

Northern Territory

Roadmap to Renewables

Fifty per cent by 2030



September 2017

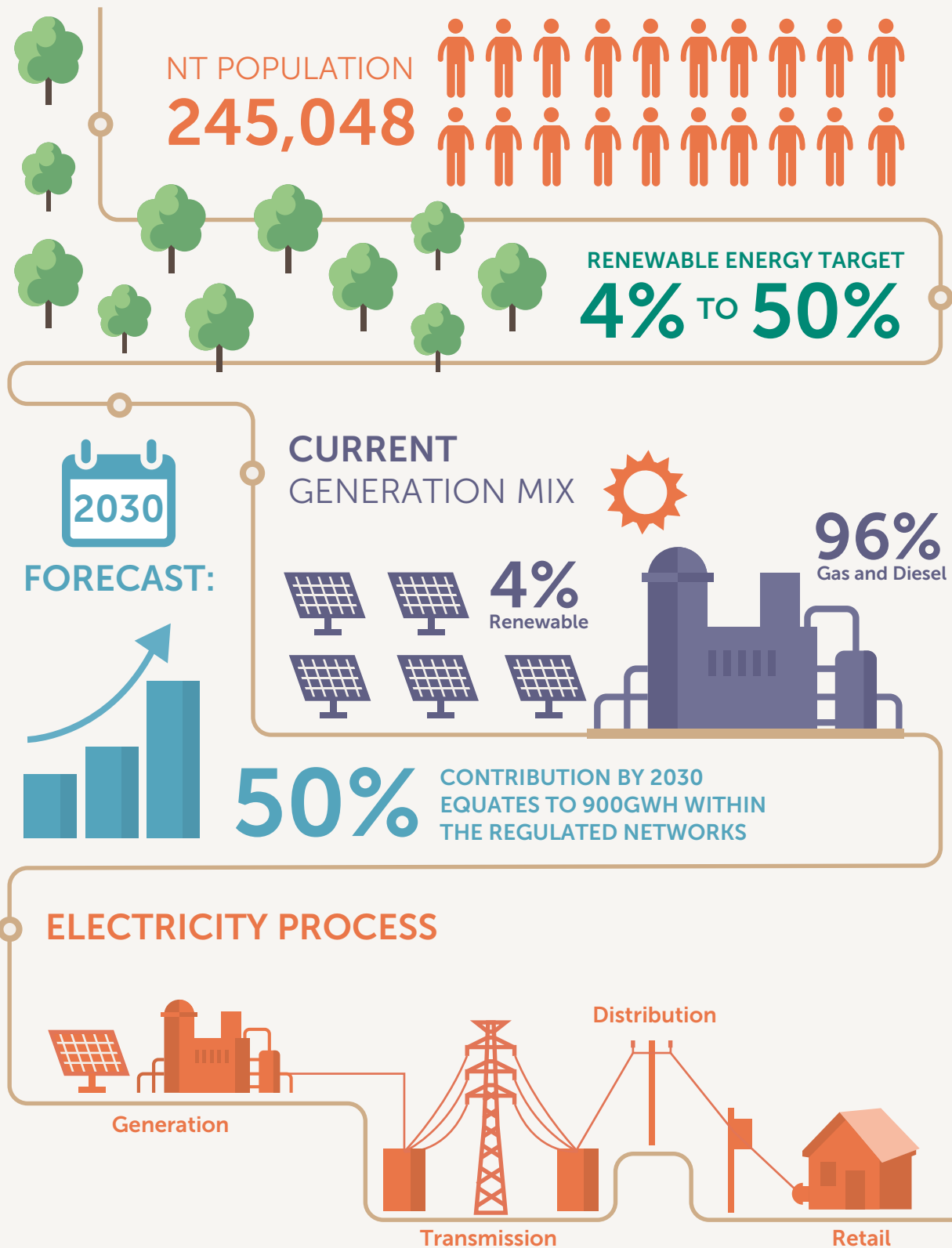
Alan Langworthy, Chair - Expert Panel

Greg Bourne, Lyndon Frearson, Katherine Howard, Amanda McKenzie, Owen Peake

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Summary



Letter from the Chair

Dear Chief Minister and Cabinet

It is with pleasure that I present the Roadmap to Renewables report for the Northern Territory.

This report, provides a roadmap to achieve the 50 per cent renewable energy target for the Northern Territory, over the next decade, whilst maintaining the affordability of energy supply and without compromising network reliability and security. In preparing the Roadmap, we consulted widely with government agencies, community groups, developers, financiers and industry. It quickly became evident that there is considerable support for affordable and reliable renewable energy electricity generation.

The Northern Territory electricity system consists of several relatively small networks with low inertia. As the generation mix inevitably changes, with the progressive incorporation of renewables, these networks will require a variety of specific technical and legislative actions by Government to preserve security and reliability.

Private investment and supply competition is desirable to encourage downward pressure on wholesale electricity costs. The proposed energy and capacity market design, currently being developed by the Northern Territory Government, which is based on competitive bidding for long term supply contracts, is endorsed. This could ultimately deliver the most affordable energy for Territorians. However, a number of market stimulus actions may be required to kick start the rollout of renewable energy as the Territory transitions from the predominantly single supply gas turbine power generation to the mixed regime. This is considered consistent with the building of a competitive market framework.

I was ably assisted in the development of this report by an excellent advisory panel and secretarial support from the government. Significant input and advice came from the Northern Territory Government owned electricity entities and departments.

The Roadmap has been developed across five themes which broadly encapsulate the key issues that will be faced in the Northern Territory as the rollout commences: *'renewable energy as a supporter of economic development', 'finance and investment', 'governance and regulation', 'technology, security and reliability' and 'engaging the community'*. The report includes eleven **Recommendations** that the Panel considers will put the Northern Territory on a sustainable, reliable, and least cost path towards achieving the 50 per cent renewable energy target. The Panel has also provided some suggested Enabling Actions that detail specific actions and measures that will support the implementation of the Recommendations.

By capitalising on the Northern Territory's natural endowment of abundant renewable resource, there is an exciting opportunity to drive economic development by using competitively priced renewable energy to underpin energy intensive industrial development, thus potentially creating significant job opportunities for Territorians.

Yours sincerely,

Alan Langworthy
Expert Panel Chair

Executive summary

Rapid disruptive change to energy systems is occurring globally. New innovations in renewable energy are altering the way energy is generated, distributed and consumed.

The panel's role was to provide a roadmap to achieve the 50 per cent renewable energy target for the Northern Territory, whilst maintaining the affordability of energy supply and without compromising network reliability and security. It was not possible in the allotted time and with the limited data available to complete comprehensive quantitative modelling leading to comparative options (such as that completed by NYSERDA¹) so we focussed on practical actions that the Government could take.

The Northern Territory Government's 50 per cent renewable energy target is defined, in this report, to be 50 per cent of the electricity consumed in 2030 inclusive of behind-the-meter generation, future self-generating enterprises and new large industrial consumers. With careful planning, appropriate governance, effective regulation, and policies to encourage investment, an increase from the current renewable energy penetration of four per cent, to the Northern Territory's target of 50 per cent by 2030, is considered achievable. This presupposes an installed renewable energy capacity of approximately 450MWp would be required for the regulated networks, occupying some 700 hectares of land.

Renewable energy generation is expected to place downward pressure on wholesale electricity prices², which could stimulate significant economic development, job creation, industry growth and new investment in the Northern Territory. With the government's recent release of the 'Economic Development Framework' (EDF), its commitment to the target of 50 per cent renewables, and existing knowledge and capability around renewable energy, the Northern Territory community could benefit significantly from the rollout of renewable energy.

The regulated electricity networks in the Northern Territory are relatively small and isolated. The Darwin-Katherine system is powered by gas turbines and they have low inertia which can result in outages, due to sudden fluctuations in generation or demand, if not well managed. Specific solutions are required as the Northern Territory transitions to renewable energy. System Control, within Power and Water Corporation (PWC), manages the system to avoid outages by maintaining the correct levels of support (ancillary services).

We support completion of the validated dynamic system model, currently held by System Control, which could enable more effective evaluation of the way the Northern Territory system works. This will provide design information to ensure the injection of significant amounts of new renewable energy will not negatively affect reliability and security. To this end, it is concluded that all generators, including renewable energy generators, should be required to supply, or contract third parties to supply, the required network support (ancillary services) to maintain electricity network security and reliability.

Collectively, the technical code and rules should ensure a level playing field can be established for all generators, promoting fair competition within the market.

The recent report by Energy Networks Australia and CSIRO³ strongly supports a transformation in Australia's networks towards a future, customer oriented, decentralised system incorporating significant renewable energy plant which is in line with the Northern Territory Government's 50 per cent target.

The Northern Territory Government is considering the design of a new energy and capacity market structure which aims to promote competition. This energy market, if built on reverse auctions for long term contracted Power Purchase Agreements (PPAs) including provision for ancillary services by each generator, is supported.

¹ Large Scale Renewable Energy Development in New York: Options and Assessment. New York State Energy Research and Development Authority (NYSERDA), Report 15-12 June 2015.

² Clean Energy Australia Roadmap, Clean Energy Council, 2016.

³ Electricity Network Transformation Roadmap, April 2017.

The Northern Territory has not yet completed all the requirements associated with the partial roll out of the National Electricity Rules that is planned. This gives the Northern Territory an opportunity to apply only those Rules and regulations that will support the integration of significant renewable energy generation.

In wholesale cost terms, renewable energy electricity generation is increasingly competitive with fossil fuel generation in many parts of Australia⁴. While we appreciate the concerns of some, that new renewable technologies could result in the stranding of existing gas turbine assets, it is our view that the Northern Territory has an ideal generation opportunity, in its aged gas turbine assets, to provide fast start supply to fill the gaps of intermittent renewable energy. Far from stranding these generator assets, the onset of renewable energy generation may enable cost effective replacement and extended utilisation.

To encourage rooftop photovoltaics (PV) and behind the meter energy storage, it is proposed that the Feed In Tariff (FIT) be altered to reflect electricity demand at different times of the day (a time-of-day structure). These initiatives may encourage greater uptake of rooftop PV and battery storage systems and could enable consumers to reduce their electricity costs during the most expensive times of the day, promote energy efficiency, and increase reliability and security by reducing demand pressure on the system at times of high demand.

In order to kick start the roll out of renewable energy generation, it is proposed that government uses its purchasing power to create initial demand through purchasing electricity from renewable energy suppliers, meeting its existing large-scale generation certificate (LGC) obligations from Territory based renewable energy installations and installing roof top PV systems to government housing.

The Government should use its ownership of the three Government Owned Corporations (GOCs) to ensure an open and fair investment environment. Replacement of aged prime or base load gas turbine plant should not be like for like. Instead, the capacity could be filled by renewable energy plant funded by private investment.

Currently, most remote communities rely on diesel generators for their electricity. To reduce the reliance on diesel, PWC, in partnership with the Australian Renewable Energy Agency (ARENA), is rolling out the Solar SETuP program to some 30 Northern Territory communities⁵. There is considerable scope, building on the learning developed through this program, to create high penetration renewable energy systems in these communities utilising battery storage technology.

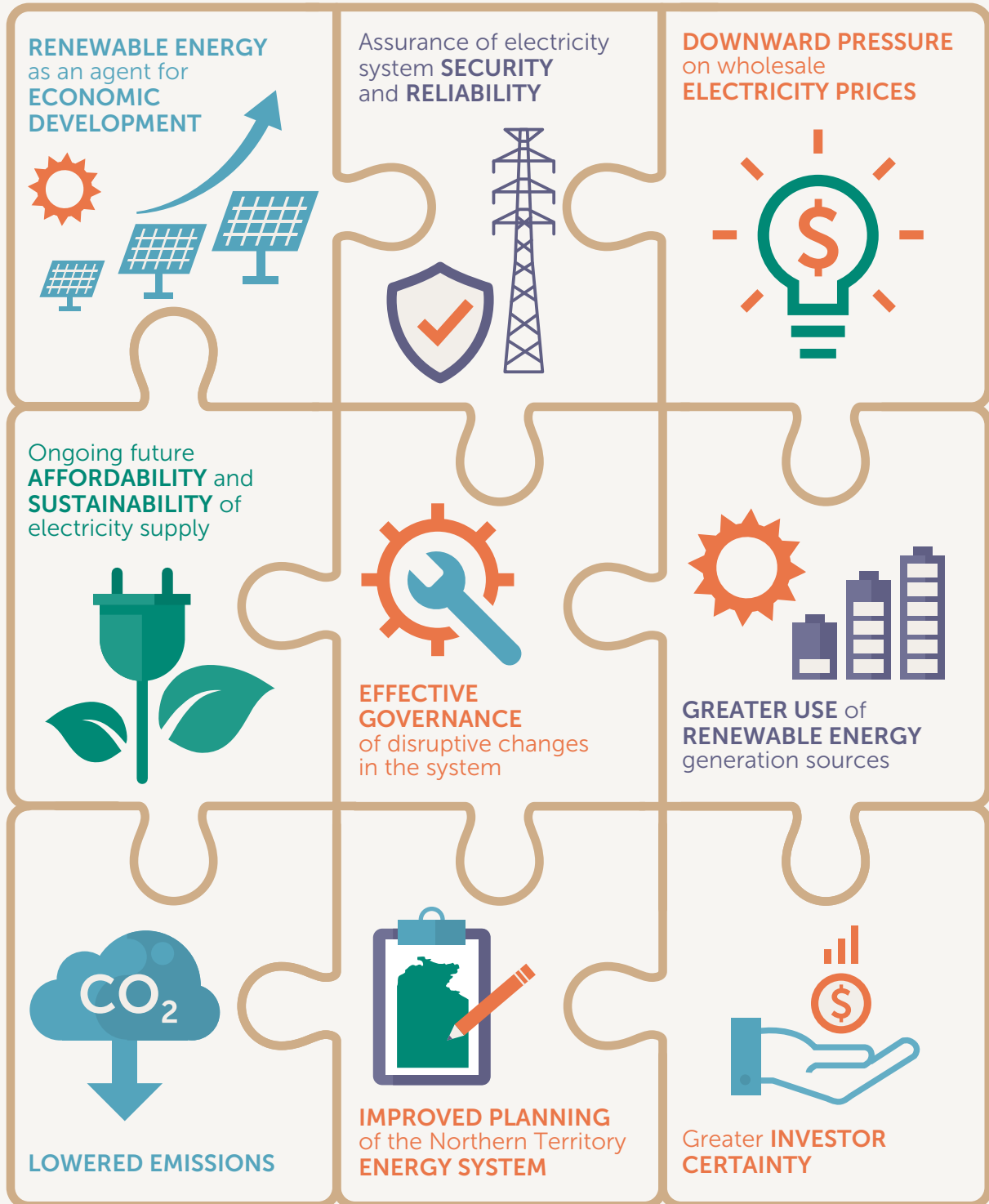
Alice Springs has often led the way in renewable energy, through programs such as the Solar City, as well as through research, studies, and technical solutions developed by a range of agencies, such as the Centre for Appropriate Technology (CAT), Desert Knowledge Australia (DKA), the CSIRO, the City of Alice Springs, private interest groups and Charles Darwin University (CDU). Building on this important work, it is recommended that Alice Springs be supported as a hub for solar energy research and development.

The Northern Territory Government should also ensure support is provided for the required service industries, including training, education and accreditation.

⁴ Australian Renewable Energy Agency, Large-scale solar in Australia: Past, present and future, 2016.

⁵ Australian Renewable Energy Agency, An introduction to ARENA's remote and regional projects, March 2017.

Outcomes



Principles



SECURE

The Northern Territory must maintain a secure supply of electricity to support business and community at all times.



RELIABLE

The Northern Territory must maintain the energy supply without compromising network reliability.



STABLE

The Northern Territory must not compromise the stability of the current network as the generation mix changes.



FLEXIBLE AND ADAPTIVE

The Northern Territory must retain the flexibility to respond quickly to the rapid and changing nature of the modern electricity system.



TRANSPARENT

The Northern Territory must support an open, transparent and accountable market.



COMPETITIVE

The Northern Territory must support a competitive, open market in which all investors are treated equally.



PRACTICAL

It is important the Northern Territory take a practical and pragmatic approach when adopting new technologies.



COST EFFECTIVE

Decisions about the future electricity system and its sources should consider lowest cost.



