting

Recent reforms of the electricity sector and changing dynamics in the electricity retail market in the NT represent an opportunity for the City of Darwin. As a relatively large electricity user in the Darwin-Katherine region, the City of Darwin should consider running a reverse auction amongst electricity retailers with a view to reducing the costs through new retail contracts.

5.9.1 Background

All electricity customers in the Northern Territory have been contestable (i.e. able to select their retailer of their choice) from April 2010. However, prescribed classes of customers (as set out in section 13A of the *Electricity Reform (Administration) Regulations*[47]) have access to prices dictated by the NT government in an Electricity Pricing Order made by the Treasurer.

Prior to July 2015, there were two pricing orders for prescribed customers:

- One for prescribed classes **less than 750 MWh annual consumption** contestable customers; and
- One for prescribed classes **750 MWh to 2 GWh annual consumption** contestable customers.

[47] Available at: https://legislation.nt.gov.au/Legislation/ELECTRICITY-REFORM-ADMINISTRATION-REGULATIONS

The effect of the pricing orders was to protect these classes of customers from the imposition of cost-reflective tariff prices.

From July 2015, the pricing order for customers with annual consumption between 750 MWh to 2 GWh ceased in the Darwin-Katherine Region and then ceased in January 2016 for remaining areas. The only pricing order remaining in place relevant to the City of Darwin is the one which applies to customers with annual consumption less than 750 MWh per annum. For avoidance of doubt, this also includes unmetered customers i.e. streetlights and traffic lights.

The current pricing order is due to expire on 30 June 2017[48] and since this pricing order also covers residential customers we would expect the NT government to continue to replace the pricing order each year until they determine otherwise. The decision not to continue with a pricing order for the above mentioned classes of customers is being driven by the fact that tariffs have reached cost reflective levels and the existence of adequate competition in the retail market space.

5.9.2 Current contracting arrangements

The City of Darwin currently contracts for electricity with two retailers. QEnergy supplies power to the Civic Centre and Jacana (previously PWC) remains the retailer for electricity supplied at all other sites including unmetered loads (streetlights and traffic lights).

The annual electricity consumption is less than 750 MWh per annum at all of City of Darwin sites except for the Civic Centre (Appendix B provides a summary of historical annual electricity consumption each asset). As all customers in the NT have been contestable since April 2010, annual consumption does not restrict the retailer that can be chosen, however, at this level of consumption the customers are considered 'prescribed' customers under the regulations and therefore able to access pricing at or below rates set out in the NT Governments Electricity Pricing Order.

To the extent that rates in the Electricity Pricing Order plus any subsidy paid directly to the retailer by the NT Government are less than cost reflective, retailers will be disinclined to service these customers. The rates in Electricity Pricing Orders have been steadily increasing over time and are moving towards cost reflective levels.

Currently there are six licensed electricity retailers[49] in the NT. Shading indicates retailers who are either not currently active in the NT market or are otherwise providing services that are not well suited to City of Darwin requirements.

The information in the table indicates that there are three retailers who are likely to be interested in supplying electricity to City of Darwin.

48 NT Government (2016) *Electricity Pricing Order (prescribed class of contestable customers using less than 750 MWh of electricity each year – 1 January 2017 to 30 June 2017*, 22 December 2016, available at: http://www.utilicom.nt.gov.au/PMS/Publications/UC-PO-E-1701.pdf

49 A list of the licenced retailers in NT is available here: http://www.utilicom.nt.gov.au/Electricity/Pages/Licensed-Electricity-Retailers.aspx Details on the licence granted is available here: http://www.utilicom.nt.gov.au/Publications/Registers/Pages/Registry-of-Electricity-Licences-and-Exemptions.aspx

Table 16: Summary of electricity retailers in NT

Retailer	Licence details	Suitability of services for City of Darwin
Jacana Energy	Effective 1 July 2014 Latest variation 3 April 2015	Retailer of Last Resort (RoLR). Licenced to operate in Darwin, Katherine, Tennant Creek, Alice Springs, Daly Waters, Borroloola, Timber Creek, Elliot, Newcastle Waters, Yulara, Ti Tree and Kings Canyon. Pricing as per Electricity Price Order: https://jacanaenergy.com.au/my_account/pricing#commercialtariffs
Rimfire Energy Pty Ltd	Issued on 11 August 2014	Rimfire is taking expressions of interest from small electricity users and appear to be looking to break into the small business and residential customer market. Upgrades to meters may be required as Rimfire usually require communications enabled meters in order to take on responsibility for accounts. As part of contract negotiations, upgrades to meters or alterative solutions are considered. Licenced to operate in Darwin, Tennant Creek, Katherine, and Alice Springs.
QEnergy Limited	Issued on 4 February 2011 Latest variation 31 March 2015	Tends to only supply to customers >350 MWh per annum but will consider if several sites combined add to greater than this. Licenced to operate in Darwin, Tennant Creek, Katherine, and Alice Springs.
ERM Power Retail Pty Ltd	Issued 1 June 2012	ERM only look after business accounts (any levels of consumption so long as it's not residential), however they are not currently retailing in NT. The purpose of the licence is to enable them to expand into this market should they choose to in the future, however no plans are known to be in place to take up this option. Licenced to operate in Darwin, Tennant Creek, Katherine, and Alice Springs.
EDL NGD (NT) Pty Ltd (aka Energy Development Limited)	Effective 30 June 2016	Remote and clean energy specialist. EDL are not actively retailing to new customers in the NT. The purpose of the retail licence is to enable them to contract with retailers or a single large user for the sale of power from their 26.6 MW gas fired power station in Pine Creek. The plant has capacity to produce around 210 MWh of electricity annually and is connected to the D-K system, however it is likely already contracted with NT retailers. EDL does not maintain typical retailer accounts management systems designed for high numbers of customers and/or accounts. Licenced to operate in Darwin, Tennant Creek, Katherine, and Alice Springs.
Power and Water Corporation	Issued 31 March 2015 Latest variation 3 April 2015	Only licenced to operate in Indigenous communities under the Indigenous Essential Services (IES) program; Jabiru; Nhulunbuy; Alyangula; and McArthur River Mine. Pricing as per Electricity Price Order - http://www.powerwater.com.au/customers/business_customers/pricing

5.9.3 Project description

City of Darwin should continue to run reverse auctions with the three retailers able and willing to supply suitable services in the NT.

A reserve auction works like a tender process. Suppliers are invited to bid to provide services to the buyer, with the buyer typically selecting the successful supplied based on a number of factors including price, capacity to deliver services and the service standards offered.

Marsden Jacob supports the City of Darwin's current procurement approach. Depending on internal processes, the City of Darwin may select to run the process via an open tender (to attract all retailers) or may select to send a request to selected retailers only.

City of Darwin will need to provide a complete listing of all sites and accounts to be covered, including any unmetered infrastructure. City of Darwin should also undertake a review of the current tariffs that apply to each account and metering technology in place (noting upgrades may be necessary to facilitate switching to some retailers) as part of this process.

As part of the preparations for the tender or alternatively upon award of the new contract, City of Darwin should also look to consolidate or otherwise streamline the number of active accounts set up for each asset. The Planet Footprint data base currently house data for around 168 accounts across 100 City of Darwin site. While not all accounts are active, a vast majority do appear to be active. Appendix A provides a summary of the accounts and meters at each site. To the extent that additional accounts are active but not strictly required City of Darwin may avoid daily charges (amounting to $287 annually per account) being incurred if accounts are closed down.

5.9.4 Potential energy cost savings

The potential energy cost savings will depend on the outcomes of the reverse auction process, however the following sets out a framework that City of Darwin may use to determine rates at which the strategy is beneficial.

Assuming all accounts are on the commercial flat tariff rate outlined in the Electricity Pricing Order (and no changes in meters or tariffs – as discussed in section 5.7), City of Darwin's annual electricity cost for the metered sites included in the Planet Footprint data base is approximately $1.2 million based on 2015-16 annual consumption.

Unmetered street lighting costs are estimated to account for an additional $1.5 million of electricity costs and unmetered traffic lighting account for a further estimated $22,000 in 2015-16.

The City of Darwin should, at a minimum, look to achieve rates below the current Electricity Pricing Order rates – with allowance for auction costs and any metering upgrades to be covered.

The tables set out below provides the current rates which City of Darwin should look to beat.

Table 17: Commercial tariffs (<750 MWh annual consumption)

Commercial tariffs (<750 MWh annual consumption)	Fixed Daily Charge ($/day)	Peak charge (6am to 6pm) ($/kWh)	Off-Peak charge (6pm to 6am) ($/kWh)
Flat rate tariff	0.7862	0.297199	0.297199
Time of use tariff	0.7862	0.3803	0.214

Table 18: Unmetered street lights

Light wattage range	Annual charge ($)
1 to 50	58.167
51 to 100	116.333
101 to 200	232.666
201 to 300	348.998
301 to 400	465.331
401 and above	1163.328

Table 19: Unmetered 24 hour lights (e.g. traffic lights)

Period of operation	Annual charge ($ per watt)
Off-peak operation (6pm to 6am)	1.12
Peak operation (6am to 6pm)	1.245
24 hour operation	2.42

5.10 Metering upgrades at selected sites

Metering upgrades at a number of selected sites will enable City of Darwin to switch to alternative tariff arrangements and potentially reduce the overall cost of electricity purchased. As outlined in the previous project (Section 5.9), the upgrades of meters will also facilitate movement of sites between retailers, however in this section we consider the meter upgrades as an independent project assuming no change in retailer.

5.10.1 Background

There are two types of tariffs set as under the Electricity Pricing Order applicable to commercial customers using less than 750 MWh of electricity per year.

- The *'flat rate tariff'* comprises a fixed daily charge and a flat rate consumption charge; and
- The *'time of use tariff'* also comprises a fixed daily charge, however the consumption based charge distinguishes between peak and off-peak consumption times, with the peak time consumption rate being higher than the off-peak rate.

Table 20 summarised the current tariff rates set out in the Electricity Pricing Order.

Table 20: Current commercial tariff rates (less than 750 MWh per annum)

Tariff type	Fixed daily charge	Consumption charge		
		Any time rate	Peak (6am to 6pm)	Off-peak (6pm to 6am)
Flat rate tariff	76.62 cents per day	29.72 cents per kWh		
Time of use tariff	76.62 cents per day		38.03 cents per kWh	21.40 cents per kWh

Source: Electricity Pricing Order

In order to take advantage of the time of use pricing, customer must have a suitable time of use meter installed at the site.

Current meter upgrade costs available from Jacana are outlined in Table 21. These cost levels provide the basis on which the metering project has been developed. Additional savings may be possible if a retailer or service provider other than Jacana is able to undertake the meter upgrades and the cost of the alternative supplier is lower.