EFFICIENT

To achieve the 50 per cent renewable energy target by 2030, the Northern Territory must ensure the most efficient use of the current energy sources, infrastructure and plant when integrating renewable energy into the system.



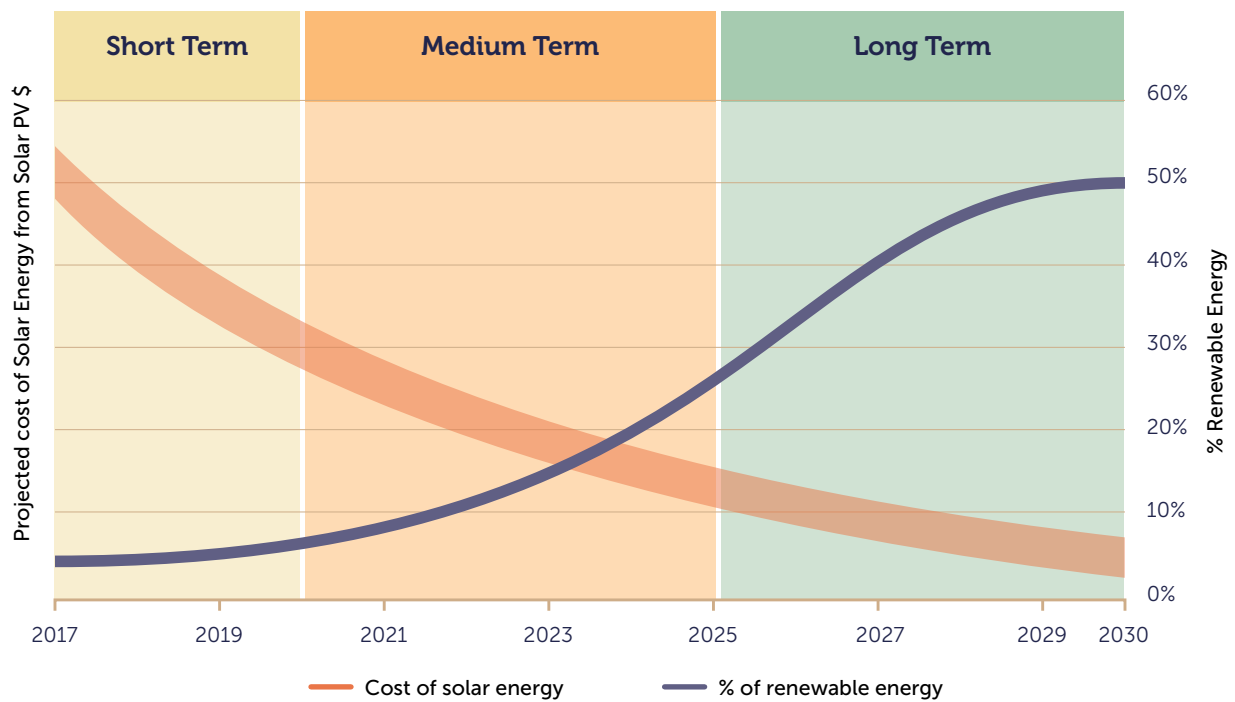
CLEAN

It is important that the Northern Territory government, stakeholders and the broader community protects and maintains its unique natural environment by ensuring environmental impacts are considered as part of decision making.

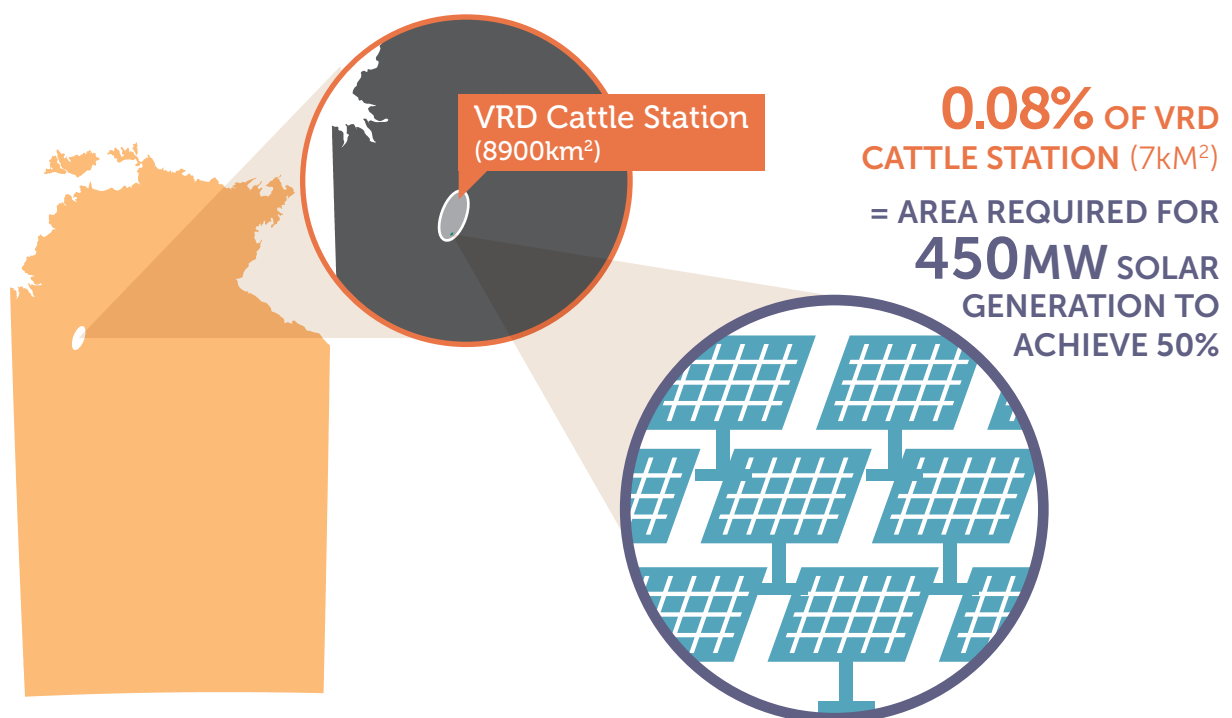
Renewable energy as an enabler of economic development

Finance	Governance	Technology, Security and reliability	
Align Policy Objectives	Build industry and community confidence	Validate network capabilities ensuring system security and reliability	Short Term
Certainty for investors	Support a competitive market	Future system planning	Medium Term
Asset Optimisation	Adaptive Regulatory Framework	Implementation of future grid	Longer Term
Enabling the Community			

Predicted cost of solar energy from solar PV



Land area comparison - how much space is taken by solar power?



Recommendations list

OVERARCHING

Recommendation 1 – Renewable Energy-Enabling of Economic Development: To ensure long-term benefits for all Territorians, the Northern Territory Government should include renewable energy as a central pillar of economic policy, maximising benefits of forthcoming disruptive change in the electricity sector caused by the global transition to competitively priced renewable energy.

FINANCIAL

Recommendation 2 – Align Policy Objectives: The Northern Territory Government should align its policy objectives, departmental activity and government programs toward the development and purchase of renewable energy-generated electricity.

Recommendation 3 – Certainty for Investors: The Northern Territory Government should actively create an environment that has policy certainty that attracts long term renewable energy investment and financing.

Recommendation 4 – Asset Optimisation: The Northern Territory Government should publicise an asset retirement/replacement optimisation strategy for existing gas-fired generators to facilitate the adoption of new, competitively priced renewable energy generation alternatives.

REGULATORY

Recommendation 5 – Build Industry and Community Confidence: The Northern Territory Government should align regulatory and energy system reform to ensure congruence with the 50 per cent renewable energy target and reposition current technical, legislative and social parameters to build community and industry confidence in the renewable energy industry.

Recommendation 6 – Support a Competitive Market: The Northern Territory Government should endorse a competitive energy and capacity market framework for renewable energy in the Northern Territory.

Recommendation 7 – Adaptive Regulatory Framework: The Northern Territory Government should develop a consolidated governance and regulatory framework that is able to adapt to new and emerging technologies.

Recommendations list

TECHNICAL

Recommendation 8 – Validate Network Capabilities Ensuring System Security and Reliability: The Northern Territory Government should immediately improve knowledge of the existing capability and capacity of the entire power system, including its ability to accommodate new renewable energy generation. Where possible, the government should take immediate action to kick-start the rollout of renewable energy projects.

Recommendation 9 – Future System Planning: The Northern Territory Government should support the development of a detailed technical plan for the future power system, including reviewing the nature and requirement of demand, supply and transmission in the context of new technical and business models, while ensuring security and reliability as the nature of the system changes.

Recommendation 10 – Implementation of the Future Grid: The Northern Territory Government should optimise the implementation of existing plans for progressive network upgrades to facilitate the future grid required to support the transition to higher per cent of renewable energy.

SOCIAL

Recommendation 11 – Engaging the Community: The Northern Territory Government should undertake a variety of community engagement measures to ensure inclusion of disadvantaged customers, training of the workforce, and education of the public regarding renewable energy.

Introduction

The Northern Territory Government has committed to a target of 50 per cent renewable energy by 2030, up from an estimated four per cent currently in 2017. To achieve this target, the Northern Territory Government commissioned the renewable energy Expert Panel to develop a roadmap and make recommendations for a reliable, secure and sustainable transition (Appendix 1).

In compiling the roadmap, we reviewed a range of relevant local, national and international reports and briefs. We met with many stakeholders: government departments and industry representatives, community interest groups, commercial entities, financiers and individuals and considered 17 submissions from interested parties (Appendix 2).

Report Context

The renewable energy target was defined as 50 per cent of the actual electricity consumed in the Northern Territory in 2030 (Appendix 3).

Consumers were defined as:

- All classes of electricity supply customers in the three major systems within the Northern Territory (Darwin/Katherine, Tennant Creek and Alice Springs).
- All classes of electricity supply customers in smaller community systems (such as Ti Tree, Elliott/Newcastle Waters, Daly Waters, Borroloola and Timber Creek).
- All Aboriginal communities with their own power stations (Aboriginal communities whose electricity is supplied from one of the categories above are counted in those categories).
- Energy generated by self-generating commercial enterprises (primarily mines and tourist facilities, including Yulara, Jabiru, Nhulunbuy, Groote Eylandt, McArthur River, Pine Gap, Tanami Gold and Seven Spirit Bay). But not existing large projects such as ERA, Ranger, Gove Aluminium Finance Ltd at Nhulunbuy, GEMCO at Groote Eylandt, Tanami Gold NL, ConocoPhillips LNG plant, Wickham Point and the INPEX LNG plant, Bladin Point.

The inclusion of self-generating enterprises in the target recognises that many of these, particularly mining, are already active or showing strong interest in renewable energy generation. All of these self-generating

enterprises rely on either diesel or gas, and as such renewables provide an increasingly viable and lower cost, alternative. It was also determined that major industry should be included in the definition of consumers because, as large users of electricity, failure to include these groups would reduce the effectiveness of the 50 per cent target and effectively make it only a domestic customer target. However, it is important to recognise the impact that inclusion of the existing large self-generating projects such as INPEX would have on the 50 percent calculation. The proposal to include large projects and self-generating enterprises is not intended to overburden the Target calculation but to recognise the importance of encouraging future large enterprises to use renewable energy generation.

Following the conclusions of the Northern Territory's Green Energy Taskforce^{6,7} in 2010, and noting that the situation has not altered significantly since this time (Appendix 4), we focused on PV as the most prospective renewable energy technology for the Northern Territory⁸. This conclusion has been reinforced by the very significant cost reductions the PV industry has achieved in recent years.

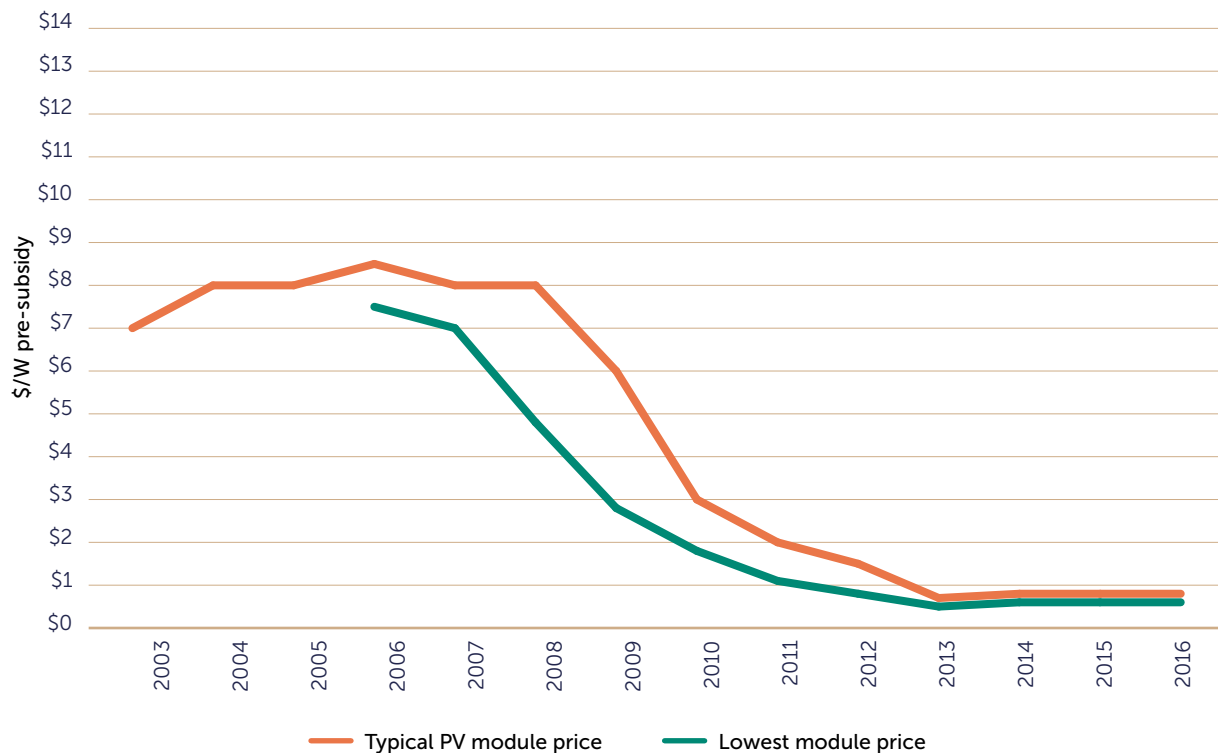
It is noted that the Territory has extensive reserves of gas that can be utilised for backup generation and to fuel new precursor chemical gas intensive industries. Along with the downward pressure on wholesale electricity costs by renewable energy, this may offer significant economic growth opportunities for the Northern Territory.

⁶ Green Energy Taskforce, Roadmap to Renewable and Low Emissions Energy in Remote Communities Roadmap, 2010.

⁷ Green Energy Taskforce, An evaluation of the relative merits, feasibility, and likely costs of the potentially available renewable energy technologies to be used in the NT, including geo-thermal, solar, biomass and tidal, 2010.

⁸ Climatecouncil.org.au/solar-report.

Price evolution of PV Panels and Systems



Source: National Survey Report of PV Power Applications in Australia, 2016

The global context

Over the last decade, there has been a significant acceleration in the global approach to renewable energy electricity generation, transmission and consumption. This can be attributed to a global drive to address climate change and rising electricity costs, coupled with the broad desire of governments to create new economic opportunities and industries in the wake of disruptive changes in renewable energy technology⁹. This disruptive change will see innovations not only in how electricity is generated but also how it is distributed and managed over time, such that the entire electricity system may be completely different from its current form.

Globally, state and territory governments have played a key role in driving this change, with many adopting stronger and more innovative policies than their national counterparts. In the United States (US), a majority of state governments have had renewable energy goals in place for a decade¹⁰. This played a major role in the US placing second in the world for renewable energy capacity⁸.

By banding together, sub-national jurisdictions are creating significant economic and political momentum for change. In November 2015, more than 1000 mayors and governors from 150 countries committed to switching to 100 per cent renewable power¹¹.

⁸ Climatecouncil.org.au/solar-report.

⁹ IRENA, Rethinking Energy: Renewable Energy and Climate Change, 2015.

¹⁰ Climate Council of Australia, State of Solar 2016, Globally and in Australia by Petra Stock, Andrew Stock and Greg Bourne.

¹¹ Climate Council of Australia, Game on: The Australian Renewable Energy Race heats up by Andrew Stock and Petra Stock, 2016.

The national context

In 2015, within the United Nations Framework Convention on Climate Change, 196 parties negotiated the Paris Agreement. 153 parties have subsequently ratified this agreement with the core aim of limiting the increase in the average temperature to well below 2 degrees and endeavouring to limit the increase to 1.5 degrees, which would help to significantly reduce the risks and impacts associated with climate change¹².

In line with this agreement, the Australian Government committed to reducing Australia's greenhouse gas emissions by 26 to 28 per cent (based on 2005 levels) by 2030. To achieve this target, there has been considerable focus on reducing emissions from the electricity sector and many state and territory governments have adopted renewable energy targets. Queensland, South Australia and the Northern Territory now have targets to grow renewable energy to 50 per cent by 2030 and Victoria has a target of 40 per cent by 2025¹³. The Australian Capital Territory has a target of 100 per cent renewable electricity by 2020, which it is on track to meet through a reverse auction scheme.

The NT is vulnerable to climate change. Some of the impacts include:

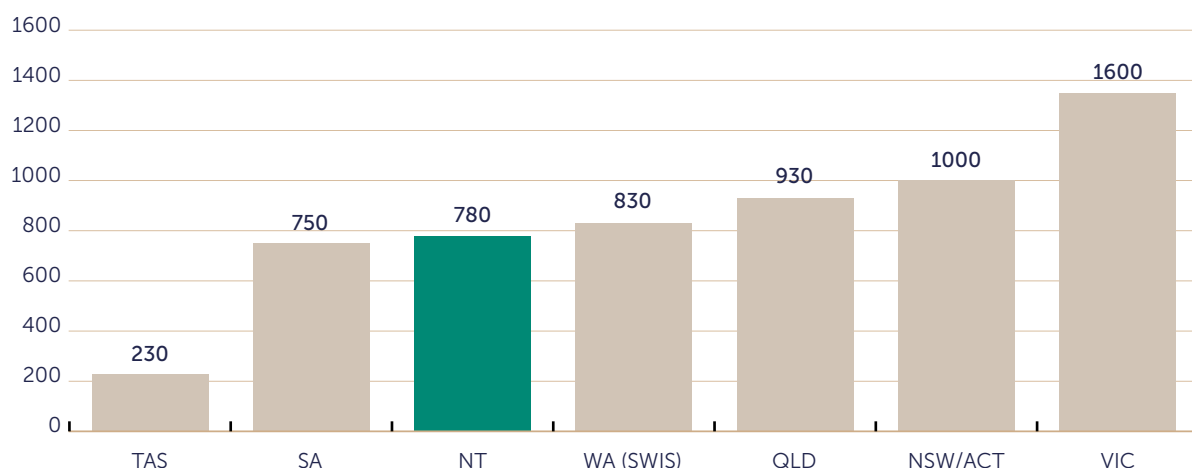
Heat: In Darwin, the number of days over 35 degrees Celsius is expected to increase from 11 to 43 per year by 2030, and to 265 per year by 2070 at current rates of global warming (CSIRO and BoM 2015). Heatwaves are the most significant natural hazard in Australia in terms of loss of life.

Sea Level Rise: Darwin is expected to experience a mean sea-level rise of up to 0.25 m by 2050 relative to 1986-2005 levels (McInnes et al. 2015). A present-day 1-in-100 year flooding event would likely occur every day or so by 2100 at current rates of emissions (Hunter 2012).

Extreme Rainfall: Rainfall patterns are expected to change and extreme rainfall events are expected to worsen. Maximum one-day rainfall is expected to increase by up to 18 per cent for the NT by the end of the century for a high emissions scenario, relative to 1986-2005 CLIMATE (CSIRO and BoM 2015).

Electricity emission factors by jurisdiction

(kg/kWh) Source: National Greenhouse accounts, 2011/2012



¹² unfccc.int/paris_agreement/items/9485.php

¹³ Climate Council of Australia, Game on: The Australian Renewable Energy Race heats up by Andrew Stock and Petra Stock, 2016.

ClimateWorks report¹⁴ considered what action Australia could take to do its fair share of the global effort. All scenarios demonstrated achieving at least 50 renewable electricity generation by 2030 is both critical and achievable (ClimateWorks 2015). After 2030, renewable energy would be further increased leading to net zero emissions before 2050.

Over the last decade, many jurisdictions introduced a solar feed in tariff (FIT), which is the rate paid for electricity fed back into the electricity network from a designated renewable energy generation source, such as a rooftop solar panel array. These tariffs aimed to encourage the uptake of solar rooftop panels. In some jurisdictions, these tariffs have been reduced (from 60 cents, 25 cents, 44 cents¹⁵) to between 5 and 12 cents per kilowatt hour. The Northern Territory currently has a flat feed in tariff of 25.67 cents per kilowatt hour for domestic and 29.87 cents per kilowatt hour for commercial consumers (Appendix 5).

Nationally, large scale solar and wind generation plants mainly feed energy directly into the electricity network at points in the transmission system and generally contract a wholesale supply price (quoted as dollars per megawatt-hour (MWh)) within the National Electricity Market (NEM). This price has network and retail charges added to determine the consumer tariff. Wholesale prices for electricity from medium and large-scale solar PV installations are now proving competitive with conventional fossil fuel generation, and prices continue to fall¹⁶. In remote areas where generation is by diesel plant, the high costs of delivery and storage of fossil fuels mean solar PV generation costs can be significantly lower than fossil fuel generation even when energy storage is included¹⁷.

Recently, a major report on the National Electricity Market (NEM) has been completed by the Chief Scientist, Alan Finkel AO and his Expert Panel¹⁸. The key outcomes of this national report are; Increased Security, Future Reliability, Rewarding Consumers and Lower Emissions, and these parallel closely the proposed outcomes of this report. In addition, the Chief Scientist's report strongly supported renewable energy generation, as does this report.

The challenges facing the NEM differ in many ways from the issues facing the Northern Territory, however, the goals of security, reliability, emissions reduction, downward pressure on the wholesale cost of energy remain the same.

The Territory is in a favourable position compared to other jurisdictions, because it is still in the process of applying the National Electricity Rules and may ensure it only applies the Rules in a manner that is fit-for-purpose for the Territory.

Building on the Chief Scientist's work, and the Recommendations of this roadmap report, the Northern Territory Government has the opportunity to achieve a successful transition to a reliable electricity system powered largely by renewable energy.

¹⁴ ClimateWorks (2014) Pathways to Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world. Technical Report. Accessed at: http://climateworksaustralia.org/sites/default/files/documents/publications/climateworks_pdd2050_technicalreport_20140923.pdf

¹⁵ <https://mozo.com.au/energy/articles/2-17-changes-to-australia-s-solar-feed-in-tariffs-what-they-mean-for-you>

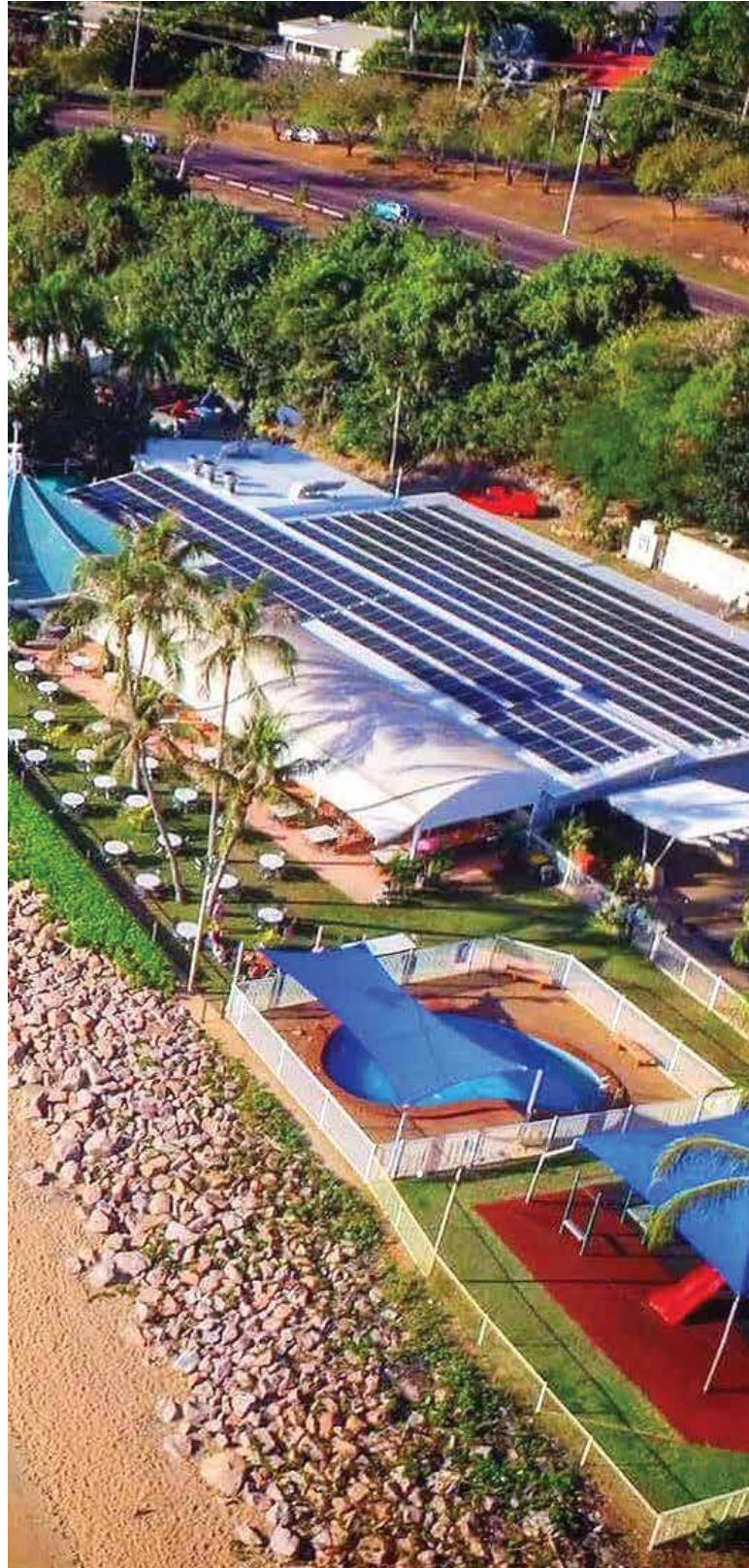
¹⁶ Clean Energy Australia Roadmap, Clean Energy Council, 2016.

¹⁷ Green Energy Taskforce, Roadmap to Renewable and Low Emissions Energy in Remote Communities Roadmap, 2010

¹⁸ Independent Review into the Future Security of the National Electricity Market. June 2017

Through the reverse auction process (a competitive bidding process between government and commercial entities), the ACT Government has achieved the cheapest wind power ever contracted, at \$73 / megawatt-hour (MWh) at Neoen's Hornsdale 3 Wind Farm. The recent sale of the Stockyard Hill Wind Farm in Victoria led to Origin Energy contracting renewable energy from the project for less than \$60 / MWh.

Indicative modelling provided by industry representatives indicates that it is realistic to expect that, after taking into account the remoteness premium of the NT, as well as the additional costs associated with building in our challenging environment, contracted prices for energy from renewables plants will be in the order of \$80-100 / MWh, and likely to reduce.



Darwin Trailer Boat Club - Country Solar, 2017

The National Renewable Energy Target (RET)

The national Renewable Energy Target (RET) is an Australian Government scheme designed to reduce emissions of greenhouse gases in the electricity sector and encourage electricity generation from sustainable and renewable sources. Previously known as the 'Mandatory Renewable Energy Target', the scheme's initial aim was to source two per cent of Australia's electricity generation from renewable energy sources, which was later increased to 20 per cent.

In 2011, the RET was split into two parts: the Large-scale Renewable Energy Target and the Small-scale Renewable Energy Scheme. It works by allowing both large-scale power stations and the owners of small-scale systems to create large-scale generation certificates (LGCs) and small-scale technology certificates (STCs) for every megawatt hour of power they generate. These certificates are then purchased by electricity retailers and submitted to the Clean Energy Regulator to meet legal obligations under the RET, creating a marketplace that provides a financial incentive. The Large-scale RET is designed to deliver the majority of the 2020 target, while the Small-scale Renewable Energy Scheme supports the installation of small-scale renewables, such as household solar rooftop panels and solar hot water systems.

More recently, in 2015, the Australian Government passed the *Renewable Energy (Electricity) Amendment Bill 2015*, reducing the Large-scale Renewable Energy Target from 41 000 GWh by 2020 to 33 000 GWh by 2020 with interim and post-2020 targets.

South Australia sources over 36 per cent of its electricity from renewable sources, with 25 per cent of homes having solar PV panels. South Australia has installed more large-scale renewable capacity than any other state since 2001.

Ref: Climate Council of Australia, *The Australian Renewable Energy Race: Which states are winning or losing?* 2014.



Rolls Royce Gas Turbine at Channel Island - Owen Peake

The Economic Debate

It has historically been assumed that the principal financial barrier to new renewable energy investment was the high capital cost. This was offset to some extent by the lower cost of operation, generation and maintenance that could be realised from renewables¹⁹.

The cost of producing renewable energy electricity has declined significantly over recent years and is still on a rapid downward trajectory. For example, the average investment cost of both wind and solar power has decreased by more than 50 per cent since 1990²⁰. It is anticipated that the cost of renewable energy will decline even further as markets mature and companies increasingly take advantage of economies of scale.

According to IRENA (2016), doubling the share of renewable energy within the energy mix by 2030 would increase global GDP by up to 1.1 per cent, improve welfare by up to 3.7 per cent and support more than 24 million jobs in the sector.

The annual average daily solar exposure



Bureau of Meteorology, Licence: <https://creativecommons.org/licenses/by/3.0/au/>

¹⁹ IRENA, The Power to Change: Solar and Wind Cost Reduction Potential to 2025, 2016.

²⁰ IRENA, Renewable Power Generation Costs in 2012: An Overview, 2012

Australia has a substantial renewable energy resource potentially capable of providing 500 times the electricity currently used in Australia²¹. It has been estimated that growth in renewables worldwide would see a corresponding growth in Australia's economy of 1.7 per cent above 'business as usual', even when factoring in a decline in coal exports²².

Critical to considering the economic benefits of renewable energy is to what extent solar power with storage technologies will continue to develop and whether the cost of solar energy production will continue to decline^{23,24}.

Many argue renewable energy brings significant opportunity for job growth.

In the United States of America in 2016, electricity generation and fuels technology directly employed 1.9 million workers. Of these, 55 per cent, or 1.1 million, worked in traditional coal, oil and gas, while almost 800 000 were employed in low carbon emission generation technologies, including renewables, nuclear and low-emission natural gas²⁵. In the Australian context, modelling has shown that a national policy of moving to 50 per cent renewable energy would create 28,000 nett jobs²⁶.

In the Northern Territory, the real potential for job creation is in the energy intensive industries that lower cost renewable energy may attract. It is a central conclusion that renewable energy electricity generation may well be a driver for economic development and as such a source of jobs growth.

Many countries are investing significantly in renewable energy to reduce their emissions and their reliance on fossil fuels, with over 170 countries implementing renewable energy targets²⁷. Given today's considerable disruptive change as a result of technology developments across generation, storage and control in electricity systems, many governments are aware of the potential significant opportunity costs if they do not transition to renewable energy sources²⁸.

In the Northern Territory, ongoing oversight, analysis and road-mapping will be required to determine the extent of the benefits of renewable energy for jobs, and investment in new and emerging technologies as they become available.

In 2009, the Union of Concerned Scientists conducted an analysis of the economic benefits of a 25 per cent renewable energy standard by 2025; it found that such a policy would create more than three times as many jobs as producing an equivalent amount of electricity from fossil fuels—resulting in a benefit of 202 000 new jobs in 2025.

<http://www.ucsusa.org/clean-energy/renewable-energy/public-benefits-of-renewable-power#.WVRhtmcUkis>

²¹ Commonwealth of Australia 2014; AEMO 2013.

²² IRENA, Renewable Energy Benefits: Measuring the Economics, Abu Dhabi, 2016.