Table 21: Jacana selected service charges

New supply service connection	Price as at March 2017
New connection, re-establishment after disconnection, transfer of an existing account	$56.00 (BH)* $728.00 (AH)*
Three Phase at customer's request (when only Single Phase is deemed necessary)	$1085.00 (BH)
Time of Use meters	
Provision of Time of Use meter - Single Phase	$267.00 (BH)
Provision of Time of Use meter - Three Phase	$631.00 (BH)
Reprogramming of meter (CT or No CT) - visit required	$183.00 (BH)
Reprogramming of meter (CT meter) - no visit required	$42.00
Solar PV meters	
Provision of single phase PV meter at customer's request	$555.00 (BH)
Provision of three phase PV meter at customer's request	$763.00 (BH)

Source: Jacana, 'Pricing and Tariffs' webpage, accessed 6 March 2017. Refer to:https://jacanaenergy.com.au/my_account/pricing#commercialtariffs

5.10.2 Current situation

Current tariff rates and interval data was provided for a small number of City of Darwin sites, including several sites with PV currently installed (Table 22). All sites were identified by Jacana has being on a commercial flat rate tariff.

Table 22: Selected site information and data supplied

Facility name	PV capacity	Current tariff type	Period of data	Metering at site
Lyons Community	-	Commercial flat rate	1 July 2015 to 30 June 2016	Unknown – likely time of use

Facility name	PV capacity	Current tariff type	Period of data	Metering at site
Centre				
West Lane Car Park	-	Commercial flat rate	1 July 2015 to 30 June 2016	Unknown – likely time of use
China Town Car Park	-	Commercial flat rate	1 July 2015 to 30 June 2016	Unknown – likely time of use
Casuarina Library	Up to 99.8 kW	Commercial flat rate	1 July 2015 to 30 June 2016	Unknown – likely time of use
Operations Centre	Up to 99.6 kW	Commercial flat rate	15 Oct 2015 to 30 June 2016	Unknown – likely time of use
Nightcliff Pool [(a)]	Up to 58.0 kW	Commercial flat rate	24 June 2015 to 30 June 2016	Time of use

Notes: (a) Only six days of data supplied – insufficient data for analysis

Source: Marsden Jacob analysis of data supplied by Jacana to the City of Darwin

5.10.3 Project description

The hypothesis was that upgrades to time of use meters at selected sites should enable City of Darwin to move to more favourable tariffs, however as noted below, this hypothesis proved false.

5.10.4 Project net benefits

Time of use data was available at seven of City of Darwin's sites. Three of the sites (Lyons Community Centre, West Lane Car Park and China Town Car Park) do not currently have any PV installed, while the remaining four sites each have PV already installed.

Marsden Jacob analysis (shown in Table 23) suggests City of Darwin should remain on the existing flat rate tariffs regardless of metering or installation of solar panels.

Table 23: Benefit of changing tariffs at selected sites

Facility name	Consumption for period of data (kW)			Benefit in switching to TOU tariff from flat rate tariff	Recommendation
	Peak	Off-peak	Feed-in[(a)]		
Lyons Community Centre	142,737	128,149	N//A	-$1,199	Remain on flat rate tariff
West Lane Car Park	1,072,439	369,702	N/A	-$58,360	Remain on flat rate tariff, consider solar to offset high peak use.
China Town Car Park	132,421	118,138	N/A	-$1,175	Remain on flat rate tariff
Casuarina Library	1,031,880	355,928	-	-$56,136 (assuming no solar)	Remain on flat rate tariff, solar panel is providing a marginal benefit
	979,479	355,786	52,401 (peak) 1 (off-peak)	-$55,817 (with solar demand) -$51,793 (with solar and feed-in tariff)	

Facility name	Consumption for period of data (kW)			Benefit in switching to TOU tariff from flat rate tariff	Recommendation
	Peak	Off-peak	Feed-in[(a)]		
Operations Centre	227,689	220,520	-	-$574 (assuming no solar)	Remain on flat rate tariff, solar panel is providing a marginal benefit
	222,576	220,519	48,555 (peak) 128 (off-peak)	-$149 (with solar offsetting demand) -$4,692 (with solar and feed-in tariff)	

Note: (a) Feed in amount is the excess above demand (i.e. the amount feed back into grid after demand at site is netted off)

5.11 Alternative Transport Options

5.11.1 Current Transport Fleet and Usage

As outlined in Section 2.6, the City of Darwin had 140 vehicles in 2016, most ICE vehicles. The City of Darwin has also started to utilise hybrid light vehicles (6 vehicles) and hybrid trucks (16 vehicles). Emissions from the vehicle fleet were estimated to be 619 tonnes of CO_2^e in 2016.

Table 24 shows the energy content and emission intensity factor of ICE vehicles using ULP or diesel, as well as that for compressed natural gas and electricity – alternative low emission fuels that could be considered in the future.

Table 24: Energy Content and Emission Intensity of Vehicle Fuels

Fuel Type	Energy Content (GJ/kL)	Emission Intensity Factor (kg CO2e) per GJ
Unleaded Petrol (ULP)	34.2	67.4
Diesel	38.6	69.9
Electricity	NA	51.4
Compressed Natural Gas	6.04	51.4

5.11.2 Alternative Transport Vehicles

The alternative to ICE vehicles includes the following options:

- Hybrid Electric Vehicles (HEVs) such as the Toyota Prius have been in Australia for about 10 years and effectively use liquid fuel (petrol) as their sole power source, but supplement this with electrical energy from the braking system and that stored in on-board batteries (e.g. typically lithium ion). Offers an improvement in fuel efficiency of between 10 to 15 percent over ICE vehicles.
- Plug-in Hybrid Electric Vehicles (PHEVs), use both electrical energy and liquid fuel. Plug in vehicles include the Mitsubishi Outlander. Can reduce fuel costs by up to 50 per cent, but have higher capital costs associated with increased battery storage and home/business recharging facilities.
- Battery Electric Vehicles (BEVs) only use electrical energy as their sole energy source. The light vehicles available in Australia include the Nissan LEAF and Mitsubishi i-MiEV.

Can substantially reduce fuel costs (up to 60 per cent), but have substantially higher capital costs associated with increased battery storage and home recharging facilities. Depending on the electricity generation fleet that is producing grid energy, may not reduce overall emissions if coal or gas fired generation is the primary fuel type used for power generation. However, given that the DKIS is dominated by gas plant, using electricity only in vehicles should lower emissions.

- Compressed Natural Gas (CNG) Vehicles, uses natural gas that is compressed into storage tanks (1 per cent of gas volume) on the vehicle. Typically used in trucks, since there is usually plenty of space available for large gas tanks on the vehicle. Used widely in the world where natural gas is available and relatively cheap (e.g. Iran, Pakistan and Argentina). CNG is more fuel efficient than diesel and has lower emissions. CNG vehicles are not standard and therefore more expensive to purchase and require access to CNG refill facilities which can cost $0.5 M to build.

Marsden Jacob have calculated the levelised cost of the different vehicle types to assess the financial benefit to the City of Darwin and the costs of emission abatement.

5.11.3 Levelised Cost Analysis – by vehicle segment

We have calculated the levelised costs for four vehicle types:

- Passenger vehicle
- Suburban Utility Vehicle (SUV)
- Light Commercial Vans
- Trucks with a Gross Vehicle Mass (GVM) of 4.5 tonnes

The full analysis, levelised cost and unit cost of abatement is presented for each vehicle type, with commentary provided below each Table.

Table 25: Levelised Cost Analysis for Passenger Vehicles (2017) – current dollars

Vehicle Type - Passenger Vehicle					
Fuel Type	Petrol	Diesel	Petrol Hybrid Electric Vehicle	Petrol Hybrid Electric Vehicle	Battery Electric Vehicle
Electric Type			No recharge (HEV)	With recharge (PHEV)	With recharge
Purchase Price ($)	$28,627	$27,843	$31,809		$46,818
Recharge Capital Costs ($)					$2,500
Annual Maintenance Cost ($)	$1,480	$1,480	$1,480		$740
Vehicle Life (Years)	5	5	5		5
Residual Value ($)	$ 8,588	$ 8,353	$ 9,543		$ 14,045
Discounted Residual Value ($)	$ 6,602	$ 6,421	$ 7,336		$ 10,798
CO2 (g/km) - ICE	183	178	121		
CO2 (g/km) - Electric					77.9
Fuel Consumption Litres/100 km	7.8	6.6	5.2		
EnergyConsumptionWhkm					173
Distance (km per annum)	15,000	15,000	15,000		15,000
Petrol Consumption Litres	1,170	990	780		
Electricity Consumption kWh					2,595
Energy Costs $/annum	$ 1,494	$ 1,176	$ 996		$ 623
Emissions (CO2e) - tonnes	2.75	2.67	1.82		1.17
Annualised Costs $/annum	$ 8,118	$ 7,659	$ 8,192		$ 10,359
Incremental Costs $/annum	-	(459.03)	73.55		2,240.67
Incremental Abatement CO2e - tonnes	-	0.08	0.93		1.58
Unit Cost of Abatement - $/tonne		(6,120)	79		1,421

Source: MJA analysis

Key findings for passenger vehicles:

- Petrol, diesel and HEV's had a similar levelised cost (~$8000 per annum). Given that the annualised cost of diesel plant was lower than for petrol cars, it is commercially feasible to switch to diesel vehicles today.

- HEV's are slightly more expensive and help to reduce emissions by 0.93 tonnes per annum. It is estimated that the cost of abatement was $79/tonne in 2017. However, by 2022, the cost of battery storage reduces sufficiently that HEV's are more economic than both diesel and petrol cars.
- BEV's reduce emissions by 1.58 tonnes per annum per vehicle. However, BEV's are not economically viable until 2027 due to the relatively high cost of battery storage.