²³ Refer to Lazards Levelized Cost Of Energy analysis – Version 10.0 December 2016

²⁴ Fraunhofer ISE (2015): Current and Future Cost of Photovoltaics. Long-term Scenarios for Market Development, System Prices and LCOE of Utility-Scale PV Systems. Study on behalf of Agora Energiewende. 2015

²⁵ US Energy and Employment Roadmap, January 2017

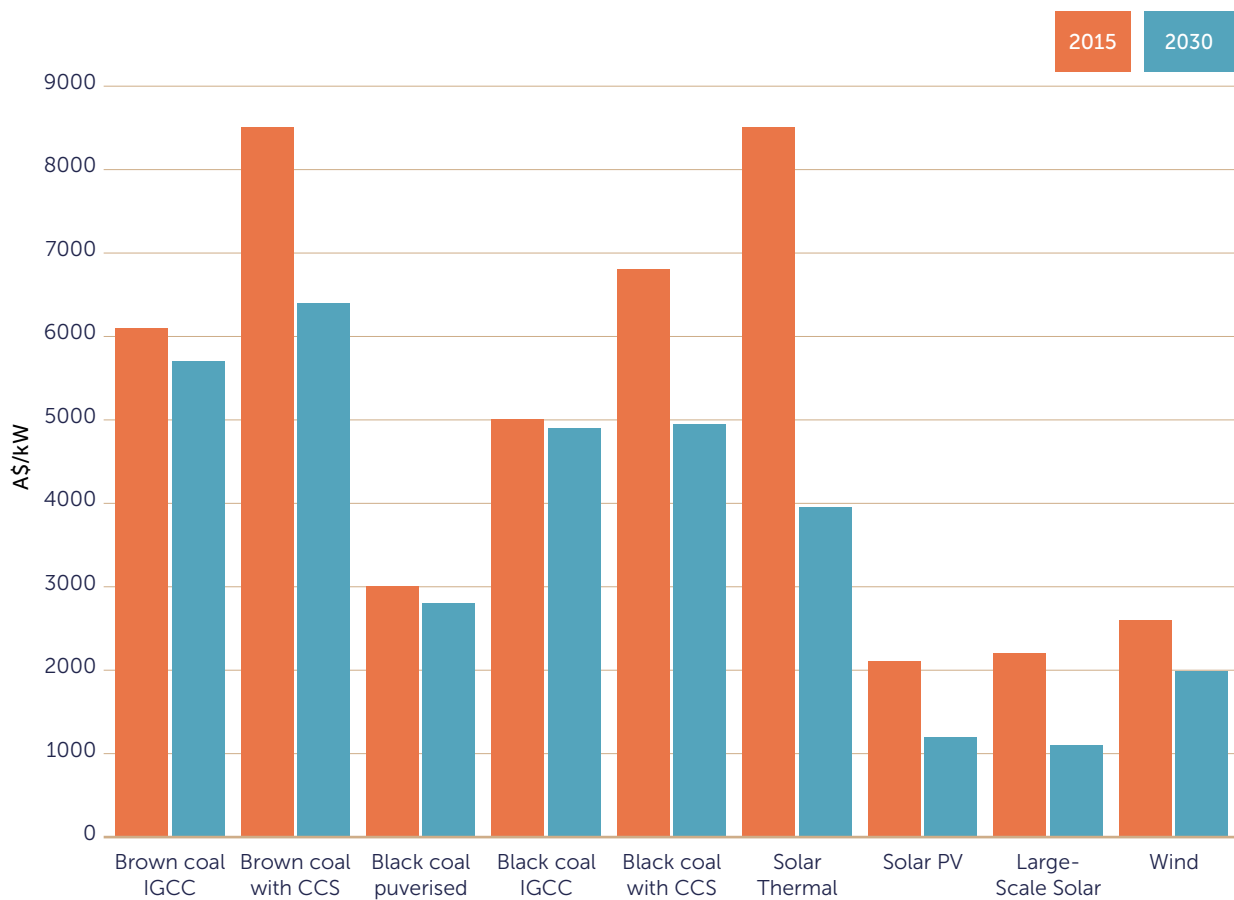
²⁶ <http://www.climatecouncil.org.au/renewablesreport>

²⁷ <http://www.climatecouncil.org.au/towards-morocco-report>

²⁸ Institute for Sustainable Futures, 100 per cent renewable energy for Australia: Decarbonising Australia's energy sector within one Generation, 2016.

Generation capital costs 2015 and 2030

Summary of capital costs, inflation adjusted



Source: CO2CRC, 2015, p 252

The Northern Territory Context

Building a Secure Grid for the Future

Providing secure, reliable power is a key objective for both National and Territory Governments which has gathered significant public debate. To maintain reliable supply, electricity systems need to keep supply and demand in balance. Electrical systems are dynamic, and rapid changes can adversely affect key elements such as voltage and frequency. Generators and control systems need to act quickly to maintain the balance or system protection devices may operate to avoid catastrophic failure (their operation may result in systems wide blackouts). A robust network has significant inertia to buffer against instability. Power plants with large rotating engines provide inertia and maintain power stability. An inverter connected renewable energy plant usually lacks inertia and can increase instability if not well managed. A range of technologies other than large rotating engines can provide inertia and the term “ancillary services” is used in this report to refer to these types of system support services.

Given the very high levels of solar radiation in the NT, the relatively low average wind speeds and other environmental constraints, the primary source of renewable electricity for the Northern Territory will likely be solar photovoltaics (PV)^{29,30} and as solar power is intermittent (varying with changing solar availability) this will require energy storage, particularly batteries, to maintain reliable supply.

Global benchmarking completed by firms such as Lazard has highlighted significant progress in the application and implementation of large-scale storage, with cost dramatically reducing in some areas³¹. Coupling low-cost renewable generation capacity like solar PV with batteries, at both household and grid scale, may become increasingly the norm in Australia in the next decade as costs continue to fall. Experience

in Australia of both household batteries and utility scale technologies are limited at present but are increasing. Victoria and South Australia are implementing relatively small grid scale batteries, while the ACT initiated the largest roll out of household batteries in the world (outside of Germany) in 2016.³²

The Northern Territory already has experience and expertise in integrating renewables and managing variability and intermittency.³³

Policy Settings

In 2016, the Northern Territory Government adopted a 50 per cent renewable energy target by 2030, (Appendix 1). A formal, whole-of-government renewable energy policy will help agencies make informed decisions to achieve the target. The secondary benefit will be to increase investor certainty.

Community and stakeholder consultation showed broad support for this renewable energy target. However, some restrictions were identified that could impede the uptake of renewable energy, including:

- Financing options and arrangements, which are usually not flexible for use by government agencies or government-owned corporations or are not permissible under existing Northern Territory legislation
- Procuring large-scale generation certificates mainly from interstate renewable energy generators, which limits investment in renewable energy in the Northern Territory
- Insufficient transparency in procurement, evaluation and tendering processes, which is important for facilitating a pathway for investors to enter the Northern Territory market
- A lack of transparency in the cost of ancillary services, which makes it difficult for investors to assess the true cost of energy generation in the Northern Territory and to make appropriate contractual arrangements

²⁹ All the latest LCOE work (Lazards, Bloomberg, Finkel etc validate previous reports findings (detailed in Appendix 4). Solar thermal may play an economic role in the medium term if CAPEX can be reduced.

³⁰ Green Energy Task Force Report

³¹ <https://www.lazard.com/media/438042/lazard-levelized-cost-of-storage-v20.pdf>

³² <http://www.environment.act.gov.au/energy/cleaner-energy/next-generation-renewables>

³³ Please refer to Appendix 9 and 10 for further discussion.

- A lack of transparent and appropriate tools, maps, price data, and demand and forecasting data for proponents to use in making investment plans and decisions
- Insufficient information on investment opportunities and available investment processes, such as the reverse auction process used in the ACT, an expression of investment process or competitive long term power purchase agreements
- Lack of an accreditation system aimed at reducing the financial and regulatory requirements of obtaining a building permit for every new installation of rooftop solar PV.
- Insufficient education and training programs, which will be required to meet the growing requirement for technical expertise and engineers as a result of the increase from four per cent to 50 per cent renewable energy penetration.
- The need for targeted education and engagement to ensure all components of the Northern Territory community can contribute to the renewable energy target.

The recommendations and supporting enabling actions detailed in this report aim to address these barriers.

The renewable energy target should be supported by the Energy Policy for the Northern Territory, which is currently in development. The Energy Policy should outline government's policy position for energy in the Northern Territory and help the government to establish goals around energy generation, distribution and consumption; make informed decisions; prioritise actions, and adopt an appropriate legislative and regulatory framework.

The Economic Development Framework (EDF), released by the Northern Territory Government in June 2017, confirms the importance of renewable energy in growing the economy. The EDF particularly highlighted the benefits from integrating best-practice technology in solar power generation, storage and management and the potential for Northern Territory businesses to earn income from selling this expertise outside the Northern

Territory. We are confident that this Roadmap to Renewables report supports the delivery of the government's EDF.

The Legislative Framework

On 1 July 2015, the *National Electricity (NT) (National Uniform Legislation) Act* commenced. Among other things, it transferred the economic regulation of the Territory's regulated electricity networks (Darwin–Katherine, Alice Springs and Tennant Creek) from the Utilities Commission to the Australian Energy Regulator (AER). The Utilities Commission will continue to regulate under the Northern Territory's existing electricity legislative framework until 1 July 2019. The future framework will need to be carefully crafted to ensure a consistent and trusted environment is in place for investors looking beyond 2019.

Under the Northern Territory Government's electricity networks regulatory reforms, jurisdictional regulation by the Utilities Commission under the *Electricity Networks (Third Party Access) Act* transferred to the Australian Energy Regulator (AER) on 1 July 2015. The AER will continue to regulate under existing Territory legislation while simultaneously preparing the 2019-24 Network Price Determination under the National Electricity Law and National Electricity Rules to commence on 1 July 2019. It is important that Northern Territory arrangements and national obligations, such as those associated with the Renewable Energy Target, NER and NEM, are aligned to minimise compliance costs, confusion and barriers to entry by requiring proponents established in other jurisdictions to be able to adapt to the requirements of the Northern Territory. Derogations from the national rules that are being adopted are required to improve the arrangements for the Northern Territory electricity market with the onset of renewable energy generation. Under the electricity networks reform program, the *Electricity Networks (Third Party Access) Act* will fall away on 1 July 2019 with the transition to the national regulatory

arrangements for electricity networks. This will affect (at least) the:

- Network Technical Code
- Connections processes

Currently, there is overlap and unclear content in the Electricity Networks (Third Party Access) Code, Network Technical Code (NTC), Network Planning Criteria and System Control Technical Code. This can create confusion for new market participants. The generator and load notifications and requirements must also be clarified, including for when generators do not meet the automatic access standards.

Grid System

The Northern Territory is made up of three regulated electricity grid networks: Darwin–Katherine, Tennant Creek and Alice Springs (Appendix 7). These regulated systems are powered by gas-fired generators. These grids provide a total electricity capacity of

650.3 megawatts (MW). However, the average energy demand for the Northern Territory is 212.3 MW, with a maximum aggregate demand of 353.7 MW (Appendix 8).

There are also minor grid systems at Yulara, Timber Creek, Borroloola, Nhulunbuy and Ti Tree, which are primarily powered by gas, diesel or a mixture of the two. Other areas of the Northern Territory are categorised as unregulated systems, where generation is generally provided by diesel or gas fired generators. Increasing portions of renewable energy are being injected throughout the Northern Territory, including within outstations and remote communities.

These smaller communities offer significant opportunity for high penetration solar and battery systems as the renewable energy replaces expensive diesel fuel.

Summary of installed capacity generation in NT

Power System	Capacity (MW)
Darwin-Katherine	501
DLNG (Conoco Phillips)	180
Tennant Creek	17
Alice Springs (inc Uterne)	93
Yulara and Kings Canyon	12
Remote communities / IES	80
Remote mining operations	165
Operating total	1,048
Ichthys LNG (not commissioned yet)	500
TOTAL	1,548

Figure 3: NT power system (Power and Water Corporation, 2017)



The Role of Government Owned Corporations

The three Government Owned Corporations (GOCs), Power and Water Corporation (PWC), Territory Generation (TGen) and Jacana Energy operate in the Northern Territory electricity system.

The generation sector is dominated by TGen which operates and maintains a fleet of gas powered generation assets. As well as supplying the Northern Territory with most of its electricity, these gas generation assets also provide the necessary support services, including ancillary (back up) services, voltage control, frequency control and inertia (the ability of the system to recover quickly from sudden equipment outage)³⁴.

PWC has an independent System Control unit which functions to regulate the power systems. This includes managing the system's reliability by ensuring the right support services are always available (including real-time operations, managing system risk, demand side management, outage coordination, power system technical assessments and long-term system planning, according to the requirements of the System Control Technical Code, NTC and Electricity Ring Fencing Code (RFC).

System Control manages the electricity system by instructing generators such as TGen to operate in certain ways in the system.

The electricity networks in the Northern Territory are largely Northern Territory Government owned, and operated by the PWC.

Power Networks is an independent unit in the PWC and is responsible for planning, building and maintaining distribution and transmission networks for the regulated DKIS, Tennant Creek and Alice Springs networks *according to the requirements of the Electricity Networks (Third Party Access) Act, NTC and RFC until 1 July 2019, and under the requirements of the NER thereafter*.

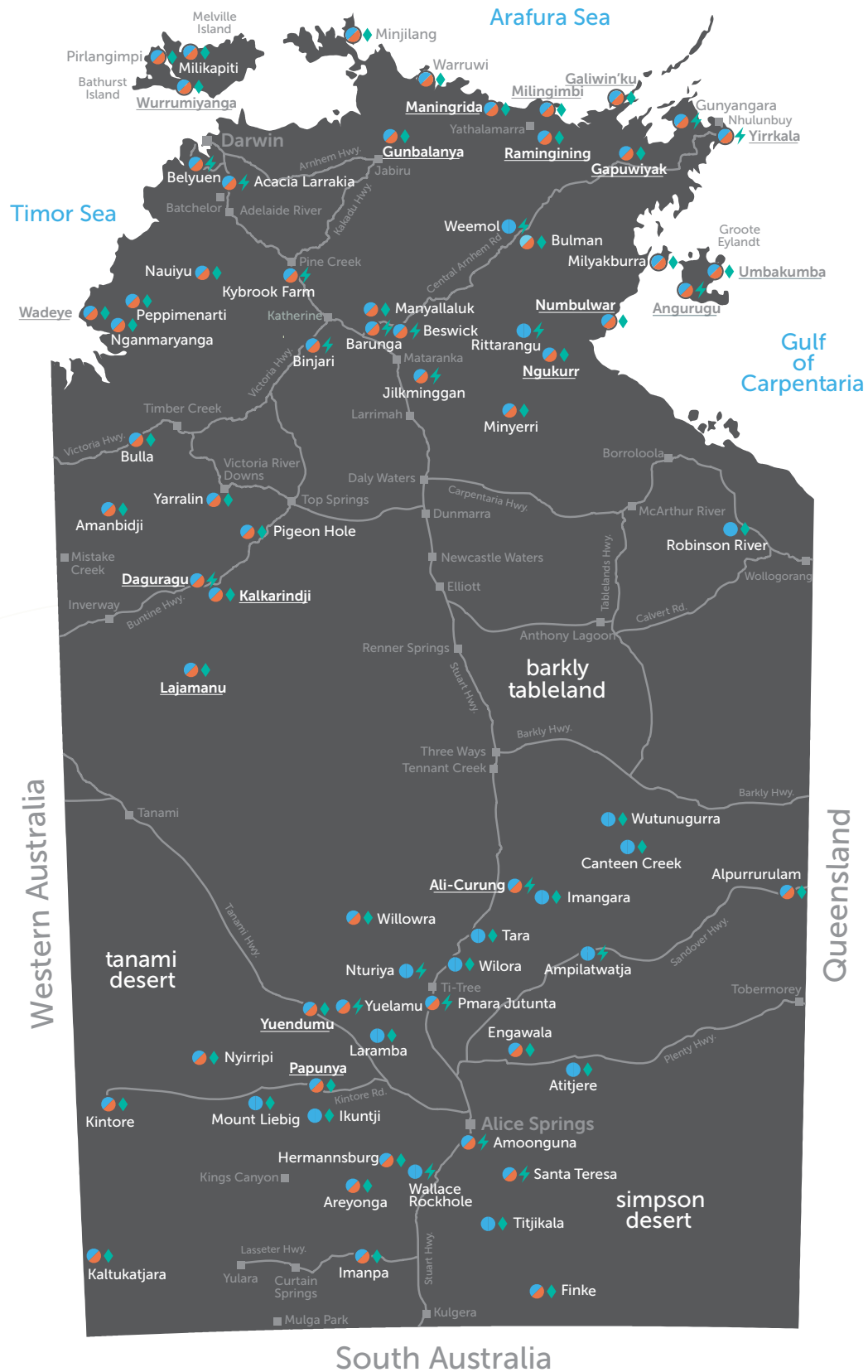
PWC also generates electricity in some minor centres and communities serviced by Indigenous Essential Services Pty Ltd through contracts with PWC. PWC is currently delivering the Solar Energy Transformation Program (SETuP) that will see the installation of 9MW of 'medium penetration solar' (renewable energy systems established to supplement the diesel generated system but without back up storage) across about 30 communities to achieve approximately 15 per cent diesel fuel saving annually. These renewable energy systems are of simple low-cost design, using tried and tested renewable energy technology, to maximise diesel fuel savings for minimal cost. A 1MW 'high penetration' (differs from the medium penetration renewable energy system because it also includes storage capacity) renewable energy system has been built at Daly River. This uses storage technology to achieve approximately 50 per cent diesel fuel saving annually. Once SETuP is completed, over 13GWh per annum will be provided by renewable energy in remote communities. This represents over 10 per cent of total generation in remote communities.



Bathurst Island remote community power station
typical diesel generator

³⁴ http://www.mjbradley.com/sites/default/files/MJBA%20NG%20and%20Renewable%20Discussion%20Paper%20FINAL_10Dec2012.pdf

Map of IES centres in the Northern Territory



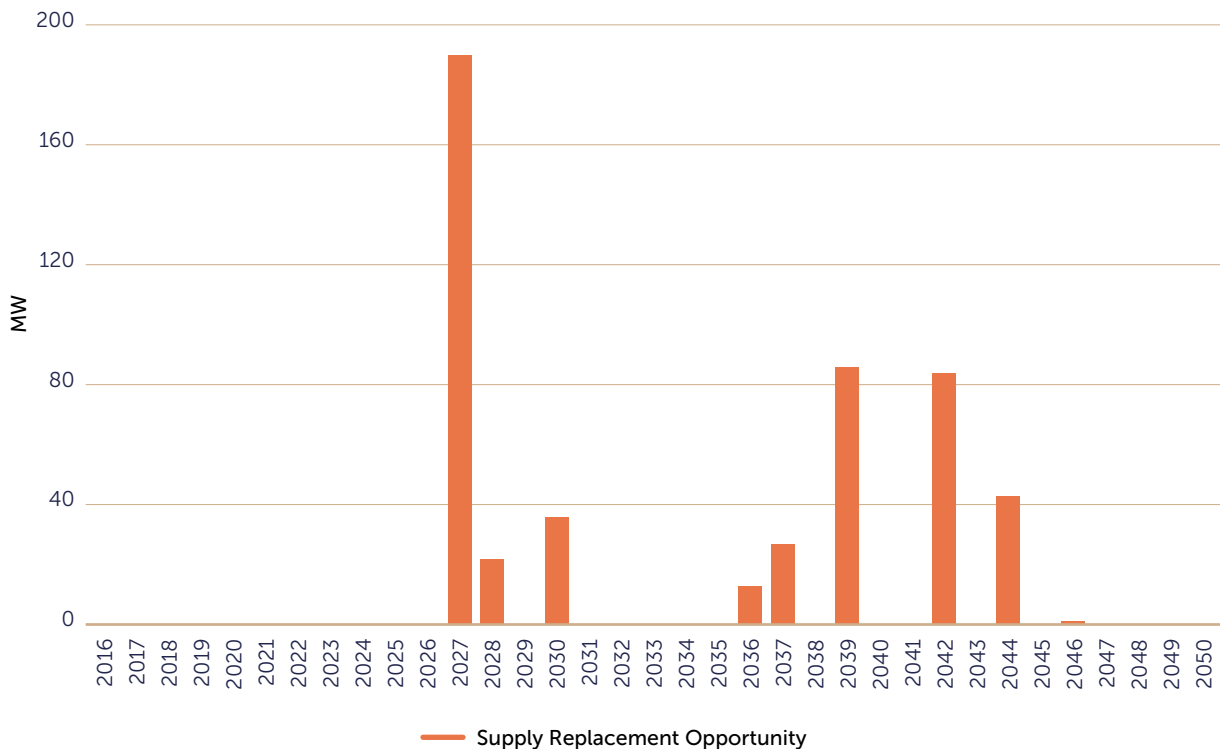


There are six licenced electricity retailers in the Northern Territory, which includes the government owned Jacana Energy and PWC. The market reform initiatives, currently being rolled out in the Northern Territory have Jacana Energy facing increasing retail competition across its customer portfolio. However, Jacana Energy remains the dominant electricity retailer across both the regulated residential and small business customer market and the commercial and industrial customer market.

While there is considerable opportunity for renewable energy to replace the TGen gas generation assets as they retire, planning will

be important to ensure the renewable energy systems can provide a reliable supply and have the necessary system support services, to maintain the system's security and reliability. This may include dispatchable or scheduled power supply in which proponents are required to provide the back up and ancillary services irrespective of whether the conditions are optimal for renewable energy generation (such as through storage, backup generators, etc.). The existing gas generation assets, or their components, could be used in a different way to support the growing system renewable energy plant. This approach could also extend the TGen asset's life.

Darwin/Katherine Supply

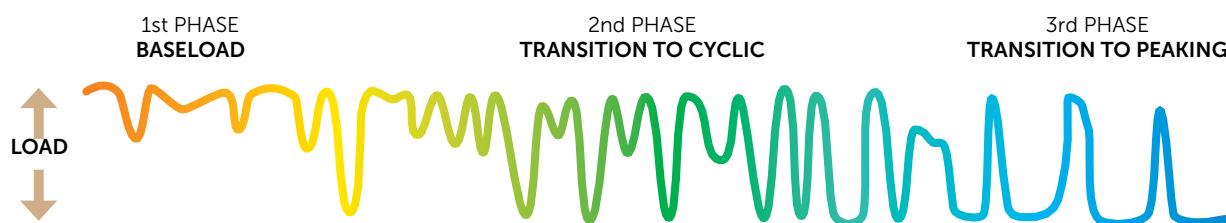


Territory Generation, 2017

Power Products	Purpose (dispatch)	Desired Attributes
Base Load	Provide continuous (or near-continuous) power (>6000h/y)	• High efficiency • Lowest \$/MWh
Cyclic	Cover real-time fluctuations between demand and supply from intermittent renewables (1500-6000 h/y)	• High efficiency • Operating flexibility • Low \$/MWh
Peaking	Supply intermittent power for seasonal peak hour demands (100-1500 h/y)	• Low \$/MWh • Low NOx emissions • High start reliability
Stand-by	Back-up power for reliability (<100 h/y)	• Low \$/MWh • Black-start capacity • Small footprint
Ancillary Services	Frequency regulation, spinning and non-spinning reserves, reactive power	• Fast start and ramping • Black-start capacity • Frequency response

The operating profile of a plant can change over its life. Plants initially purchased to provide baseload generation may experience a decrease in their dispatch over time and migrate towards cyclic operation as newer technologies are added to the grid, with even lower variable operating costs. In other cases, plants initially built as peakers are converted to combined cycle to improve the economic return on their investment over time. GE provides solutions that can be adapted to changing industry needs and help you sustain and even grow the value of your plant assets over time.

Changes in Lifestyle Duty



The Frame 6 gas turbines at Channel Island power station are GE machines and the above commentary is appropriate.³⁶

³⁶ Sourced from GE document https://powergen.gepower.com/content/dam/gepower-pgdp/global/en_US/documents/product/2016-gas-power-systems-products-catalog.pdf

Market Arrangements

The Northern Territory's electricity market currently relies on 'bilateral contracting' arrangement rather than a spot market (electricity is purchased every 30 minutes from generators offering the lowest cost). Under a bilateral contracting arrangement, a new generator company entering the Territory market is required to secure customer contracts up front through a licenced retailer and then to generate a set volume of electricity on a half-hourly basis. The bilateral contracting arrangement lacks pricing transparency and is considered a significant barrier to private investment in the Territory's generation sector³⁷.

In September 2013, the Utilities Commission reviewed the wholesale electricity market arrangements for the Territory and recommended developing market design and rules suitable for the Territory's circumstances³⁸. The Commission's report recommended a market design called the Northern Territory Electricity Market (NTEM), which comprises an energy and capacity component, meaning that the market is designed to encourage investment to ensure there is adequate capacity of electricity generation to meet forecasted demand and to achieve the reliability targets specified in the Rules. The Commission's analysis suggested that a spot market would not be appropriate for the Northern Territory situation because of the small size of the market³⁹. The interim form of the NTEM (the I NTEM) has been operating since May 2015. The I-NTEM does not include the investment mechanism or reliability mechanism that will be included in the full NTEM design. These components will be critical to competition in the Northern Territory market in the future.

The Department of Treasury and Finance, on behalf of the Northern Territory Government, has commenced work on the transition from I NTEM to NTEM. This will see bilateral contracting replaced with this energy and capacity market, which will create a cost-effective and secure supply of electricity while

creating investor certainty, transparency and competition. The following actions are being undertaken in consultation with industry stakeholders:⁴⁰

- Designing the roles and responsibilities of the key market bodies to ensure the NTEM operates efficiently and delivers its intended market outcomes
- Designing a managed investment regime and a central dispatch process to facilitate efficient short-term dispatch, including unbundling the cost of back up ancillary services from the cost of generating electricity
- Developing a reliability standard to ensure adequate generation capacity is built to meet customer demand
- Establishing an appropriate legislative and regulatory framework.

Capacity plus energy markets are used in many countries and in the Western Australian Wholesale Energy Market that operates around Perth. The NTEM design has similarities to the National Electricity Market (NEM) that operates in the much larger interconnected power system of eastern and south-eastern states but differs because the NEM uses a single price and revenue stream for both energy and capacity (an energy-only design) supported by external contracts. In the Northern Territory, it will be important to assure investor certainty. It is proposed that long term off-take agreements (also called Power Purchase Agreements or PPAs) should be offered through a reverse auction process. This process has proven very successful in the Australian Capital Territory's move to 100 per cent renewable energy electricity consumption and is in line with the broader capacity and energy market design.

It is expected that by mid-2018, a competitive wholesale electricity market will be in operation in the DKIS network to allow generators and retailers to trade electricity on commercial terms and under competitive conditions,

³⁷ Northern Territory Department of Treasury and Finance, Strategy for the Northern Territory Utilities, 2016.

³⁸ Utilities Commission, Review of the wholesale electricity generation market arrangement for the Northern Territory, February 2014.

³⁹ Oakley Greenwood, Wholesale Electricity Generation Market Review, 2013.

⁴⁰ Northern Territory Department of Treasury and Finance, Strategy for the Northern Territory Utilities, 2016.

while supply reliability and security is closely managed within defined standards⁴¹. As well as clear standards, these Rules must stay flexible so new and emerging technologies can be used in the Northern Territory as they become available, such as virtual grids, micro grids, appropriate energy meters, distributed generation systems, community generation projects and storage.

Emerging Technologies

Globally, disruptive change is driving the development of new and innovative approaches to capture, integrate and store renewable energy. This is not only driving down the cost of renewable energy infrastructure and wholesale electricity prices, but it is delivering fast solutions to existing challenges. There is a significant opportunity for the Northern Territory to increase penetration of renewable energy across locations and times, and to maintain ongoing security and reliability of the network.

Storage will likely play a particularly important role in the Northern Territory's progress towards the 50 per cent renewable energy target (Appendix 9). As noted previously, solar PV has the highest potential as a renewable energy source in the Northern Territory, however, solar energy is intermittent (Appendix 10), which means energy is only produced when the sun is shining: cloud cover can rapidly reduce energy capture. Storage can compensate for this intermittency^{42,43} and will become more attractive as the cost declines. Ideally, this storage will provide the necessary system support, including inertia, frequency and voltage control⁴⁴ as the penetration of renewable energy increases. In the short term, backup plant such as gas turbines can play an important supporting role. Much of the existing installed fast start gas turbine plant operated by Territory Generation is ideal for this support mechanism.

To optimise the use of known and emerging technologies, the Northern Territory Government agencies need to improve their knowledge of the existing systems and networks. This could be achieved in part through advancing, and fully accrediting, the existing dynamic network model held by System Control. An effective model will provide current information about the impact of renewable energy injection at different locations within the existing network, enabling predictions to be made about the most appropriate locations for renewable energy injection. It will assist System Control to more effectively plan and manage the system in real time. Given that all new renewable generators will be expected to supply network support⁴⁵, and may even consider becoming dispatchable, it is essential that Networks and System Control have the modelling tools and staff to evaluate each proposal and to advise what network support is required.

⁴¹ Northern Territory Department of Treasury and Finance, Strategy for the Northern Territory Utilities, 2016.

⁴² Refer to Lazards Levelized Cost Of Energy analysis – Version 10.0 December 2016

⁴³ There are various types of storage and long term intermittency can be managed with gas turbine support

⁴⁴ Climate council.org.au/price-of-gas

⁴⁵ See EA 6(b) and 8(d)

Community Support for Adopting Renewable Energy

Ninety-six per cent of the fuel used for the three regulated networks (Darwin–Katherine, Tennant Creek and Alice Springs) is natural gas which has allowed the Northern Territory to achieve relatively low wholesale electricity prices (Appendix 11).⁴⁶ It is noted, however, that retail tariffs to domestic customers have only been able to be capped at a constant level through direct government subsidy to Jacana Energy. Even so, natural gas has been a good choice for the Northern Territory because of its local abundance and accessibility.

However, Territorians are well aware of the immense solar resource available in the Northern Territory. Technology that allows us to convert this solar energy into electricity for use in homes, businesses and community facilities is becoming more affordable. Many Territorians have already installed solar PV on the roofs of their homes and businesses to save on their electricity bills, reduce the consumption of fossil fuels, and to reduce greenhouse gas emissions. The paradox is why there is only 6 per cent of households with PV compared with a national average of 14 per cent. This seems to lag behind other Australian states and territories even though the Northern Territory has the highest availability of solar energy in Australia. The community is asking why the Northern Territory can't achieve more (Appendix 2).⁴⁷ It needs to be noted here that a breakdown of the adoption rate shows home owners in the Northern Territory are equally keen on roof top PV as their southern counterparts but that the Territory has a high proportion (40 per cent) of rental and government housing which has not taken up rooftop PV (Appendix 11).

The Northern Territory Government also owns many properties—public housing, hospitals, schools, recreational facilities, health clinics, police stations and community halls—but historically has not explicitly encouraged the installation of solar PV on its own buildings.

The government accounts for about 25 per cent of electricity consumed in the Northern Territory, meaning that by not installing solar on its own buildings, there are missed opportunities for installation of large quantities of renewable energy. If consumption by rental households and government were combined, some 50 to 60 per cent of facilities could potentially benefit from renewable energy.

There are several recommended actions to increase PV on rental and government housing.

It was observed in community engagement consultations, that the community wants all levels of government to lead more aggressively in adopting renewable energy and to support households and businesses that want to contribute with their own investment in renewable technologies and storage systems. This will benefit all consumers and add to overall network reliability and performance.

⁴⁶ [Climatecouncil.org.au/price-of-gas](https://climatecouncil.org.au/price-of-gas)

⁴⁷ Community consultations

Leveraging the Northern Territory's Existing Advantage

Over time, the Northern Territory has acquired considerable knowledge, capability and expertise in renewable energy technology, particularly in the Alice Springs region. Alice Springs has a national and international reputation for solar energy adoption and integration and was declared a Solar City under the National Program.

There is considerable value in building on this existing infrastructure, knowledge and expertise. In particular, Alice Springs offers an excellent location to develop and understand the requirements of a city with a high penetration of solar energy. In addition, the lessons learnt in Alice Springs can be applied across the Northern Territory. The government has committed to an Alice Springs Centre for Excellence in Solar Energy, which will act as a 'research hub', concentrating resources and capability and sharing knowledge. This hub approach will allow Alice Springs to attract other resources through co-investment from other parties, including research organisations, industry and other government partners. Alice Springs will also provide an ideal location for new research and development programs, trials, demonstration projects and other initiatives.

The Northern Territory is a prime location for large scale solar PV plants. There is considerable open space, land for development and sunshine. The location of plants will need to be carefully chosen and integrated into the grid. It may be possible to upgrade or extend the existing transmission lines to facilitate greater input of renewable energy throughout the Northern Territory, not just in locations close to major centres and existing grid connections.