Table 26: Levelised Cost of SUVs (2017) – current dollars

Vehicle Type - SUV Vehicle					
Fuel Type	Petrol	Diesel	Petrol Hybrid Electric Vehicle		Battery Electric Vehicle
Electric Type			No recharge (HEV)	With recharge (PHEV)	With recharge
Purchase Price ($)	$29,636	$39,702	$36,809	43,173	$56,942
Recharge Capital Costs ($)				$2,500	$2,500
Annual Maintenance Cost ($)	$1,800	$1,800	$1,800	$1,800	$900
Vehicle Life (Years)	5	5	5	5	5
Residual Value ($)	$ 8,891	$ 11,911	$ 11,043	$ 12,952	$ 17,083
Discounted Residual Value ($)	$ 6,835	$ 9,156	$ 8,489	$ 9,957	$ 13,133
CO2 (g/km) - ICE	161.36	167.28	202.00	202.00	
CO2 (g/km) - Electric				60.3	63.7
Fuel Consumption Litres/100 km	7	6.2	8.4	7	
EnergyConsumptionWhkm				134	141.51
Storage (kWh)				5.57	
Electric Power Use Per Year (kWh)				2,010	2,123
Electric Distance Per Year (km)	0	0	0	15,000	15,000
Petrol Distance Per Year (km)	15,000	15,000	15,000	-	-
Distance (km per annum)	15,000	15,000	15,000	15,000	15,000
Petrol Consumption Litres	1,050	930	1,260	-	-
Energy Costs $	$ 1,341	$ 1,105	$ 1,609	$ 482	$ 509
Emissions (CO2e) - tonnes	2.42	2.51	3.03	0.90	0.96
Annualised Costs $/annum	$ 7,986	$ 9,395	$ 9,427	$ 9,924	$ 11,302
Incremental Costs $/annum	$ -	$ 1,409	$ 1,441	$ 1,938	$ 3,316
Incremental Abatement CO2e - tonnes	-	(0.09)	(0.61)	1.52	1.47
Unit Cost of Abatement - $/tonne		$ 15,846	$ 2,363	$ 1,278	$ 2,263

Source: MJA analysis

Key findings for SUV's:

- Petrol SUV's are substantially cheaper than other SUV types. For the vehicles chosen, both diesel and HEV had higher emissions because the fuel consumption efficiency was lower than the nominated petrol vehicle.
- The PHEV and BEV had substantially lower emissions but had significantly higher annualised costs.
- Even in 2027, PHEVs and BEV's were not economically viable when compared to diesel or petrol vehicles.

Table 27: Levelised Cost Commercial Vans (2017) - current dollars

Vehicle Type - Light Commercial Vans					
Fuel Type	Petrol	Diesel	Petrol Hybrid Electric Vehicle		Battery Electric Vehicle
Electric Type			No recharge (HEV)	With recharge (PHEV)	With recharge
Purchase Price ($)	$29,082	$34,536	$32,264	34,236	$45,000
Recharge Capital Costs ($)				$1,371	$1,371
Annual Maintenance Cost ($)	$1,800	$1,800	$1,800	$1,800	$900
Vehicle Life (Years)	5	5	5	5	5
Residual Value ($)	$ 8,725	$ 10,361	$ 9,679	$ 10,271	$ 13,500
Discounted Residual Value ($)	$ 6,707	$ 7,965	$ 7,441	$ 7,896	$ 10,378
CO2 (g/km) - ICE	238	232	205	205	
CO2 (g/km) - Electric				-	63.7
Fuel Consumption Litres/100 km	10.1	8.8	8.3	10.1	0.0
EnergyConsumptionWhkm	0	0	0	134	141.51
Storage (kWh)				5.57	
Electricity Consumption kWh				2,010	2,123
Electric Distance Per Year (km)	0	0	0	15,000	15,000
Petrol Distance Per Year (km)	15,000	15,000	15,000	-	-
Distance (km per annum)	15,000	15,000	15,000	15,000	15,000
Petrol Consumption Litres	1,515	1,320	1,242	-	-
Energy Costs $	$ 1,935	$ 1,568	$ 1,587	$ 482	$ 509
Emissions (CO2e) - tonnes	3.57	3.48	3.07	-	0.96
Annualised Costs $/annum	$ 8,489	$ 9,014	$ 8,661	$ 8,199	$ 9,086
Incremental Costs $/annum	$ -	$ 525	$ 172	$ (290)	$ 597
Incremental Abatement CO2e - tonnes	-	0.09	0.50	3.57	2.61
Unit Cost of Abatement - $/tonne		$ 5,833	$ 344	$ (81)	$ 228

Source: MJA analysis

Key findings for Commercial Vans:

- Provided the Van's did 15,000 km per year, it was viable for the City of Darwin to invest in PHEV's. Both HEV and BEV's were not economic.
- However, by 2022, all electric commercial vans are viable.

Vehicle Type - Truck (4.5 tonne GVM)						
Fuel Type	Petrol	Diesel	Petrol Hybrid Electric Vehicle		Battery Electric Vehicle	CNG
Electric Type			No recharge (HEV)	With recharge (PHEV)	With recharge	
Purchase Price ($)		$57,927	$65,927		$157,927	$67,927
Re-Charge Capital Costs ($)					$1,000	$10,667
Annual Maintenance Cost ($)		$5,000	$5,000		$2,500	$5,000
Vehicle Life (Years)		5	5		5	5
Residual Value ($)		$ 17,378	$ 19,778		$ 47,378	$ 20,378
Discounted Residual Value ($)		$ 13,360	$ 15,205		$ 36,423	$ 15,666
CO2 (g/km) - ICE		529	407			345
CO2 (g/km) - Electric					241.7	
Fuel Consumption Litres/100 km		19.6	15.1			19.6
EnergyConsumptionWhkm					537.0	
Distance (km per annum)		15,000	15,000		15,000	15,000
Petrol Consumption Litres		2,940	2,264			2,940
Electricity Consumption kWh					8,055	
Energy Costs $		$ 3,493	$ 2,892		$ 1,933	$ 2,513
Emissions (CO2e) - tonnes		7.93	6.11		3.62	5.17
Annualised Costs $/annum		$ 17,963	$ 18,669		$ 30,484	$ 21,108
Incremental Costs $/annum		$ -	$ 706		$ 12,521	$ 3,145
Incremental Abatement CO2e - tonnes		-	1.83		4.31	2.76
Unit Cost of Abatement - $/tonne			$ 386		$ 2,907	$ 1,138

Table 28: Levelised Costs for Trucks (2017) - current dollars

Source: MJA analysis

Key findings for trucks with a GVM of 4.5 tonnes:

- Diesel trucks had the lowest annualised cost. All other truck technologies were not viable. This includes CNG trucks, which are not viable because of the relatively high cost of delivered natural gas in the Northern Territory and the cost of establishing a CNG charging station.
- HEV's had the second lowest annualised cost and did reduce emissions by 1.83 million tonnes per annum. However, the abatement cost was still about $386 per tonne.
- HEV's were viable by about 2027.

5.11.4 Net Benefits of Alternative Transport Fuels

There are considerable uncertainties with the estimates of both current and future costs of vehicle technologies utilising electric motors and battery storage. We have assumed a particular 'learning curve' impact on capital costs over the study period, which is subject to conjecture.

In addition, we have had to make adjustments to the purchase price of vehicles to eliminate price premiums that car dealers may charge for new vehicles which are based on novelty or scarcity value of the vehicle.

In other instances, such as the case for all electric trucks, we had to rely on international data on the cost and performance of these vehicles given that they are not sold in Australia.[50]

Despite these caveats, there is sufficient evidence to suggest that hybrid passenger vehicles and commercial vans should be considered when replacing existing vehicles.

In relation to the truck fleet, hybrid electric vehicles are a relatively expensive way of reducing greenhouse emissions at the current time ($386/tonne). However, with the improving economics of battery storage, all electric trucks may be viable in the mid 2020's.

5.11.5 Opportunities and Limitations

Given the developments in renewable generation technology, it can be argued that solar PV could be used solely to recharge electric vehicles. This would further decrease the emission intensity of electricity vehicles (which is currently based on the emission intensity of the Darwin-Katherine Interconnected System) and decrease energy costs since the marginal cost of electricity from solar farms is zero.

The latter argument ignores the fact that solar farms are capital intensive ($2200/kW) and have a levelised cost of around $105/MWh. To recover this cost, the City of Darwin needs to utilise the output to avoid purchasing power from the grid (behind the meter) at $400/MWh in peak periods and $200/MWh in off peak periods, or alternatively exporting the power into the Wholesale market (network connected solar farms) at around $150/MWh in the energy market and earning LGC's of around $80/MWh. This implies that the opportunity value of solar generation is extremely valuable in both retail and wholesale electricity markets. In effect, the real cost of charging electric vehicles are avoided retail tariffs or wholesale market prices (energy and LGCs).

The installation of PV systems by the City of Darwin will reduce the emission intensity of the City of Darwin in aggregate. This benefit can't be allocated to one particular use (e.g. transport) and should be shared across all activities undertaken by the City of Darwin.

5.12 Carbon Offsets

5.12.1 Purchasing Carbon Offsets

Instead of undertaking emission reduction strategies itself, the City of Darwin could purchase carbon offsets to reduce its emission intensity. Specialist retailers can source carbon offset from legitimate emission reducing projects, such as tree planting, reducing land clearing, methane capture and use (for generation) and/or renewable generation.

50 California Hybrid, Efficient and Advanced Truck Research Center

The carbon offset market have a range of validation and verification standards that can ensure that emission reductions are legitimate. For example, The Australian Government's National Carbon Offset Standard (NCOS) provide guidance on what is a genuine voluntary offset and sets minimum requirements for calculating, auditing and offsets. Other well-known standards that are used in Australia and overseas include: Verified Carbon Standard (VCS), The Gold Standard (GS), Social Carbon, Australian Carbon Credit Unit (ACCU) and Reducing Emissions from Deforestation and Forest Degradation (REDD).

Reputable companies in this space include Carbon Neutral, CO2 Australia and Climate Friendly.

Historically, councils have not used such offsets to contribute to emissions reductions. This has primarily been for two reasons. Firstly, domestic offsets may not provide additionality, that is, they may not ensure that purchase of offsets reduces domestic emissions incrementally. Secondly, councils have been reluctant to purchase international offsets.

The advantage of offsets is cost. Voluntary offsets typically trade at price lower than mandatory carbon prices ($AUD 5 to $AUD 15 per tonne). Therefore, voluntary offsets would be expected to be traded at a lower price than the anticipated Australian carbon price of $20/tonne in 2020. However, the feasibility and cost of purchasing voluntary carbon offsets over the period of this energy strategy is difficult to estimate due to the inherent policy uncertainty of a national carbon scheme.

5.12.2 Developing Carbon Offsets through Carbon sequestration

Carbon sequestration is the process of removing carbon from the atmosphere and depositing it in a long term storage. Sequestration methods include:

- enhancing the storage of carbon in soil (soil sequestration);
- enhancing the storage of carbon in forests and other vegetation (plant sequestration); and
- storing carbon in underground geological formations (geosequestration).

The most likely option is for the City of Darwin to revegetate suitable land that it owns or to undertake plantings on private land or land outside of the City of Darwin.

There are significant risks associated with carbon sequestration projects involving revegetation including poor performance (due for example to drought) or damage to or loss of trees due to fire.

Studies undertaken by Marsden Jacob indicated that typically tree planting projects can cost up to $25 to $30 per tonne of CO_2^e.