The cost of High Voltage Direct Current (HVDC) transmission is decreasing and globally more and more networks are using this alternative transmission system to efficiently move electricity over long distances. Such a network could form a backbone across the Northern Territory, assisting projects such as distributed large scale solar PV and future solar thermal power generation and be funded by The North Australian Infrastructure Fund.



Channel Nine TV station, Darwin - Country Solar, 2017

The Structure of the Roadmap

We consider the technology exists, and is rapidly becoming more cost competitive, to meet the 50 per cent renewable energy target by 2030. However, careful planning is required to manage the financial and regulatory challenges of integrating large quantities of renewable energy into the system.

This roadmap report sets out the recommended initiatives, supported by a range of specific Enabling Actions, to achieve the 50 per cent renewable energy target under five key themes (Appendix 12).

- Renewable energy as a supporter of economic development
- Finance and investment
- Governance and regulation
- Technology, security and reliability
- Engaging the community

Given the considerable interaction between these themes and the need for some recommendations to precede others, we also considered the timing for implementation across three time periods:

- **Short term:** Recommendations and actions that can be implemented over the coming 12 months (2017–18).
- **Medium term:** Recommendations and actions that require greater levels of planning or effort and that can be implemented over the following four years (2018–2021).
- **Longer term:** Recommendations and actions that could be implemented over a longer period either due to waiting for prior recommendations or actions to be completed (market reforms for generation competition) or for external time frames to be aligned (asset retirement time frames).

The **11 Recommendations** provide the essential foundation, needed to achieve the government's 50 per cent renewable energy target. They have been crafted on the basis that further detailed modelling and planning for their implementation will be required, however in anticipation of this work, a number of Enabling Actions have been proposed for each recommendation. These have been separated into Core actions which are considered 'essential' and Supporting Actions which provide additional guidance on how to meet the Recommendations.

The Panel considers that the effective implementation of the recommendations will require a co-ordinated effort across government. To that end the panel has proposed that a central body be tasked to coordinate the actions required to achieve the 50 per cent renewable energy target, working in partnership with agencies and government owned corporations is proposed. While the precise mechanism by which the central body is for government to determine, giving thought to existing agencies, departments and capabilities, for ease of reference the body has been referred to as the Independent Implementing Agency (IIA) throughout the report.

It is important to note that we have drawn our conclusions and recommendations utilising a variety of highly regarded data sources and references. On that basis, while the actions have not been individually costed or subject to specific benefit-cost analyses (such as that completed by NYSERDA⁴⁸), it is considered that the recommendations are realistic and viable. It is recommended further work, including detailed costing, be undertaken as part of the detailed planning and implementation of the recommendations.

It is recommended that government undertakes this work as soon as practicable in order to maintain the momentum required to achieve the target by 2030.

⁴⁸ Large Scale Renewable Energy Development in New York: Options and Assessment. New York State Energy Research and Development Authority (NYSERDA), Report 15-12 June 2015

Renewable energy as an enabler of economic development

Finance	Governance	Technology, Security and reliability	
Align Policy Objectives	Build industry and community confidence	Validate network capabilities ensuring system security and reliability	Short Term
Certainty for investors	Support a competitive market	Future system planning	Medium Term
Asset Optimisation	Adaptive Regulatory Framework	Implementation of future grid	Longer Term

Enabling the Community



Renewable Energy as a Supporter of Economic Development

Around the world, governments and businesses are using renewable technologies to achieve lower electricity costs, even after accounting for the additional investment in infrastructure required to capture, store and transmit renewable energy.

Around the world, governments and businesses are using renewable technologies to achieve lower electricity costs, even after accounting for the additional investment in infrastructure required to capture, store and transmit renewable energy. Each situation is different, but the trends are clear. There is no reason why the Northern Territory can't aspire to the same outcome by adopting greater levels of renewable energy. This could contribute to making the Northern Territory a more attractive place for businesses that see electricity as a significant part of their cost base. In addition, the expected downward pressure on the wholesale cost of electricity generation, as a result of the ongoing and

sustained reductions in the cost of energy from renewables source, particularly solar PV and batteries, could attract energy intensive industry to invest in the Territory.

Most of Australia has had the advantage of relatively low cost, reliable and secure electricity for decades. However, after recent, well publicised, extreme weather events in south-eastern Australia⁴⁹, and the increase in domestic gas prices⁵⁰, Australia has come to realise reliable and secure electricity 24/7 should not be taken for granted. The Northern Territory is fortunate not only because its three regulated networks have generally achieved a high standard of reliability and performance but also because the technology is available to maintain these high standards as increased levels of renewable energy are adopted. Decisions to retire ageing gas-fired generators can be made after careful consideration of the effect on future network reliability and performance.

The Northern Territory is in a strong position to achieve lower wholesale electricity prices than those in other Australian states and territories in coming years.

⁴⁹ [Climatecouncil.org.au/sa-storms-fact-sheet](https://climatecouncil.org.au/sa-storms-fact-sheet)

⁵⁰ [Climatecouncil.org.au/price-of-gas](https://climatecouncil.org.au/price-of-gas)

A commitment to maintaining high levels of network reliability and performance can differentiate the Northern Territory from other states and territories in Australia in the short term and will help make the Northern Territory a more attractive place to live and do business

It is a commitment of the Northern Territory Government to grow the population, both in urban centres and regional areas. A growing population and economy are likely to require increased electricity supply, and this can be delivered by scaling up the level of renewables. The scalable nature of renewables and the potential to include storage capacity on the networks increases the flexibility available to respond to increases in future demand.

With appropriate planning, there is considerable opportunity for the Northern Territory Government to realise the economic benefits from a transition to renewable energy sources.

RECOMMENDATION 1

Renewable Energy Enabling of Economic Development: To ensure long-term benefits for all Territorians, the Northern Territory Government should include renewable energy as a central pillar of economic policy, maximising benefits of forthcoming disruptive change in the electricity sector caused by the global transition to competitively priced renewable energy.

SHORT TERM ENABLING ACTIONS

Core Enabling Action

- 1(a)** As an integral part of the Northern Territory Government's Economic Development Framework, renewable energy electricity generation should be endorsed as a whole-of-government initiative towards Northern Territory economic development, founded on competitively priced and environmentally responsible, electricity generation. This should include action to ensure that the Energy Policy being developed for the Northern Territory is aligned with the 50 per cent renewable energy target.

Supporting Enabling Action

- 1(b)** The Northern Territory Government should establish an Independent Implementation Agency (IIA) to coordinate the actions required to achieve the 50 per cent renewable energy target, working in partnership with agencies and government owned corporations. In particular, the Agency could develop the necessary financial instrument and run a reverse auction process. This approach would align with the ACT Government Environment and Planning Directorate (EPD) which proved particularly successful in achieving open and fair competition whilst also delivering record low pricing for renewable energy provision.



Finance and investment

The Northern Territory Government is in a unique position to influence the uptake of renewable energy.

The Northern Territory Government is in a unique position to influence the uptake of renewable energy. The government currently procures energy that equates to roughly 25 per cent of the total energy consumption of the Northern Territory. As such, the Northern Territory Government has a significant capacity to drive investment in renewables, both through requiring minimum levels of renewables, directing agencies to preferentially purchase renewable energy, and creating a transparent commercial environment for investment in renewable energy. This includes publishing technical requirements, commercial terms and evaluation criteria, demand and forecasting data, a program of investment opportunities, and investor planning tools and information.

Jacana Energy, wholly owned by the NT Government, has an obligation under the Commonwealth Renewable Energy Target legislation to source RET Certificates (applicable to the DKIS system) equivalent to its liability for the national 33,000GWh requirement in 2020 which is estimated to be 23 percent renewable energy nationally. Supportive action from the NT Government to Jacana Energy either directly or indirectly could see the money currently spent on

renewable certificates being invested in the Northern Territory rather than supporting purchases from renewable energy projects interstate.

In the short term, it will be critical for government to ensure the alignment of existing legislation, policies and incentives, as well as to develop specific policies and initiatives to support the investment and uptake renewable energy. For instance, the government could counter existing uncertainty for investors through initiating contracted long-term off-take agreements (also called Power Purchase Agreements (PPAs)). These could be offered following a reverse auction process (similar to that undertaken by the ACT Government). Not only would this create greater investment certainty, but it could generate greater competition in the market, which in turn may put downward pressure on wholesale electricity prices.

The cost of producing renewable energy electricity has declined significantly over recent years and remains on a downward trajectory. As a result, the economic viability of renewable energy projects is largely guaranteed provided organisations can access appropriate finance for the upfront capital outlay.

There is, however, a need for more flexible finance options, such as solar leasing and behind the meter schemes, including for local governments, government departments, and government owned buildings.

The Northern Territory Government can also seek to capitalise on opportunities for Northern Territory investors to access Federal finance through the Clean Energy Finance Corporation, The Australian Renewable Energy Agency and the Northern Australia Infrastructure Fund. States like South Australia have benefited from the Commonwealth Government's Renewable Energy Target driving renewable energy development in their state.

RECOMMENDATION 2

Align Policy Objectives: The Northern Territory Government should align its policy objectives, departmental activity and government programs toward the development and purchase of renewable energy generated electricity.

SHORT-TERM ENABLING ACTIONS – Align policy objectives toward the development and purchase of renewable energy

Core Enabling Actions

- 2(a)** The Northern Territory Government should have a whole-of-government policy to preferentially purchase renewable energy generated electricity.
- 2(b)** The Northern Territory Government should direct the government owned corporation Jacana Energy to procure its legislated 'large-scale generation certificates' (LGC) from Northern Territory renewable energy sources.
- 2(c)** The Northern Territory Government (possibly through the IIA (see Enabling Action 1(b))) should develop and communicate transparently to industry a procurement policy and commercial terms for renewable energy projects in the Northern Territory that have clear evaluation criteria to ensure competitive tendering processes, such as reverse auctions.

Supporting Enabling Actions

- 2(d)** The Northern Territory Government should, following the unbundling of the costs associated with ancillary services from current electricity generation by Territory Generation, communicate transparently to industry the unbundled pricing models and the proposed structure and timing of implementation of an ancillary services market, or other similar mechanism to value ancillary services, within the Northern Territory Electricity Market (NTEM).
- 2(e)** The Northern Territory Government should facilitate access for schools, health centres and similar agencies to have more flexible financing options to enter into renewable energy projects for government owned buildings.

RECOMMENDATION 3

Certainty for investors: The Northern Territory Government should actively create an environment that has policy certainty that attracts long term renewable energy investment and financing.

MEDIUM-TERM ENABLING ACTIONS – Certainty for Investors

Core Enabling Actions

- 3(a)** The Northern Territory Government should develop a 10-year program of renewable energy investment opportunities to optimise the size and characteristics of target projects. This should assist access to low-cost finance, suitable technologies and available concessional financing (e.g. NAIF, CEFC, ARENA). In addition, System Control or Power Networks should publish annual, detailed and accurate demand and energy forecasting data for each network system.
- 3(b)** The Northern Territory Government, (possibly through the IIA see Enabling Action 1(b)), should hold a series of reverse auctions (or other similar procurement process) for renewable energy electricity projects, based on the procurement policy, commercial terms and evaluation criteria developed by IIA, to enable meeting the 50 per cent renewable energy target.

Supporting Enabling Actions

- 3(c)** The Northern Territory Government should provide investment and planning information—including tools such as a map of the northern transmission network showing potential connection points, topography and solar radiation data—for renewable energy developers and investors.
- 3(d)** The Northern Territory Government should report on financing options and possible methods of measuring and recovering financial returns on investment in ancillary services, such as batteries. Renewable energy generators may need to contract for these services, and the benefit received for these services is currently not easily quantifiable.
- 3(e)** The Northern Territory Government should report on mechanisms to refine solar feed-in tariffs (FIT) for all new solar PV customers, incorporating arrangements to reflect time-of-day of energy generation, costs/benefits for customers and networks using electronic interval metering. This may include higher daytime import and lower export tariffs.

RECOMMENDATION 4

Asset optimisation: The Northern Territory Government should publicise an asset retirement/replacement optimisation strategy for existing gas-fired generators to facilitate the adoption of new, competitively priced renewable energy generation alternatives.

LONGER-TERM ENABLING ACTIONS – Asset optimisation

Core Enabling Actions

- 4(a)** The Northern Territory Government should ensure there is a clear understanding of existing asset base life and maintenance requirements, with a direct instruction to Territory Generation to not replace existing gas power generation assets with like-for-like gas engines as they are retired. The required replacement capacity to be provided by renewable energy generation.
- 4(b)** To optimise the Northern Territory's existing gas fired generator assets with the onset of renewable energy generation capacity, ageing prime power gas turbines operated by Territory Generation should be considered for low merit order or standby operation before they are retired.

Supporting Enabling Actions

- 4(c)** Owners of existing rotating generation plant, including government owned corporations (gas turbines, steam turbines or reciprocating engines), should consider reusing the alternators as synchronous condensers when the generation plant is retired from prime power status. Synchronous condensers can add significant inertia and fault level contribution to the network.



Governance and regulation

The Northern Territory is in the process of rolling out the National Electricity Rules (NER)⁵¹. The NER will be rolled out in phases until 1 July 2019, which will give the PWC and the AER regulatory certainty and fulfil their obligations to prepare PWC's 2019–24 Network Price Determination⁵².

It is critical that the Northern Territory adopts rules aimed at optimising competition. However, given the significant challenges faced by the National Electricity Market, the emerging roles of new technologies, and the changing financial models for investment. It is recognised that the connection rules under the NER may need significant derogations to support the government's 50 per cent renewable energy target because of the unique nature of the Northern Territory electricity system.

Nationally, there is considerable debate about the role of renewable energy in system stability and reliability. While renewable energy can play an important role as an economic, social and environmental enabler, it is crucial that the community and industry are assured that the electricity source is reliable, secure, safe and sustainable and that the appropriate governance and regulation is in place.

This requires a multifaceted approach, focusing on ensuring:

- Agencies and government-owned corporations are appropriately resourced, governed, and aligned with the 50 per cent renewable energy strategy.
- Regulatory frameworks are sufficiently adaptable to allow the rapid integration of new technologies as they become available.
- Technical and third-party access codes, regulatory frameworks, **licencing mechanisms and tariffs are appropriate** to encourage responsible, secure and reliable renewable energy integration into the grid.

As the generation mix changes and the energy and capacity market develops, it is assumed that a competitive environment will develop. This new environment will require firm and transparent management, by Networks and System Control, of security and reliability issues.

⁵¹ Australian Energy Regulator, State of the Energy Market, 2015.

⁵² Australian Energy Regulator, State of the Energy Market, 2016–17.

Complete independence and strong financial support for these two functions are essential.

It is recognised that current work is underway by the government to fully develop the Northern Territory Electricity Market (NTEM) and endorses the energy and capacity competitive contracting model. Long term supply contracts are required to attract private enterprise renewable energy generation investors.

Although the accepted plan forward is for a competitive market structure, it needs to be recognised that the Territory is moving from a highly regulated and 'single supplier' base. Thus, it may be essential for the government to tightly manage the Government Owned Corporations (GOCs), in the transition phase, to remove any inhibition for private enterprise to invest in long term supply contracts.

RECOMMENDATION 5

Build Industry and Community Confidence: The Northern Territory Government should align regulatory and energy system reform to ensure congruence with the 50 per cent renewable energy target and reposition current technical, legislative and social parameters to build community and industry confidence in the renewable energy industry.