5.12.3 Opportunities and Limitations

While carbon offsets reduce emissions, they do not reduce overall energy costs. As outlined earlier, solar PV and energy efficiency projects reduce both emissions and electricity costs. This implies that these projects have a positive net benefit, whereas carbon offsets only have a net cost which is likely to rise overtime if carbon trading is introduced in Australia (i.e. increased demand for carbon offset projects will result in increased price rises).

Purchase of carbon offsets at the current time is cheaper than other options, such as replacing ICE vehicles with electric vehicles.

However, given the availability of other options to reduce emissions (e.g. solar PV), purchasing or developing Carbon Offset projects are not recommended.

6. Future Energy Use and Emission Reductions

6.1 Background

Based on the options developed in Chapter 5, we have estimated the reduction in energy use and emission intensity that would result if those options are implemented over the study period. This analysis is used to understand the magnitude of reductions that could be achieved by 2030.

We also provide estimates of the capital investment required to build new facilities and solar generation, and install equipment necessary to achieve the forecast energy use and emission reductions.

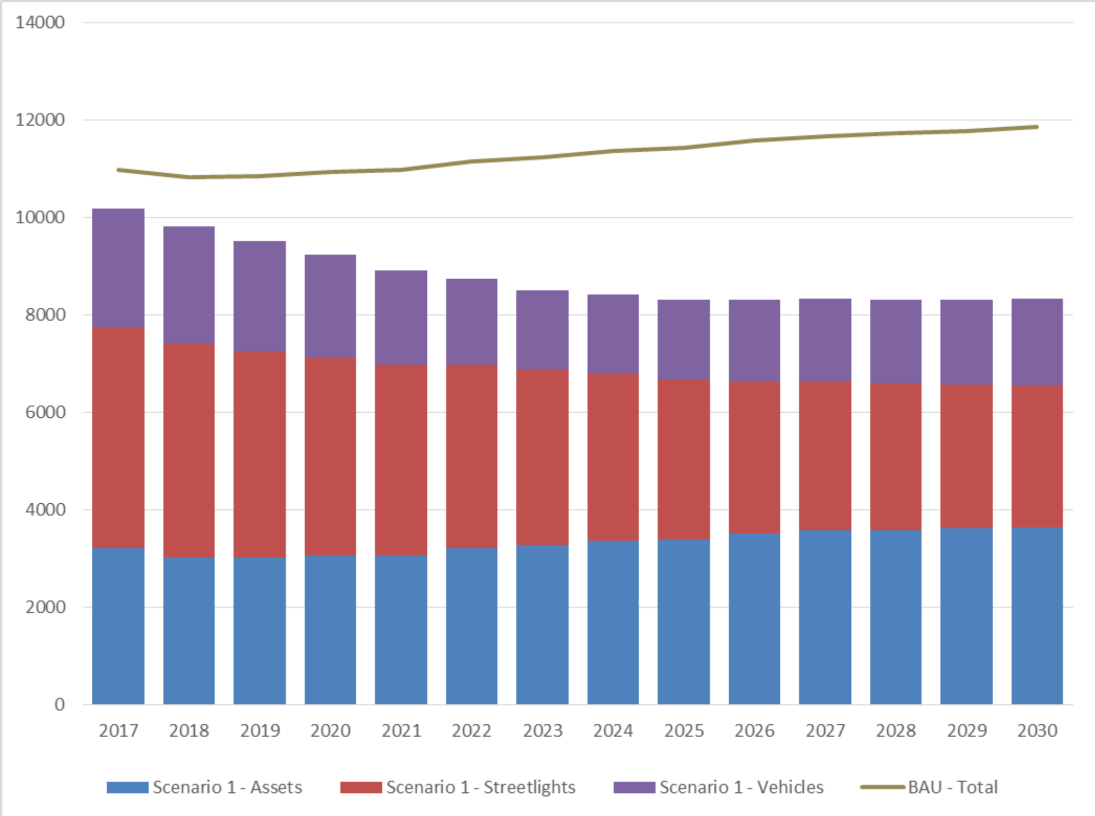
The initiatives that have been quantified include the following:

- Installation of a solar PV system at the Shoal Bay Waste Management Centre;
- Installation of rooftop solar at the Civic Centre;
- Put in place a power purchase agreement with a large-scale solar farm developer to help underwrite the project;
- Installation of energy efficient public lighting at end of life, except for Mercury Vapour lights which are replaced with LED lighting in accordance with the Minamata convention.
- Replacement of existing HVAC systems with more energy efficient systems (i.e. accelerated replacement);
- Replace conventional vehicles using either petrol or diesel with hybrid (electric) vehicles.

6.2 Outcomes of implementing all measures – Scenario 1

Shown below is total energy use if the initiatives are implemented in 2017. What this shows is that overall energy consumption is reduced by 30 per cent by 2030 when compared to the base case.

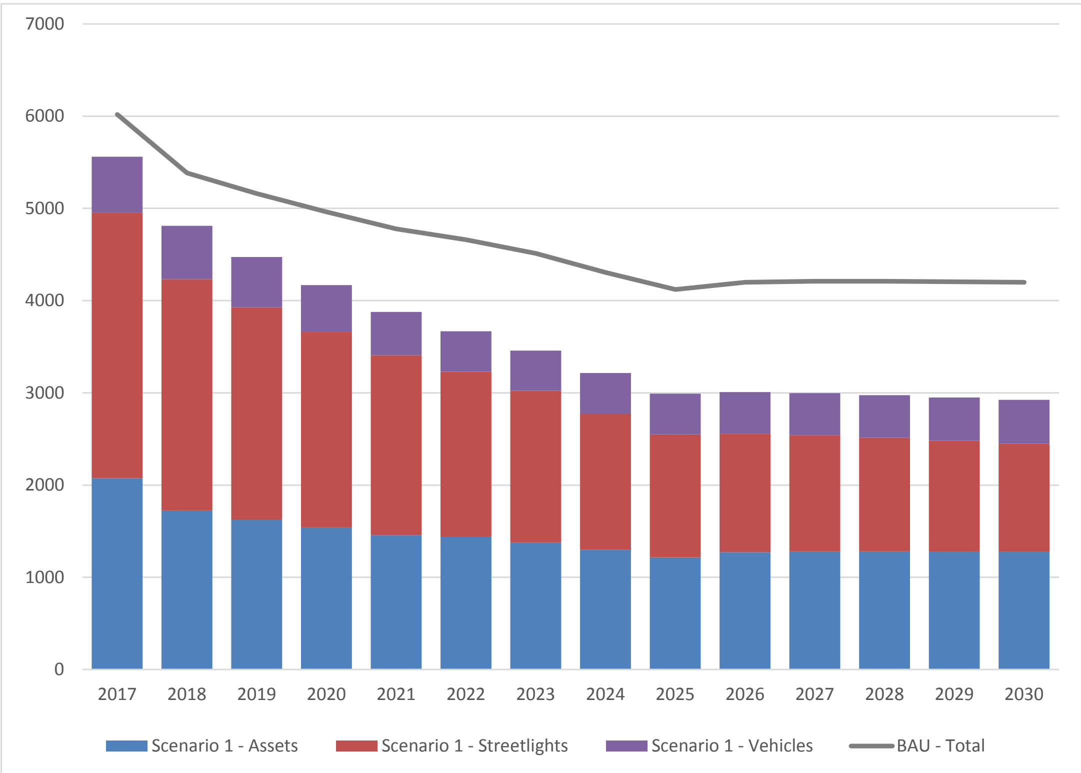
Figure 35: Energy Consumption by Segment - Alternative Scenario 1 (MWh)



Source: MJA analysis

In relation to emissions, by 2030 the City of Darwin's emissions have reduced by 30 per cent, which is in line with the reduction in energy use.

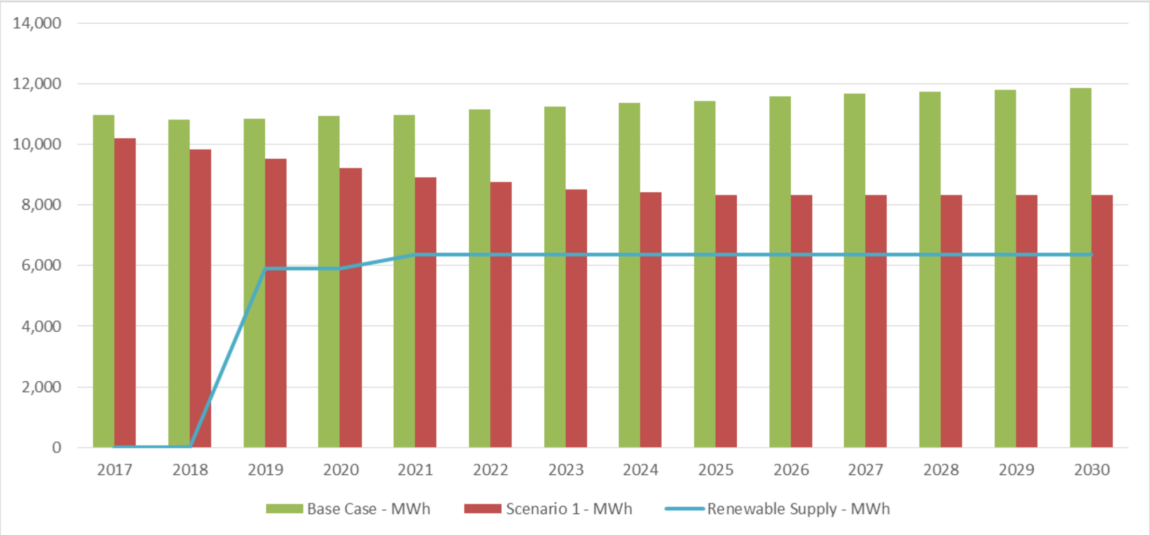
Figure 36: Emissions by Segment - Alternative Scenario 1 (tonnes)



Source: MJA analysis

While energy consumption and emissions have reduced, there is a further reduction in emissions because the City of Darwin is using renewable energy from solar PV to meet most of its power needs. As outlined below, solar PV is supplying the City of Darwin with over 6000 MWh per annum.

Figure 37: Energy Consumption (by Scenario) and Renewable Generation (MWh)



Source: MJA analysis

As a result, the net emissions for the City of Darwin (after taking into account the zero emissions from electricity generated from solar PV), are only 13.8 per cent of total emissions in the Base Case by 2030. Over the entire period, emissions avoided are around 47,000 tonnes.

Figure 38: Net Emissions (tonnes)

Source: MJA analysis

6.3 Scenario 1 Capital Budget

The estimated capital funding requirements to achieve the forecast reductions in energy use and emissions are summarised in the table below.

Table 29: City of Darwin Capital Budget – by project

Project	Incremental Capital Expense ($)
Street lighting upgrades	$500,000
Long term solar farm PPA	Operating Expense
Shoal Bay solar PV	$2,000,000
Hybrid vehicles	$1,113,500
Civic Centre rooftop PV	$489,600
HVAC replacement (Audit Report Proposal)	5,707,000
Total Capital Cost	**$9,810,100**

Source: MJA analysis

6.4 Alternative Scenarios

Alternative Scenarios (and emission reduction targets) that have been considered in this study include the following:

- Zero emissions – implementing measures to ensure that the City of Darwin has zero (net) emissions by 2030.
- NPV Positive Projects Only – implementing measures that are economically viable.
- 50 per cent Renewables – achieving a 50 per cent renewable energy target by 2030.

To achieve zero (net) emissions by 2030, we have increased the installed capacity of the solar farm at the Shoal Bay Waste Management Facility (1 to 1.2 MW capacity). This increases the capital cost of the facility from $2 M to $2.4 M.

The NPV Positive projects include the Civic Centre rooftop PV, street lighting upgrades, replacement of the HVAC systems with VRF at the end of useful lives ($0.9 M instead of $5.7 M), purchase of hybrid commercial vehicles (not trucks), and the long term PPA with a solar farm. The capital cost of these projects (excluding the solar farm) is $5.2 M.

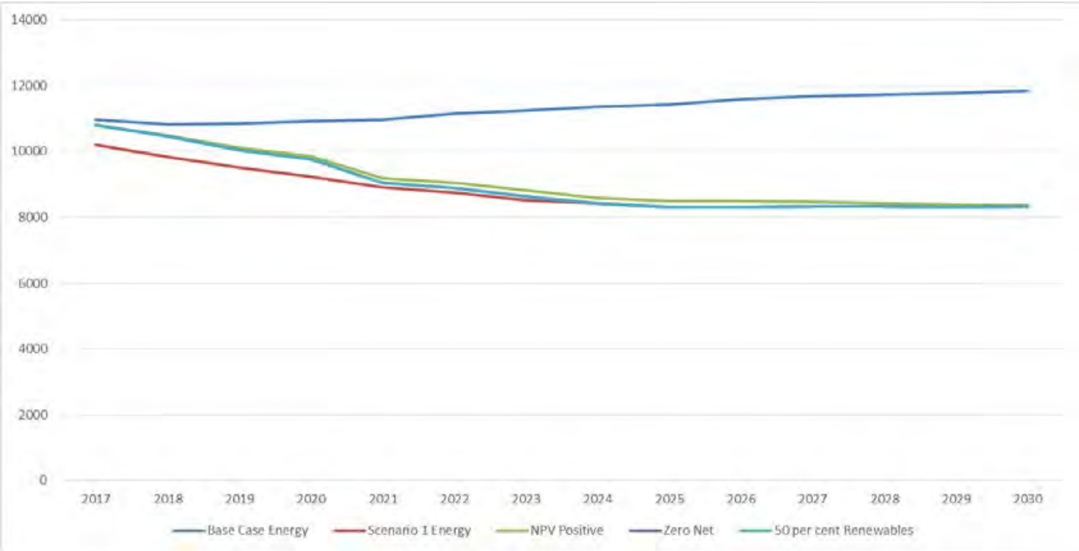
Table 30: Capital Expenditure (NPV Positive Projects Only)

Project	Incremental Capital Expense ($)
Street lighting upgrades	$500,000
Long term solar farm PPA	Operating Expense
Shoal Bay solar PV	$2,200,000
Hybrid vehicles	$1,113,500
Civic Centre rooftop PV	$489,600
HVAC replacement (End of Life Replacement Only)	900,000
Total Capital Cost	**$5,203,100**

Note: CAPEX on hybrid vehicles does not change as it is assumed that all trucks are converted to hybrid by 2030 in both Scenario 1 and the NPV Positive Projects Case. However, the timing in CAPEX is different in each case.

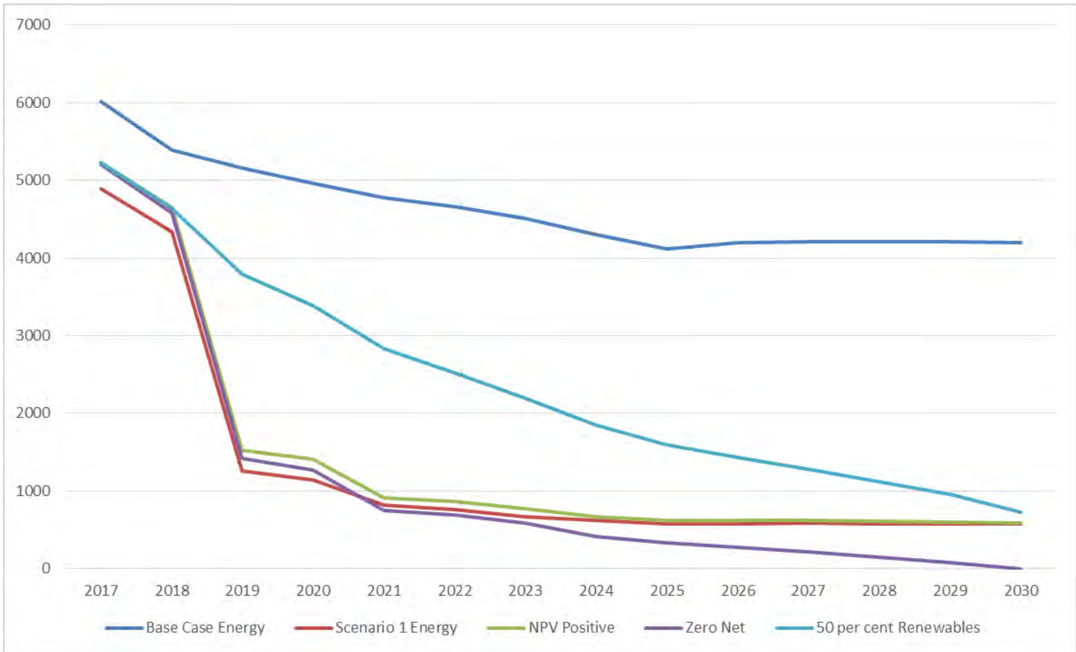
The energy use and net emission trajectories for the above scenarios are shown in the Figures below, along with both base case and scenario 1 energy and emission trajectories.

Figure 39: Energy Use (MWh) trajectories



Source: MJA analysis

Figure 40: Emission (tonnes) trajectories



Source: MJA analysis

6.5 Potential Challenges to Achieving Targets

A range of targets have been outlined in the previous sections. To a large extent the achievement of various energy use and emission reduction targets is highly dependent on installing solar installations at the Civic Centre and at the Shoal Bay Waste Management Facility, as well as purchasing energy from a large-scale solar farm (PPA).

It is our understanding that the Power and Water Corporation (PWC) have received more than 100 proposals for large-scale solar systems to date (~100 MW of capacity). The deployment of solar systems will be dependent on meeting technical requirements for network connection as well as permitting these generation sources to export surplus power to the wholesale electricity market, or permitting owners of these systems to net meter (further discussed in Section 7.1.1).

However, given the NT government is committed to a 50 per cent renewable energy target by 2030 and the opening up of the competitive electricity market, Marsden Jacob is confident that reforms will be implemented to permit the increased penetration of solar generation.

Further discussions of some of the major implementation issues associated with large-scale solar proposals are discussed in the next chapter.

7. Implementation Plan

7.1 Implementation Issues

7.1.1 Virtual Net Metering

Virtual Net Metering (VNM) is an arrangement whereby generation at one site can be utilised by a load at another site, therefore minimising the amount of energy that is "spilled" into the grid. The significant advantage of this approach is that instead of the energy being spilled into the network and the generator only receiving a "feed-in" tariff rate, which can be 0 in some jurisdictions (e.g. commercial customers in WA) and below 10 c/kWh for residential and small business customers, the surplus generation can be used to help the (net) load avoid a retail energy tariff rate of 30 c/kWh. This implies that the net load customer will be willing to pay the generator a price significantly higher than most feed in tariff rates (0 to 10 c/kWh).

This is not so much of a problem for small scale PV systems in the Northern Territory given that energy fed into the grid receives the retail tariff rate. However, the 1:1 feed-in tariff for solar systems is applicable to solar PV systems smaller than 30 kVA and producing less than 750 MWh per annum.

This implies that the City of Darwin (or another solar developer) is unlikely to receive the generous feed-in tariff rate. Therefore VNM has potential value to the City of Darwin.

A number of VNM (paper) trials are taking place in the National Electricity Market, led by the Institute for Sustainable Futures (ISF) and funded by the Australian Renewable Energy Agency (ARENA) and other partners.[51] This includes Councils that are listed in the following table, along with some specifics of the trials.

Table 31: Virtual Net Metering Trials (NEM)

Proponent	Winton Shire Council	Byron Shire Council	Willoughby Council	Wannon Water
State	QLD	NSW	NSW	VIC
Network provider	Ergon Energy	Essential Energy	Ausgrid	Powercor
Retailer	Ergon Energy	Origin Energy	Energy Australia	AGL
Technology	Geothermal	Solar PV	Cogen	Wind
Size	310 kW	150kW	173 kW	800 kW
Generation site	New plant	Sports Centre	Leisure Centre	Waste Water Treatment Plant
Netting off sites	29 Winton Council sites	Waste Water Treatment Plant	Concourse	17 Wannon Water & 4 Glenelg Shire Council
LET model	1-to-1 transfer	1-to-1 transfer	1-to-1 transfer	1-to-2 transfer

Source: Rutovitz et al.

It is hoped that the paper trial will improve the benefits of VNM in helping to improve the payback on investment in embedded generation (which includes PV). While the introduction of VNM can improve the benefits of PV in the NT, our feasibility studies indicated that solar PV was feasible today without any additional subsidies. The high cost of energy in the NT

51 Rutovitz, J., Langham, E., Teske, S., Atherton, A. & McIntosh, L. (2016), *Virtual trials of Local Network Charges and Local Electricity Trading: Summary Report*. Institute for Sustainable Futures, UTS.

made it economic for solar PV systems to be installed in the NT. In fact, the NT has the highest paybacks on investment in large-scale solar compared to any other jurisdiction in Australia.[52]

While the City of Darwin can be supportive of these initiatives, they are not critical to the business case for solar in the Territory.

7.1.2 Wholesale Energy Spilling

In the absence of Virtual Net Metering, the City of Darwin will be required to put in place arrangements to sell the excess energy to retailers or into the wholesale electricity market.