SHORT-TERM ENABLING ACTIONS – Building Industry and Community Confidence

Core Enabling Actions

- 5(a)** The Northern Territory Government should pause the process of committing the Northern Territory to the full tranche of, '**National Electricity Rules**' under the AER, until a full review has been undertaken into the implications for the changing circumstances expected in the Northern Territory network with the proposed increases in renewable energy generation. This is to ensure that the Rules are appropriate for the Northern Territory and the Government's policy objectives.
- 5(b)** The Northern Territory Government needs to ensure that the amendments to the Chapters 5, 5A, 6, 7A, 8 and 10 of the National Electricity Rules for the Northern Territory are in line with renewable energy connection, policy and the target. This is to ensure that the connection rules are appropriate for the Northern Territory and do not inhibit the achievement of the 50 per cent target.
- 5(c)** The Northern Territory Government should ensure that Systems Control and networks are independent, appropriately resourced and well governed. Possible separation of networks and System Control from PWC to ensure that they are truly independent functions to undertake their essential roles in the electricity system should be considered. This is to support the efforts to reach the renewable energy target while maintaining system security and reliability,

Supporting Enabling Actions

- 5(d)** Under the electricity network regulatory reform program, the Northern Territory Government should remove duplication and overlaps that currently exist in the Technical and Electricity Networks (Third Party Access) Codes to provide greater clarity of process and technical requirements for new generators and other market participants.
-
- 5(e)** Under the NTEM program, the Northern Territory Government should expedite the development of appropriate reliability standards, setting guidelines and the role of the System Reliability Manager for the Darwin–Katherine system to inform the system technical requirements for ancillary services and enable assessment of large-scale renewable generation and dynamic energy storage projects.
-
- 5(f)** The Northern Territory Government should review the proposed Frequency Control Ancillary Service (FCAS) and Inertia Ancillary Service (IAS) contained in the Secure System Guidelines and ensure they are appropriate for the Northern Territory network stability and reliability targets (avoiding the pitfalls of the FCAS system in the National Electricity Market).
-

RECOMMENDATION 6

Support a Competitive Market: The Northern Territory Government should endorse a competitive energy and capacity market framework for renewable energy in the Northern Territory.

MEDIUM TERM ENABLING ACTIONS – Support a Competitive Market

Core Enabling Actions

- 6(a)** The Northern Territory Government should review enabling legislation for existing government owned corporations (GOCs) in the energy sector to ensure the objectives, incentives and strategy of each GOC are aligned to the objectives of the Northern Territory Government's Energy Policy and the 50 per cent renewable energy by 2030 target. This may include confining Territory Generation, at least during the transitional market phase, to improving the efficiency of its existing gas-fired generation capacity and to not monopolise future renewable energy projects.
- 6(b)** The Northern Territory Government should ensure the capacity and energy market design is drafted in a way that encourages developers of renewable energy projects greater than 2 MW to provide dispatchable, or scheduled, power supply, which further supports the security and reliability of the system.

Supporting Enabling Actions

- 6(c) The Northern Territory Government should define competitive bidding for ancillary services in a way that allows renewable energy generators to purchase long-term contracts for these services.
- 6(d) The Northern Territory Government could investigate alternative governance arrangements, for supply and operation of electrical systems in remote communities, to improve transparency and governance.

RECOMMENDATION 7

Adaptive Regulatory Framework: The Northern Territory Government should develop a consolidated governance and regulatory framework that is able to adapt to new and emerging technologies.

LONGER-TERM ENABLING ACTIONS – Adaptive Regulatory Framework

Core Enabling Actions

- 7(a) On a five yearly basis, the Northern Territory Government should review and adapt the regulatory frameworks to ensure they are flexible and can respond quickly to ongoing changes in technology.
- 7(b) The Northern Territory Government should ensure that tariffs structures are developed that are both “cost reflective of generation and delivery” and “opportunity cost reflective of demand reduction”. To achieve this, the rules about energy metering should be developed so retailers can offer meters compatible with progressive tariffs. Also, retailers (through licensing) should be encouraged to develop tariffs to support ‘behind the meter’ customer-owned renewable energy, including storage.

Supporting Enabling Actions

- 7(c) The Northern Territory Government should investigate new market structures such as peer-to-peer trading to act as a driver for increased rooftop PV rollout by private investors, both household and light industrial.
- 7(d) The Northern Territory Government should require all new industry projects, particularly those that achieve major project status, to progressively (concurrent with the rest of the Northern Territory) source up to 50 per cent of the electricity from renewable sources. This may be achieved through generator licencing or environmental approvals.
- 7(e) The Northern Territory Government should support fast-acting demand side management systems to give System Control other power flow options. This will assist the management of intermittent renewable energy generation.



Technology, security and reliability

There are many benefits from disruptive technology change. Many of the new renewable energy technologies offer increased system reliability and security and this will be required as the per cent of renewable energy increases. On the demand side, smart meters, interval meters, and demand side management hardware may help optimise supply and/or consumer cost.

While the role of government in encouraging and facilitating the uptake of renewables in the Northern Territory may diminish over time, in the short term, the government will need to both encourage and facilitate the uptake of renewable energy in the Northern Territory. Central to this will be addressing the issue of intermittency, system stability and inertia, which may be overcome by optimising the use of existing gas generation assets, as well as through incentivising emerging energy storage and other ancillary service technologies.

Over the next five to seven years, large-scale batteries are expected to become increasingly affordable. Storage systems, such as batteries, capture energy to help counter intermittency in solar generation and supply power at high-demand periods or night time. In the Northern Territory, storage technology may also assist achieving 'dispatchable' or 'scheduled' power supply from renewable energy generators, helping to assure the security and reliability of the system. As these technologies emerge,

there are likely to be opportunities for government to replace mature prime, or baseload, gas power generation assets with renewable energy generation assets, without compromising system stability or reliability. Consequently, existing assets such as the 190MW plant at Channel Island (due to retire in 2027) may be seen as providing an opportunity for the deployment of more renewable energy facilities as these operations become progressively more able to compete with the gas-fired plant (Appendix 13).

The Northern Territory Government needs to support the further development and completion of a validated dynamic network model to assist System Control and Networks improve their knowledge of the current electrical system. Utilising this model could help create a level playing field for all generators, and provide developers with accurate information regarding their connection obligations. Also, the model could be used to increase knowledge about the most

appropriate locations for renewable energy injection, and assist in assessing the volume of energy that can be injected at any given location in the grid. This knowledge could support the planning and development of large-scale solar plants and enable faster assessment and approvals for renewable energy projects. Following this, in the medium term, the validated dynamic model could be coupled with economic modelling to allow development of future system designs and to identify required system upgrades, including transmission lines, to expand the roll out of renewable energy.

Alice Springs is well known as a centre for solar energy in Australia, having built considerable expertise, knowledge and capability, including managing the impact of managing power systems with high levels of renewable energy penetration. The designation of Alice Springs as a Solar Hub would enable the full realisation of these benefits.

In the long term, it may be necessary to augment the Northern Territory transmission system to support large scale solar plants, including solar thermal plants. In particular, system studies and economic plans regarding transmission between Darwin and Katherine may need to be considered.

RECOMMENDATION 8

Validate Network Capabilities Ensuring System Security and Reliability: The Northern Territory Government should immediately improve knowledge of the existing capability and capacity of the entire power system, including its ability to accommodate new renewable energy generation. Where possible, the government should take immediate action to kick-start the rollout of renewable energy projects.

SHORT-TERM ENABLING ACTIONS – Validate Network Capabilities Ensuring System Security and Reliability

Core Enabling Actions

- 8(a)** The Northern Territory Government should immediately invest in and support the further development of the validated dynamic network model, held by System Control. This model will enable System Control to test and evaluate the impact of a new generation at any connection node within the existing network. It will also facilitate the process of connection and approval for renewable energy projects. This is essential to ensure the security and reliability of the system. In doing so, the Northern Territory Government should support System Control to obtain the validated dynamic data for all generators in the electricity system and in so doing, expand the modelling to include verifying the underlying steady state model (zero sequence data).
- 8(b)** The Northern Territory Government should build on the existing capability in Alice Springs and establish Alice Springs as a solar hub by re-establishing the Alice Solar City concept. The Northern Territory Government should develop a research agenda for the future grid based on the Alice Springs grid system, drawing on the experience, goodwill and community engagement of the original Alice Solar City program. It should also position the Northern Territory as a System Security Learning Centre for the National Electricity Market through an Inertia-Fast Frequency Control Demonstration Project in Alice Springs.

Supporting Enabling Actions

- 8(c)** The Northern Territory Government should investigate a process to coordinate Networks and System Control to ensure that the connection agreement for any new generator complies with the Third Party Access Code and conforms to acceptable dynamic stability standards to enable reliable dispatch while maintaining the independence of both organisations.
-
- 8(d)** As part of Department of Treasury and Finance Package 3, (Northern Territory NER adoption), the third party access standard (Automatic Access) should be drafted so that it encourages renewable energy generation developers to either build or contract for ancillary services to support their energy injection to ensure the security and reliability of the system. This is to achieve a level playing field for all generators.
-
- 8(e)** The Northern Territory Government should support the new connection policies, recently developed by PWC Networks for Class 1 and Class 2 consumers for rooftop PV, with the added change to remove the restriction on array size and only maintain the specification and limitation on the inverter connection. In tandem with the changes to import/export tariffs (Supporting Action 3(e), Class 2 consumers should be allowed to export up to the capacity of the inverter connection (30kVA). This allows for larger rooftop arrays and battery storage systems behind the meter.
-
- 8(f)** The Northern Territory Government should investigate how the metering rules need to be changed so that meters are provided to meet the requirements of retailers and the rollout of time-of-day tariffs. This work should support the progressive deployment of interval meters to enable more appropriate tariff structures, flexible customer services and imported data for network management. Above all, the government should resist adopting the AER smart metering requirements that include communications, unless fully financially justified.
-
- 8(g)** The Northern Territory Government should investigate solar cooling systems as an alternative energy storage technology. The installation of heat pumps, powered by solar PV, and the installation of cool energy storage in large cool rooms and for air conditioning, can assist the management of intermittent renewable energy and provide 24-hour, 7 days per week energy storage. The current Charles Darwin University system allows them to move to off-peak tariff rates, and this could be promoted more widely. Community cooling systems could be explored, where large solar arrays power chiller/storage systems for night time cooling.
-

RECOMMENDATION 9

Future System Planning: The Northern Territory Government should support the development of a detailed technical plan for the future power system, including reviewing the nature and requirement of demand, supply and transmission, in the context of new technical and business models, while ensuring security and reliability as the nature of the system changes.

MEDIUM TERM ENABLING ACTIONS – Future System Planning

Core Enabling Actions

- 9(a)** The Northern Territory Government should undertake a review of the electricity system of the Northern Territory, with a view to identifying required system upgrades to expand the rollout of renewable energy.
- 9(b)** The Northern Territory Government should undertake economic modelling of potential commercial, regulatory and technical models, that will be required as part of the future power system plans to facilitate a structured and coordinated knowledge development and sharing framework for future system planning, both for regulated and non-regulated networks. This should be done (including a view beyond 2030) with the understanding that renewable power will continue to grow as a per cent of the grid.

Supporting Enabling Actions

- 9(c)** The Northern Territory Government should undertake studies in conjunction with Power Networks and System Control to establish the optimal system pathway to support renewable energy projects to meet or exceed the 50 per cent renewable energy target by 2030. This is to develop the future system plan and provide lists of possible projects by type and location, geographic maps, infrastructure investment opportunities and other information to assist the renewable industry players in developing appropriate proposals for the Northern Territory.
- 9(d)** The Northern Territory Government should access existing data from third parties, such as Lazard's/CSIRO/ENA, to ensure the Northern Territory sources renewable energy and energy storage technologies at the lowest benchmarked cost.

RECOMMENDATION 10

Implementation of the Future Grid: The Northern Territory Government should optimise the implementation of existing plans for progressive network upgrades to facilitate the future grid required to support the transition to higher per cent of renewable energy.

LONGER-TERM ENABLING ACTIONS – Implementation of a Future Grid

Core Enabling Actions

- 10(a)** The Northern Territory Government should support the implementation of progressive network upgrades (potentially including new transmission lines to facilitate connection of new renewable energy, such as a Darwin Katherine integrated System transmission line) through optimising the existing planned network upgrades, in accordance with the findings of the future system planning activities.

Supporting Enabling Actions

- 10(b)** The Northern Territory Government should implement fast-acting demand side management (DSM) hardware to promote network security at all times.
- 10(c)** The Northern Territory Government should undertake a feasibility study, including cost benefit analysis, into the possibility of establishing an interconnecting, latest technology, High Voltage Direct Current (HVDC) transmission cable to join all Northern Territory centres from Alice Springs to Darwin. This transmission line (beginning with reinforcement of the Darwin to Katherine interconnector) would provide the infrastructure to interconnect multiple PV arrays along the central backbone of the Northern Territory and provide development opportunities across the Territory. Generation diversity and regional development would be central to the concept.



Engaging the Community

There are significant lifestyle-enhancing community benefits to be gained through the implementation of renewable energy in the Northern Territory.

Community knowledge

There is a general lack of knowledge in the wider community regarding renewable energy and, as the Territory transitions toward the 50 per cent target, there could be benefit in the Northern Territory Government introducing renewable energy education and engagement programs. For example, people need information in order to make informed decisions about the installation of rooftop PV systems.

The COOLmob Living Water Smart – Water Efficiency/Usage program for energy efficiency education was very well received and the Northern Territory Government could support funding to promote a similar scheme for PV systems. Community education will be particularly important as household battery systems become available and the efficient operation of domestic solar/battery and demand management systems become more complex. An educational program promoting the uptake of time-of-day household appliances and motors (pool pumps, etc.) could encourage demand profiles in line with the new proposed time-of-day tariff structure.

Jobs and training

Significant job creation could be expected from broad economic development associated with cost competitive electricity generated by renewable energy systems, but this may take time. In the short term, it is expected that there will be a range of jobs created directly in the planning and construction of the renewable energy projects. These would include roles in management, engineering, fabrication, construction, and maintenance.

It is recognised that many of these skills already exist in the Northern Territory and we support the continuation of the appropriate secondary, tertiary and VET education curriculums to ensure the workforce is prepared. Educational institutions, like Charles Darwin University, have indicated enthusiasm to further develop appropriate training courses.



Electricity Customers

It is important that government considers how all customers (vulnerable and disadvantaged in particular) in the Northern Territory might be able to engage in the roll out of renewable energy. As proposed earlier, a significant initiative could be the installation of roof top PV systems on all government housing.

Other initiatives might include:

- Options for renters to purchase 'green' energy in their electricity bills.
- Community PV systems (installed on the rooftop of apartment buildings).
- Installing renewable energy on the rooftops of community housing.
- Seeking new and alternative opportunities to roll out solar power in remote communities.

The Northern Territory Government could also explore a similar program to the NSW St George Community Housing program, which was supported by the Clean Energy Finance Corporation (CEFC), for solar installation in social and community dwellings. CEFC's \$250 million community housing funding program assists all states and territories to roll out such community housing programs.

RECOMMENDATION 11

Engaging the Community: The Northern Territory Government should undertake a variety of community engagement measures to ensure inclusion of disadvantaged customers, training of the workforce, and education of the public regarding renewable energy.

Core Enabling Action

- 11(a)** The Northern Territory Government should develop a policy to ensure solar PV installations are fitted to all public housing in the future and, where possible, progressively retrofit existing housing stock to allow disadvantaged and low-income customers to participate in the renewable energy supply and reduce the cost of their electricity bill.

Supporting Enabling Actions

- 11(b)** The Northern Territory Government should develop and deliver a community engagement and education program to inform all Territorians of the benefits of renewable energy.
- 11(c)** The Northern Territory Government, in collaboration with industry and training providers, should establish nationally accredited and recognised pathways to increase training opportunities for solar installation technical experts and engineers locally.
- 11(d)** The Northern Territory Government should investigate technologies and business models that could help electricity customers benefit from rooftop PV installed somewhere other than the roof of their rental property
- 11(e)** The Northern Territory Government should encourage the installation of 'behind the meter' battery storage systems in light industry and small business applications through educational programs and streamlined approval process
- 11(f)** The Northern Territory Government should align renewable energy modules in the science curriculum of Territory schools with the opportunity to learn from the Government's investment in school based renewable energy systems.