Most major retailer's contracts with Territory Generation finish in 2018, which implies that now is a good time to work with retailers to offer them excess power from solar systems. The energy provided from solar systems (levelised cost of $100/MWh) is likely to be substantially below the generation price that Territory Generation can offer to retailers ($150/MWh). As a result, retailers will be happy to accept solar off take agreements from the City of Darwin (and others).

Alternatively, the City of Darwin could supply energy into the wholesale electricity market which is currently in development. This may require that the City of Darwin become a market participant in the wholesale electricity market (which includes meeting prudential requirements) and developing a trading desk. Given that energy trading is not the City of Darwin's core business, it is recommended that the City of Darwin enter into a long term off take agreement with a retailer, unless required to be a market participant under future wholesale market rules.

7.1.3 Ancilliary Service Charges for Solar Plants

It is likely that with the development of the wholesale electricity market (NTEM) that ancilliary services will become unbundled from current wholesale market offers from Territory Generation. Ancilliary service requirements (e.g. spinning reserve and load following services) are likely to increase as more intermittent generation is added to the Darwin-Katherine system.

On the basis of "user-pays" principles, it is likely that owners of intermittent generation will bear a higher proportion of these costs.

Using our knowledge of the DK system, we have estimated the additional ancilliary services costs that may be allocated to large-scale solar farms in the Territory. We have assumed that for every 1 MW of solar PV installed, 1.2 MW of additional spinning reserve is required to meet the DK system reliability criteria. This results in an increase in ancilliary costs paid by solar farms to be $22/MWh higher than for conventional generation in the Territory. If these costs are allocated to PV installed at the Civic Centre, Shoal Bay Waste Management Facility or the large-scale solar farm (PPA), the projects will have higher costs of abatement as outlined below.

- Shoal Bay cost of abatement reduces from ($107) per tonne to ($70) per tonne;
- Large-scale solar PV (PPA) cost of abatement reduces from ($104) per tonne to ($67) per tonne

52 Bloomberg New Energy Finance, *Australian REC Market Outlook*, 21 March 2016.

- Civic Centre solar PV cost of abatement reduces from ($333) to ($291) per tonne.

However, all projects remain economically viable and should be pursued even if higher ancilliary services costs are allocated to solar systems.

7.1.4 Energy Strategy Capital Fund

In order to reduce the capital burden (e.g. equity and/or debt) of the implementation of the proposed Energy Strategy for the City of Darwin, a capital fund could be established whereby any annual energy cost savings delivered by the implementation of various initiatives could be allocated to a specific Energy Strategy Capital Fund. This funding could then be used to fund additional capital expenditure in future years.

To do this would require establishing a base case for energy expenditure (which could be based on Base Case energy consumption) and comparing with the energy expenditure under the particular target chosen by the City of Darwin.

7.1.5 CEFC Funding

In addition to the above Capital Fund, the City of Darwin should seek to obtain finance for from the CEFC for various Energy Strategy initiatives (e.g. street lighting upgrades). As outlined in Section 4.3.3, the CEFC has a specific program to finance renewable energy and energy efficiency projects undertaken by Local Governments (i.e. Local Government Finance Program). There are other programs that can also be accessed specifically for large-scale solar projects (i.e. Clean Energy Innovation Fund).

7.2 Implementation Plan

The relative timing of each initiative is outlined in the table below. Also outlined are some of the studies and steps required to implement the initiative. We have also outlined any dependencies of the initiative on other projects or major decisions that need to be made by the City of Darwin.

Table 32: Implementation Plan

Initiatives and Project Activities	
Initiative	Street lighting upgrades
Recommended Start Date	1-Jul-17
Project Activities	(a) Currently being evaluated by an external consultant
Dependencies	Cost reduction benefits will need to be determined and passed through to the City of Darwin by PWC (i.e. via street light tariffs).
Initiative	Civic Centre rooftop PV
Commissioning Date	1-Jul-20
Project Activities	(i) Engineering study to determine solar contribution of rooftop solar system and initial system design. (ii) Negotiation with retailers on solar buy back arrangements (if required). (iii) Completed Business Case (External Consultant) (iv) Application for CEFC Funding (v) Engineer, Procure and Contract (EPC)

Dependencies	Decision to replace the current Civic Centre Roof
Initiative	Shoal Bay Solar PV
Commissioning Date	1-Jul-19
Project Activities	(i) Engineering study to determine solar contribution of ground mounted solar system and initial system design. (ii) Negotiation with retailers on net metering arrangements for solar farm. (iii) Completed Business Case (External Consultant). (iv) Application for CEFC Funding (v) Engineer, Procure and Contract (EPC)
Dependencies	Permission from Department of Defense on the use of the site as a solar farm.
	Hybrid and Electric Vehicles
Commencement	1-Jul-17
Project Activities	(i) Seek quotes from suppliers (ii) Prepare Business Case (iii) Procure and Manage
Dependencies	None
Initiative	HVAC Replacement
Commissioning Date	Depends on replacement date for existing systems
Project Activities	(i) Engineering design study (ii) Completed Business Case (External Consultant) (iii) Engineer, Procure, Contract (EPC)
Dependencies	Determine end dates for replacement of existing HVAC systems
Initiative	Long Term Solar PPA
Project Activities	(i) Enter into discussions with energy retailers/generators on potential off take arrangements for multiple sites. (ii) Competitive energy and LGC procurement (all sites) (iii) Finalise contractual supply arrangements with preferred supplier.
Dependencies	None

Appendix A: Classifications and account details by site

Marsden Jacob received data from the City of Darwin's Planet Footprint database for the purposes of this project. The data covered the contained quarterly electricity consumption for 166 accounts across 100 sites. Where meter identifiers had been recorded, each meter was associated with a unique account number.

Data was available for the years full datasets were available for the years 2005-06 to 2015-16 and partial data was available for 2004-05.

Table 33 summarised the City of Darwin sites included in the database, allocated classification used in Marsden Jacob analysis, relevant account numbers and meter identifiers for the accounts (where recorded).

Table 33: Site classifications, account number and meter identifier by site

Site	Classification	Account number	Meter identifier
Amphitheatre	Sport and Leisure	1088717	91839
Amsterdam Park	Parks and Reserves	10120876	167184
Amsterdam Park	Parks and Reserves	10120877	167172
Anula Greenbelt	Sport and Leisure	1023759	167263
Austin Lane - Exeloo	Miscellaneous	1084479	48607
Aviators Park	Parks and Reserves	1047460	125447
Bagot Park	Sport and Leisure	1031102	87453
Bagot Park	Sport and Leisure	1079995	62037
Bagot Park	Sport and Leisure	103110210	-
Bayview Park	Parks and Reserves	10163200	219594
Bayview Sea Wall (Park? - Boulevarde?)	Parks and Reserves	1066130	141679
Bennett Park	Parks and Reserves	1046418	206234
Bicentennial Park	Parks and Reserves	1047049	93352
Bicentennial Park	Parks and Reserves	1093531	43480
Bicentennial Park	Parks and Reserves	1093532	125666
Bicentennial Park	Parks and Reserves	1093533	113747
Bicentennial Park	Parks and Reserves	1047049X	93352
Bilingga Park	Parks and Reserves	10132499	193126
Bill Sullivan Park	Parks and Reserves	1031767	199186
Borella Park	Parks and Reserves	1039910	154968
Byrne Park	Parks and Reserves	10152819	213010
Car Park - 54 & 60 Cavenagh Street	Carparks	1058991	97758

Site	Classification	Account number	Meter identifier
Casuarina Library	Community Services	1046937	217601
Casuarina Pool Region	Sport and Leisure	1098374	117854
Cavenagh St Medians	Parks and Reserves	10148749	206986
China Town Carpark	Carparks	10119647	165500
China Town Carpark	Carparks	1011706811	136266
Civic Centre	Municipal Centres and administration	1043160	149932
Civic Centre	Municipal Centres and administration	108971511	188807
Civic Centre	Municipal Centres and administration	DWC01	DWC01-nonmi
Colster Park	Parks and Reserves	10129316	179791
Curlew Park	Parks and Reserves	10150984	206593
Dangoerra Park	Parks and Reserves	10125230	176110
Darwin General Cemetery	Miscellaneous	1045419	62410
Dinah Beach Park	Sport and Leisure	1046297	62847
Duke Street Reserve	Parks and Reserves	1047606	190201
Duke Street Reserve	Parks and Reserves	104760610	-
Fannie Bay Oval Surrounds	Sport and Leisure	1042164	66212
Fannie Bay Oval Surrounds	Sport and Leisure	1042164_01dup	66212
Frances Park	Parks and Reserves	10130348	189629
Frances Park	Parks and Reserves	1013034710	-
Gardens Ovals Complex	Sport and Leisure	1041237	43020
Gardens Ovals Complex	Sport and Leisure	1088710	43021
George Park	Parks and Reserves	10145540	205415
Ginty Mcginness Park	Parks and Reserves	1065551	139029
Grasslands Park	Parks and Reserves	1046834	177499
Heritage Park	Parks and Reserves	10110421	138281
Hinkler Park	Parks and Reserves	10150415	206373
Jingili Park	Parks and Reserves	1039119	17139
Jingili Shopping Centre	Miscellaneous	10129419	180447
Jingili Water Gardens	Parks and Reserves	1054680	117383
Jingili Water Gardens	Parks and Reserves	1054681	97534
Kahlin Oval	Sport and Leisure	1043850	66251
Karama Childcare Centre	Community Services	1068284	154218
Karama Childcare Centre	Community Services	105248210	-
Karama Library	Community Services	1051617	95561

Site	Classification	Account number	Meter identifier
Ken Waters Memorial Park	Parks and Reserves	1049126	193208
Koolinda Park	Parks and Reserves	1068326	153507
Lake Alexander Surrounds	Parks and Reserves	1048171	159731
Lake Alexander Surrounds	Parks and Reserves	1095074	96052
Lake Alexander Surrounds	Parks and Reserves	1095075	68842
Lake Alexander Surrounds	Parks and Reserves	1095078	116144
Lake Alexander Surrounds	Parks and Reserves	1095080	119378
Leanyer Drive Depot	Miscellaneous	1052424	117783
Leanyer Drive Depot	Miscellaneous	109992810	-
Lions Club Park	Parks and Reserves	10127778	179708
Lores Bonney Park	Parks and Reserves	1065547	139026
Lot:2356 / SG10 : The Mall	Miscellaneous	108448613	-
Lot:3434 / 103, Smith St	Miscellaneous	108847912	-
Lot:5030 / S5 : Cavenagh St	Miscellaneous	109355712	-
Lot:9075 / 0, Lakeside Dr (Bike Fun Park)	Parks and Reserves	105449510	-
Lot:99999 / S/L : Parap Pl	Miscellaneous	107030010	-
Lyons Community Centre	Municipal Centres and administration	10123238	173088
Malak Oval and Surrounds	Sport and Leisure	1083779	63962
Malak Oval and Surrounds	Sport and Leisure	1083780	218002
Malak Oval and Surrounds	Sport and Leisure	1083781	170113
Malak Oval and Surrounds	Sport and Leisure	10161505	218001
Malak Shopping Centre	Miscellaneous	10128320	217586
Marina Boulevard Carpark	Carparks	1059198	106814
Matla Park	Parks and Reserves	10124856	177706
McMillans Road Greenbelt	Parks and Reserves	10127348	177697
Mindil Beach Market Area	Parks and Reserves	1041248	178283
Mindil Beach Market Area	Parks and Reserves	1088713	200206
Moil Park	Sport and Leisure	1041517	128703
Nakara Park	Parks and Reserves	1047947	17699
Nightcliff Community Centre	Municipal Centres and administration	1075166	230393
Nightcliff Community Centre	Municipal Centres and administration	1075171	231552
Nightcliff Community Centre	Municipal Centres and administration	107516610	-

Site	Classification	Account number	Meter identifier
Nightcliff Community Centre	Municipal Centres and administration	107517010	-
Nightcliff Foreshore 2	Parks and Reserves	10103429	56738
Nightcliff Foreshore 2	Parks and Reserves	10103430	100662
Nightcliff Foreshore 2	Parks and Reserves	10103431	194271
Nightcliff Foreshore 2	Parks and Reserves	10103432	154433
Nightcliff Foreshore Boat Ramp Area	Miscellaneous	10118260	163814
Nightcliff Foreshore Boat Ramp Area	Miscellaneous	10136037	191814
Nightcliff Foreshore Boat Ramp Area	Miscellaneous	10137456	191815
Nightcliff Library	Community Services	10159712	143289
Nightcliff Library	Community Services	10159713	143286
Nightcliff Oval Surrounds	Sport and Leisure	1054622	95180
Nightcliff Oval Surrounds	Sport and Leisure	10103146	210110
Nightcliff Pool Complex	Sport and Leisure	1054069	123470
Nightcliff Pool Complex	Sport and Leisure	10101593	147355
Operations Centre	Municipal Centres and administration	1047110	114477
Operations Centre	Municipal Centres and administration	1093568	221338
Parap Place - Market Area	Community Services	1015155	91537
Parap Pool	Sport and Leisure	1047858	104909
Parap Pool	Sport and Leisure	1057780	57560
Parap Pool	Sport and Leisure	1094519	104907
Parap Pool	Sport and Leisure	1057780- old	57560
Parap Pool Resdence	Miscellaneous	1061120	44592
Pavonia Way Shopping Centre	Community Services	1015156	108699
Pavonia Way Shopping Centre	Community Services	102487310	-
Peace Park	Parks and Reserves	1049566	74542
Poinciana Park	Parks and Reserves	1035754	195133
Public Convenience -Nightcliff Market area	Community Services	1075102	230114
Que Noy Park	Parks and Reserves	10169457	227709
Raintree Park	Parks and Reserves	1084507	128623
Rapid Creek Park	Sport and Leisure	1026019	59066
Ruddick Circuit Stairs	Miscellaneous	10130347	189631

Site	Classification	Account number	Meter identifier
Ruddick Circuit Stairs	Miscellaneous	1013034810	-
Shoal Bay Recycling & Waste Management Facility	Waste Management	1052501	91666
Smith Street West - Road Reserve	Parks and Reserves	10168868	226944
Somerville Park	Parks and Reserves	1048175	173327
Somerville Park	Parks and Reserves	10151100	207354
Stoddart Park	Parks and Reserves	1058361	157167
Stoddart Park	Parks and Reserves	10109316	138280
Street lighting	Street lights	1047951	50642
Street lighting	Street lights	1078205	132360
Street lighting	Street lights	1084745	151202
Street lighting	Street lights	1084783	151198
Street lighting	Street lights	10128780	177115
Street lighting	Street lights	10130397	179623
Street lighting	Street lights	10170677	228108
Street lighting	Street lights	10110360_01	138254
Street lighting	Street lights	1050030_01	128175
Street lighting	Street lights	1066896_01	152956
Street lighting	Street lights	10148573	206973
Street lighting	Street lights	10150873	205678
Street lighting	Street lights	10152156	170735
Sunset Drive (Roundabout??)	Miscellaneous	10127777	182744
Sunset Park	Parks and Reserves	1054707	172851
Tamarind Park	Parks and Reserves	1035200	55394
Tasman Park	Parks and Reserves	10150021	207060
Tesltra Tower Building Lot:5341	Miscellaneous	109484719	-
The Mall	Community Services	1015173	204919
The Pound	Miscellaneous	10127243	176487
Tiwi Oval	Sport and Leisure	1052524	21175
Tommy Lyons Park	Parks and Reserves	10130580	191181
Travellers Walk	Miscellaneous	1061444	135721
Travellers Walk	Miscellaneous	10129421	179680
Un-metered infrastructure - Street Lighting	Un-metered infrastructure	10113628	Un-Metered
Vesteys Beach	Parks and Reserves	1041309	194256

Site	Classification	Account number	Meter identifier
Wagaman Park and Oval	Sport and Leisure	1043520	17216
Wanguri Park	Sport and Leisure	1050821	43421
West Lane Carpark	Carparks	1047927	226333
West Lane Carpark	Carparks	1094622	52678
West Lane Carpark	Carparks	1094623	52207
West Lane Carpark	Carparks	1094625	54663
West Lane Carpark	Carparks	1094626	80787
West Lane Carpark	Carparks	109461211	-
West Lane Carpark	Carparks	109461311	-
West Lane Carpark	Carparks	109461313	-
West Lane Carpark	Carparks	109461711	-
West Lane Carpark	Carparks	109461912	-
Wulagi Park	Sport and Leisure	1030347	47633
Yanyula Park	Parks and Reserves	1023751	209782

Appendix B: Annual electricity use by site - CONFIDENTIAL

The data in Table 34 has been ordered from highest to lowest annual electricity consumption based on 2015-16 consumption.

Table 34: Historical annual electricity use by site (kWh)

Asset	Classification	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Civic Centre	Municipal Centres and administration	1,051,362	1,025,337	993,266	947,653	999,224	978,894	1,025,171	991,895	1,043,743	1,034,193	1,046,689
West Lane Carpark	Carparks	733,587	729,688	777,291	865,917	624,452	559,064	522,288	477,303	483,382	406,696	390,703
Casuarina Library	Community Services	492,516	499,009	566,130	598,826	563,638	554,407	545,957	552,292	492,399	390,299	351,651
Operations Centre	Municipal Centres and administration	305,738	278,563	291,565	282,823	274,515	261,995	260,700	258,397	261,725	258,043	182,189
Nightcliff Pool Complex	Sport and Leisure	141,372	136,911	146,943	143,935	137,911	133,764	132,817	133,611	136,229	139,528	177,254
Casuarina Pool Region	Sport and Leisure	205,812	205,826	182,598	186,930	184,858	161,543	166,754	164,306	165,541	163,432	149,271
Jingili Water Gardens	Parks and Reserves	114,347	120,574	123,139	153,281	169,806	177,459	177,736	184,997	151,698	134,841	145,302
Parap Pool	Sport and Leisure	168,332	172,302	167,239	172,838	181,549	186,273	184,712	183,937	183,659	187,705	130,577
Mindil Beach Market Area	Parks and Reserves	113,591	120,482	125,992	131,145	123,615	110,197	115,076	119,416	124,021	125,102	129,116
Shoal Bay Recycling & Waste Management Facility	Waste Management	54,132	61,058	74,128	65,616	71,934	68,662	68,140	72,662	67,636	66,840	120,084
China Town Carpark	Carparks		130,307	184,768	180,154	131,933	112,823	130,490	137,792	124,215	91,980	96,270
Lake Alexander Surrounds	Parks and Reserves	63,699	69,301	77,163	87,265	90,200	101,183	100,302	103,510	88,764	81,363	79,665
The Mall	Community Services	105,551	127,233	113,589	120,377	119,837	74,784	93,560	103,184	100,890	96,643	68,743
Lyons Community Centre	Municipal Centres and administration						52,624	64,134	66,819	62,214	63,293	65,449
Street lighting	Street lights	67,527	67,527	67,731	67,527	67,527	67,527	67,731	69,687	65,754	64,398	63,760

Asset	Classification	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Bicentennial Park	Parks and Reserves	56,799	65,246	60,937	66,406	65,467	59,841	64,663	65,123	65,555	65,457	56,921
Malak Oval and Surrounds	Sport and Leisure	31,923	30,558	32,743	33,928	28,367	37,818	43,856	47,306	40,692	44,013	56,560
Nightcliff Community Centre	Municipal Centres and administration	97,373	95,655	95,779	97,252	97,757	91,198	87,626	87,787	99,710	58,082	48,860
Raintree Park	Parks and Reserves	51,631	50,436	51,127	50,923	53,015	46,339	55,488	56,736	55,140	52,476	43,775
Nightcliff Library	Community Services	54,734	55,095	55,015	55,470	56,067	55,060	55,013	55,276	54,226	55,578	41,355
Gardens Ovals Complex	Sport and Leisure	56,479	52,811	47,206	46,479	46,727	43,893	44,080	47,927	45,847	45,040	41,014
Parap Place - Market Area	Community Services	31,659	34,835	33,582	32,310	29,898	31,375	33,567	34,497	37,367	34,002	34,726
Karama Library	Community Services	80,903	70,599	71,170	82,814	89,008	63,962	23,479	21,937	34,812	32,897	32,272
Amphitheatre	Sport and Leisure	16,215	23,680	16,680	15,726	28,833	25,897	23,696	22,474	17,205	19,530	31,716
Pavonia Way Shopping Centre	Community Services	40,054	38,751	35,606	35,773	36,209	35,713	33,301	34,432	32,200	30,407	30,256
Somerville Park	Parks and Reserves	1,024	1,024	3,793	6,950	6,491	3,525	5,109	5,163	5,166	5,166	25,989
Tesltra Tower Building Lot:5341	Miscellaneous			375	11,846	25,130	25,130	25,199	25,130	25,130	25,130	25,199
Karama Childcare Centre	Community Services	21,039	26,532	22,432	23,944	26,704	28,028	24,198	28,128	30,163	24,627	24,707
Nightcliff Foreshore 2	Parks and Reserves	19,504	19,763	19,109	19,026	19,558	20,101	21,992	21,375	20,896	24,514	20,806
Bagot Park	Sport and Leisure	15,965	15,995	16,519	18,029	14,165	14,277	15,519	16,814	14,327	14,224	17,057
The Pound	Miscellaneous			876	16,457	14,342	14,521	15,088	15,052	15,052	17,701	16,456
Fannie Bay Oval Surrounds	Sport and Leisure	2,285	2,285	2,292	2,285	2,285	2,285	2,292	2,285	7,058	9,575	15,923
Bayview Sea Wall (Park? - Boulevarde?)	Parks and Reserves	12,945	12,469	12,048	11,841	13,089	14,931	14,031	12,795	12,857	13,945	12,430
Kahlin Oval	Sport and Leisure	11,431	11,749	10,441	10,654	12,287	14,649	10,878	13,876	10,428	10,417	11,761
Tiwi Oval	Sport and Leisure	4,541	5,655	7,154	6,801	5,432	4,803	5,524	6,273	6,514	6,719	9,131

Asset	Classification	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Nakara Park	Parks and Reserves	4,498	5,998	5,364	5,796	5,430	4,853	6,603	7,167	6,318	7,874	9,030
Yanyula Park	Parks and Reserves	5,351	7,563	6,044	8,051	4,913	7,546	8,238	10,161	6,947	8,706	8,513
Nightcliff Oval Surrounds	Sport and Leisure	5,937	6,158	5,468	5,811	5,592	5,334	5,954	7,662	6,819	7,770	8,321
Frances Park	Parks and Reserves	4,328	4,328	4,338	4,328	4,328	5,747	7,352	7,333	7,537	7,111	7,752
Aviators Park	Parks and Reserves	9,086	8,976	9,005	9,579	9,607	8,144	9,071	8,964	8,643	8,307	7,499
Ruddick Circuit Stairs	Miscellaneous	3,205	3,205	3,213	3,205	3,205	4,949	6,835	6,936	7,356	6,902	7,418
Wanguri Park	Sport and Leisure	4,535	5,610	5,976	5,592	4,047	4,075	6,438	6,168	5,244	5,854	7,249
Wagaman Park and Oval	Sport and Leisure	3,008	6,460	8,432	7,928	6,348	7,397	7,359	9,318	6,769	7,771	6,900
Moil Park	Sport and Leisure	3,696	5,001	4,646	5,915	5,227	4,812	5,023	4,981	5,829	5,559	6,442
Wulagi Park	Sport and Leisure	7,030	9,530	7,500	8,276	5,195	7,116	8,626	7,647	6,022	5,656	6,363
Stoddart Park	Parks and Reserves	5,856	5,250	4,322	4,920	4,113	4,990	3,270	5,042	5,050	5,135	6,266
Leanyer Drive Depot	Miscellaneous	1,376	1,138	2,320	7,066	5,648	5,536	4,377	3,721	4,176	5,126	6,119
Marina Boulevard Carpark	Carparks	5,255	5,724	4,818	3,891	4,496	5,224	5,621	6,003	5,725	5,776	5,816
Austin Lane - Exeloo	Miscellaneous	6,460	4,721	3,838	4,063	3,600	5,514	6,613	7,026	5,903	5,683	5,534
Vesteys Beach	Parks and Reserves	2,871	3,597	3,278	3,546	5,739	5,059	3,856	4,196	4,928	5,207	5,500
Dinah Beach Park	Sport and Leisure	2,225	3,069	2,882	3,389	3,091	1,848	3,874	3,388	2,949	4,651	5,091
Rapid Creek Park	Sport and Leisure	1,754	2,531	2,961	3,107	1,860	2,636	3,064	3,926	3,032	3,075	5,090
Travellers Walk	Miscellaneous	5,872	5,479	1,911	2,300	4,404	4,459	3,989	4,387	5,177	4,887	4,919
Public Convenience - Nightcliff Market area	Community Services	4,588	4,588	4,602	4,588	4,588	4,588	4,602	4,588	4,588	4,434	4,653
Bennett Park	Parks and Reserves	4,209	4,372	4,178	3,917	4,125	4,061	4,189	4,765	4,581	4,663	4,611
Malak Shopping Centre	Miscellaneous				374	858	557	471	543	2,314	2,721	4,421
Nightcliff Foreshore Boat Ramp Area	Miscellaneous	232	1,154	1,672	2,264	2,699	3,610	3,504	4,082	4,524	4,261	4,370

Asset	Classification	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Anula Greenbelt	Sport and Leisure		3,158	3,874	4,046	4,013	3,730	4,040	4,317	4,282	4,061	4,307
Sunset Park	Parks and Reserves			2,999	3,826	3,316	3,334	3,675	4,008	4,404	4,332	3,838
Darwin General Cemetery	Miscellaneous	3,855	3,749	4,166	3,720	4,680	3,115	3,961	3,397	3,370	3,472	3,801
Tamarind Park	Parks and Reserves	7,061	6,130	4,935	6,769	6,543	4,595	3,460	4,902	6,216	5,095	3,771
Matla Park	Parks and Reserves				1,817	1,873	1,643	3,344	2,501	2,676	2,808	3,475
Koolinda Park	Parks and Reserves	2,798	2,628	1,477	2,700	1,984	3,193	2,745	2,648	2,853	3,115	3,284
Tommy Lyons Park	Parks and Reserves					457	3,586	4,105	4,130	3,867	3,634	3,205
Dangoerra Park	Parks and Reserves				1,544	875	1,368	2,154	2,215	2,691	2,301	3,062
Bilingga Park	Parks and Reserves					206	2,319	4,218	2,895	3,080	2,543	3,052
Heritage Park	Parks and Reserves	2,237	1,932	1,873	2,124	1,805	2,399	2,172	1,865	2,071	1,971	2,966
Jingili Park	Parks and Reserves	2,745	3,503	1,918	3,492	2,554	2,476	1,980	2,344	2,107	2,715	2,400
Poinciana Park	Parks and Reserves						5,892	6,127	5,131	3,670	4,024	2,178
Ginty Mcginness Park	Parks and Reserves	938	1,170	1,157	1,019	1,025	1,143	1,310	1,462	1,579	1,285	1,391
Amsterdam Park	Parks and Reserves	8	1,310	1,314	1,406	1,261	1,421	1,093	1,201	1,811	1,372	1,363
Lores Bonney Park	Parks and Reserves	1,348	1,709	1,189	1,566	1,397	678	1,013	1,386	1,525	1,222	1,273
Duke Street Reserve	Parks and Reserves	1,157	1,157	1,160	1,157	1,349	2,367	1,821	1,672	1,891	1,488	1,220
Parap Pool Resdence	Miscellaneous	1,421	1,421	1,425	1,421	1,421	1,421	1,425	1,421	1,421	1,421	1,181
Lot:99999 / S/L : Parap Pl	Miscellaneous	-	-	12	1,047	1,059	1,059	1,062	1,059	1,059	1,059	1,062
Byrne Park	Parks and Reserves	855	855	857	855	855	855	857	855	855	851	1,002
McMillans Road Greenbelt	Parks and Reserves			117	752	545	820	825	846	720	784	984
Jingili Shopping Centre	Miscellaneous				885	426	533	634	1,211	1,197	655	969
Lot:2356 / SG10 : The Mall	Miscellaneous	2,939	952	955	952	952	952	955	952	952	952	955
Lot:3434 / 103, Smith St	Miscellaneous						683	954	952	952	952	954

Asset	Classification	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
Borella Park	Parks and Reserves	795	621	430	266	451	748	865	864	647	722	780
Car Park - 54 & 60 Cavenagh Street	Carparks	747	685	52	111	714	452	594	824	689	1,336	661
Lions Club Park	Parks and Reserves				446	741	644	547	574	583	528	613
Grasslands Park	Parks and Reserves			56	857	879	904	917	927	773	682	609
Ken Waters Memorial Park	Parks and Reserves					218	415	381	346	538	407	434
George Park	Parks and Reserves							6	11	48	824	375
Colster Park	Parks and Reserves				441	477	420	479	411	304	354	333
Sunset Drive (Roundabout??)	Miscellaneous				127	133	176	189	169	205	208	252
Lot:5030 / S5 : Cavenagh St	Miscellaneous						85	247	246	246	246	247
Cavenagh St Medians	Parks and Reserves	215	215	215	215	215	215	215	210	215	217	215
Tasman Park	Parks and Reserves									52	101	118
Bill Sullivan Park	Parks and Reserves						4	59	113	33	90	102
Smith Street West - Road Reserve	Parks and Reserves	-	-	-	-	-	-	-	-	-	-	83
Curlew Park	Parks and Reserves	48	48	48	48	48	48	48	48	44	58	62
Bayview Park	Parks and Reserves	-	-	-	-	-	-	-	-	-	6	28
Que Noy Park	Parks and Reserves	-	-	-	-	-	-	-	-	-	-	27
Hinkler Park	Parks and Reserves	12	12	12	12	12	12	12	12	14	14	17
Peace Park	Parks and Reserves	97	68	59	28	50	79	73	64	32	15	11
Lot:9075 / 0, Lakeside Dr (Bike Fun Park)	Parks and Reserves	-	-	-	-	-	-	-	-	-	-	-
Un-metered infrastructure - Street Lighting	Un-metered infrastructure	-	-	-	-	-	-	-	-	-	-	-

Source: Planet Footprint data base maintained by the City of Darwin, data received on 17 January 2017

ATTACHMENT B

Financial Year (emission target)	*Action*	*Lead Unit (support)*	*Cost (source)*	*Annual Abatement*	*Annual Cost saving*	*Payback*
018	Civic Centre Solar PV	Capital Works (CCE)	$400,000 (operational)	121	$50,000	2026
(6,000)	Power Purchase Agreement (top 10 sites)	CCE (finance)	Nil (operational)	TBC	Estimated $30,000	2018
2019	Streetlighting	Technical Services	$500,000 (grant funded)	1932	$800,000 (once fully implemented)	2019
(4,700)	Hybrid vehicle upgrade	Fleet (CCE)	$3,182 per vehicle (Energy Capital Fund)	0.93 (per vehicle)	$494 (per vehicle)	2025 (trade in prior)
	Energy Strategy Capital Fund	CCE (finance)	Nil (operational)			-
2020	Shoal Bay Solar		$2,200,00 (externally funding)	>458	$245,500	2029
(3,500)	Extend PPA	CCE (finance)	Nil (operational)	TBC	TBC	2018
	Streetlighting	Technical Services	$500,000 (grant funded)			
	Hybrid vehicle upgrade	Fleet (CCE)	$3,182 per vehicle (Energy Capital Fund)		$180 (per vehicle)	
2021-2025	HVAC upgrade	Technical Services (CCE)	$938,875 (asset replacement, end of life)	347	170,000	2026-2031
(3,000)	Investigate offset	CCE	Nil (operational)			
2026-2030	Purchase offsets	CCE (finance)	<$5,000	TBC	Nil	nil
(net zero)						