Acronyms

Acronyms

AC	Alternating Current
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
ASI	Australian Solar Institute
CCS	Carbon Capture and Storage
CDU	Charles Darwin University
CEFC	Clean Energy Finance Corporation
COAG	Council of Australian Governments
CSIRO	Commonwealth Science and Industry Research Organisation
CSO	Community Service Obligation
EDF	Economic Development Framework
DKIS	Darwin Katherine Interconnected System
EPCC	Energy Policy and Climate Change Unit of the Department of Chief Minister
ETS	Emissions Trading Scheme
FCAS	Frequency Control Ancillary Services
FIT	Feed in Tariff
GETF	Green Energy Taskforce
IIA	Independent Implementation Agency
IES	Indigenous Essential Services Pty Ltd
IAS	Inertia Ancillary Services
LCOE	Levelised Cost of Energy
LGC	Large Generation Certificates
NAIF	North Australian Infrastructure Fund
NEM	National Electricity Market (The market currently operating in Queensland, New South Wales, ACT, Victoria Tasmania and South Australia)

NER	National Electricity Rules
NG	Natural Gas
NTEM	Northern Territory Electricity Market (the mechanisms set down, or to be set down, to regulate a market for electricity in the NT to fit broadly into the mechanisms of the NEM)
NTES	Generic descriptor for the entire Northern Territory Electricity Supply System
NTG	Northern Territory Government
ORER	Office of Renewable Energy Regulator
PPA	Power Purchase Agreement (a form of contract for the purchase of electricity)
PV	Photo Voltaic (device for converting sunlight into electricity)
PWC	Power and Water Corporation
RAM	Reliability Assurance Mechanism
RE	Renewable Energy
RET	Renewable Energy Target
RRPGP	Renewable Remote Power Generation Program
SCADA	Supervisory Control and Data Acquisition
SHW	Solar Hot Water
SRES	Small-scale Renewable Energy Scheme
STC	Small Technology Certificates
TOR	Terms of Reference
TGen	Territory Generation (NT Government-owned Generation Provider)
WACC	Weighted Average Cost of Capital

Glossary of Terms

Technical Measures

Hz	Hertz (cycles per second). The measure of system frequency in an alternating current system
km/h	Kilometres per hour (used for measuring wind speed)
kV	Kilovolt (measure of electrical pressure)
MWh	1000 kWh's (measure of electrical energy – the measure used in industry circles)
MS	Millisecond (one thousandth of a second)
MW	Megawatts (large scale measure of "real power")
MWp	Megawatts Peak (this term is often is used to describe the maximum power of a solar PV device. [This term is not used in this document for simplicity].
MVA	Mega volt amp (large scale measure called "apparent power" because it takes into consideration both the resistive load and the reactive load)
MVAR	Mega volt amp reactive (large scale measure of "reactive power")

Technical Terms

1 Inertia: A mechanical concept

Inertia is one of the most basic concepts of physics. Essentially, things that are moving keep moving unless a force – like friction – causes them to stop. And things that are not moving will continue to not move unless a force – like a gust of wind – causes them to move.

This concept is simple, but it's not always easy to see.

The reason why the concept of inertia was not immediately obvious to everyone before Newton is because our world is filled with sources of friction that acts to resist motion. For example, if you give a box a push, it will not continue moving at a constant speed, it will quickly come to a stop. That is because of the friction acting between the box and the floor. In order to see inertia at work, we need systems that have very low friction, such as in outer space.

In power systems power stations with rotating generators (coal fired steam turbines, hydroelectric water turbines or gas-fired gas turbines) have inertia because their turbine generators contain large quantities of spinning metal.

On the other hand, solar photovoltaic panels have no moving parts and therefore lack inertia. Technology solutions to this problem to create "artificial inertia" are under development.

Inertia in the power system is important because it provides the stability to ensure voltage and frequency remain within acceptable limits. It also provides energy, when needed, to operate protection devices within the network. Low inertia and fluctuating energy input can result in blackouts.

2 Network Security

Security of an electricity network is the ability of the network to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements.

Security of a power system refers to the degree of risk in its ability to survive imminent disturbances without interruption of customer service. It relates to the robustness of the system to imminent disturbances and, hence, depends on the system operating condition as well as the contingent probability of disturbances.

The most important factors which affect security are:

- Overload of system components.
- Stable voltages within the system.
- Stable frequency within the system.
- Control of the phase angle between the voltages and currents in the system.
- Fault level management (fault levels and fault ratings)

Ancillary Services (a term used within the NEM) are required in a network to address the above factors.

Systems such as those in the Northern Territory where the bulk of conventional synchronous plant is gas-fired gas turbines have low inertia compared with larger systems with large coal-fired generating stations. This situation will become more critical as renewables are added to the system as these typically have no (or little) inertia. This renders stable frequency control more difficult and requires automatic systems to react even faster to maintain frequency control.

3 Network Reliability

Reliability of a power system refers to the probability of its satisfactory operation over the long run. It denotes the ability to supply adequate electric service on a nearly continuous basis, with few interruptions over an extended time period.

The most important factors which affect reliability with particular reference to the Northern Territory are:

- The availability of sufficient generating capacity to meet the system demand at any instant in time whilst also taking into account the necessary level of reserve capacity.
- The potential for failure of any critical system component (such as a transmission line, distribution line, transformer or system switching device).
- The ability of the system to survive lightning strikes on components in the system. It must be kept in mind that parts of the Northern Territory have amongst the world's highest incidence of lightning activity.
- The ability of the system to survive cyclone⁵³ damage to components in the system. It must be kept in mind that parts of the Northern Territory are affected by more, and more powerful, cyclones than most of the planet. Cyclone Tracy which devastated Darwin in 1974 was the most powerful cyclone to ever make a landfall and Tracy still rates in the top five most powerful cyclones of all time. This presents a prodigious challenge for any electrical system.
- Disruptions due to other weather-related, vandalism and vermin-related events.
- The withdrawal of services to customers in order to carry out maintenance or repair of network assets.
- The provision of adequate system control and communications facilities within the network.

⁵³ The correct terminology is Tropical Cyclone however these most powerful of storms have other names in other regions of the world. They are called Hurricanes in the Atlantic and North Eastern Pacific, Typhoons in the Western Pacific, north of the equator and Cyclones in most of the Southern Hemisphere. They are all deadly.

Appendices

This Appendix to the Roadmap to Renewable Report provides additional detailed information and should be read in conjunction with this report.

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Appendix 1: Terms of Reference

1. Purpose of the Expert Panel

- 1.1 The purpose of the Renewable Energy Expert Panel (the Panel) is to provide the Northern Territory Government with a report of the recommended options available to pursue the target of 50 per cent renewable energy by 2030 (the target).
- 1.2 The project team is the Environment Policy unit in the Northern Territory Department of the Chief Minister (DCM).
- 1.3 The Panel's expertise spans key areas integral to the success of the project, including electricity generation, power system integration, electricity industry and consumer economics, remote energy systems, and local knowledge of the Northern Territory and national industry and regulatory environment.
- 1.4 The Panel will advise on the technical, financial, operational and economic feasibility of options in the Northern Territory context.

2. Objectives

- 2.1 The Panel's deliberations will be underpinned by the objective of a secure, reliable and least-cost electricity service for all Territorians.
- 2.2 The Panel will be guided by the work that has already been done on renewable energy options across Australia and around the world.

3. Expert Panel responsibilities

- 3.1 The Panel is not a decision-making body and will not determine government policy or outcomes.
- 3.2 The Panel will not be involved in assessing, evaluating, recommending or approving any renewable energy proposals.
- 3.3 The Panel will provide advice and practical options for consideration by government. In performing their duties, the Panel will have regard to:
 - a. protecting the long-term interests of consumers with respect to reliability, security and safety of supply;
 - b. promoting economic efficiency;
 - c. ensuring consumers benefit from competition and efficiency; and
 - d. considering short, medium and long term investment and benefits realisation.
- 3.4 All members of the Panel agree to work within the framework of these terms of reference and the agreed governance arrangements.
- 3.5 The Chair agrees to provide strategic leadership and direction to the Panel in meeting its obligations.

4. Expert Panel meetings

- 4.1 Panel members will commit to attend one meeting per month in person and participate in one teleconference meeting per month. Meetings will be held in Darwin or Alice Springs unless otherwise agreed by the project team. Travel and accommodation arrangements are the responsibility of the project team.
- 4.2 In the event a Panel member is unable to attend a meeting, they agree to notify the Chair as soon as possible and agree to give the Chair sufficient information to enable the Panel to make decisions and progress tasks as planned at the meeting.

- 4.3 The project team will provide secretariat support to the Panel meetings and will collate and distribute agenda papers at least one week prior to each scheduled meeting.

5. Quorum

- 5.1 A quorum shall be four members, including the Chair.
- 5.2 Where Panel members have alternative views, these will be noted in proceedings of meetings.

6. Scope

- 6.1 The Northern Territory Government does not favour one source of renewable energy generation over any others.
- 6.2 With this in mind, the Panel will provide advice to the project team on practical and viable options for achieving the government's renewable energy target, including technical, financial, operational and economic issues associated with the options for government's consideration.
- 6.3 When providing advice, the Panel will consider key issues and barriers, including but not limited to:
 - a. better defining the 50 per cent renewable target that is measurable and achievable for Cabinet consideration;
 - b. the impact on NT households and businesses of implementing various options, including the likely cost and potential implications for how and when they consume electricity;
 - c. impacts of increasing renewable energy supply on regulated, unregulated and off-grid power systems;
 - d. impacts of renewable energy supply on power system security and taking into consideration the characteristics of Northern Territory power systems;
 - e. storage options for intermittent/renewable energy;
 - f. the scale of potential solutions (small-scale, residential, commercial or large-scale);
 - g. any necessary pre-conditions, policy settings or incentives that might be employed to encourage commercial investment in renewable generation and industry competition, and to encourage increased uptake of renewable energy by consumers;
 - h. options to attract investment and create jobs in the renewable energy sector;
 - i. possible impacts on existing funding or contractual arrangements in the Northern Territory;
 - j. options to enable low income, remote and renting households to participate in the transition to renewable energy;
 - k. community values and expectations;
 - l. options to promote efficiency and competition in the electricity supply industry in line with the objects of the *Electricity Reform Act*; and
 - m. regulatory and market arrangements, noting the Northern Territory is progressively adopting the National Electricity Law and Rules and is finalising the design of a wholesale electricity market mechanism to be implemented during 2017.

7. Out of scope

- 7.1 Issues that are outside the scope of the Panel's review are:
- a. developing a plan to implement or implementing government's preferred option(s);
 - b. liaising with or negotiating with the Commonwealth Government on renewable energy targets, industry arrangements, funding arrangements or policy settings;
 - c. broader climate change policy or potential greenhouse gas abatement or offset schemes;
 - d. strategies to displace or reduce the consumption of fossil fuels in transport;
 - e. facilitating enquiries from potential generation applicants, and
 - f. strategies to encourage energy efficiency or off-peak use.

8. Review

- 8.1 These terms of reference and the attached governance arrangements are subject to periodic review by the project team.
- 8.2 As the project progresses, the terms of reference and governance arrangements may require amendments to ensure they remain fit for purpose.
- 8.3 The Panel agrees the project team may amend the terms of reference or governance arrangements as required.
- 8.4 The project team agrees to notify the Panel at least one week prior to amending the terms of reference or governance arrangements.

9. Stakeholder engagement

- 9.1 The Chair must authorise any public communication from the Panel. The public communication must be accompanied by a caveat that the information is not government policy.
- 9.2 The Chair agrees to inform the project team prior to any public communication activity.
- 9.3 The project team will work with the Panel to develop and implement a community engagement and education strategy to guide discussion with the Northern Territory community, business and consumer groups, industry peak bodies and academic organisations. The community engagement and education strategy will include opportunities for the public to provide written submissions.
- 9.4 The project team will maintain an online portal that includes a 'Have your say' feature where the public can give feedback on key questions. The portal will include a repository for documents endorsed for publication by the Project Team.
- 9.5 The project team will coordinate the Panel's access to government agencies, government business divisions, government-owned corporations, existing electricity industry participants and potential participants through the Interagency Working Group.
- 9.7 In the event that advice and information of the Interagency Working Group are not taken into consideration, the Panel agrees to provide the project team with an overview of why this information was not considered relevant to its deliberations.

10. Outputs and timeframes

Output	Working timeframe	Responsibility
Develop a community engagement strategy	March 2017	Project team and the Panel
Develop a 'Have your say' web portal for community input and feedback	March 2017	Project team
Develop key questions for the 'Have your say' web portal	March 2017	Project team and the Panel
Facilitate the workshop	March 2017	Project team
Undertake targeted stakeholder meetings with the Chair of the Panel and other Panel members as available	January – April 2017	Project team and the Panel
Public consultation period ends	April 2017	
Collate community feedback and submissions and provide for consideration by the Panel	May 2017	Project team
Commence drafting the Roadmap to Renewables Report	May 2017	Expert Panel
Finalise the Roadmap to Renewables Report	June 2017	Expert Panel
Submit report for Cabinet consideration	July 2017	Project team
Announce options agreed and approved by Cabinet	August 2017	Project team

Appendix 2: List of Submissions Received from Interested Parties

The Panel would like to sincerely thank all the government agencies, independent organisations, various interest groups and individuals for taking time to provide a formal submission. The Chair, Mr Alan Langworthy along with the Panel, greatly appreciate the efforts taken by all stakeholders to engage in this great initiative by the Northern Territory Government to achieve a 50 per cent renewable energy target.

	Stakeholder Response	Submission
Government Bodies	Alice Springs Town Camp	Roadmap to Renewables
	LDC	Renewable Energy Panel Letter
	LGANT	Road Map to Renewable Submission
Interest Groups	Climate Action Darwin	CAD Submission to Roadmap to Renewables Report for the NT Government
	EECCA	Recommendation for a NT market-based energy efficiency scheme ASAP as part of energy, environment and climate change policy - including renewables target planning
	EECCA	Review of climate change policies discussion paper
	RDANT	Renewable Energy Expert Panel Letter
	RePower Alice Springs - Louise Stanley	Submission to the Renewable Energy Panel
	RePower Alice Springs - Stan & Betty Davies	Submission to NT "Roadmap to Renewables" Initiative
	RePower Alice Springs - Stan & Betty Davies	http://solarlove.org/wp-content/uploads/2015/07/Brattel-1.jpg
	Solar Citizens	Homegrown Power Plan Full Report
	Solar Citizens	ISF modelling - 100% Renewable Energy for Australia
	Territory Proud	Submission to Roadmap to Renewables 0417
Business/ Industry	Aurecon	Submission to Northern Territory Government Renewable Energy Expert Panel
	Country Solar NT	Face-to-face meeting
	Delta Electrics	Renewable Energy Employment Education Training & Storage Proposal
Environment Organisations	ALEC	Submission to the Northern Territory Roadmap to Renewables
	ECNT	Road map to Renewables ECNT Submission April 2017
Individual Submissions	Vikki McLeod	Email Submission
	Dianne Koser	Email Submission
	Marthias Paul	Email Submission
	Tammie Coyne	Email Submission
Educational Institutions	Charles Darwin University	Roadmap to Renewables: Submission

Note that some submissions have not been included, as the Panel has not received approval to publish those submissions.

Appendix 3: Defining the Target

As defined in the Panel's scope, the 50 per cent renewable energy target was defined by government as applying to the electricity sector only; however, a key objective of the Panel was the consideration of how the target should be defined and where it could be applied within the electricity sector. Negotiating with the Commonwealth Government on targets, broader climate change policy, fossil fuels in transport and energy efficiency strategies was explicitly excluded from the Panel's scope.

The Panel was also required to consider the Target in the context of government commitment to adhering to the National Electricity Law and Rules and to do this through a competitive market structure.

In establishing the definition of the target, two approaches that could be used were identified:

- Per cent of installed capacity
- Per cent of consumed energy

We recognised that basing a target on installed capacity in a system had significant potential to lead to perverse outcomes, particularly given differing levels of reserve capacity that already exist in various parts of the system. Conversely, energy consumed was identified by the Panel as being much less likely to be misleading and easy to measure. All electricity generated under generation licences is recorded by the Utilities Commission and all electricity sold is measured for billing purposes in the energy units of kWh or MWh and is readily available in aggregate from retailers billing systems.

We, therefore, concluded that energy consumed should be used as the measurable unit in setting the target.

Similarly, we recognised that while there was some merit in defining the target by a single number in terms of 2017 projections of consumption, this risks becoming burdened by uncertainty in projecting future consumption in a jurisdiction as transient as the NT. Therefore, we concluded that the potentially confusing terms 'floating target' and 'fixed target' should not be used. Rather it should just be called a 'target'.

A further challenge in defining the target was the need to determine what part of the energy system in the NT would be included in the target and what parts would be excluded. This was reinforced by the principles previously articulated, specifically, the need for the recommendations to be fair and transparent.

We considered that given the Government's stated policy agenda for renewables, the target should apply universally over the parts of the energy system that are regulated by the Government (Alice Springs, Tennant Creek and the Darwin–Katherine Interconnected System [DKIS]) as well all remote communities for which the Government provides a Community Service Obligation CSO, particularly given many of the remote communities are already integrating significant per cent of renewables.

We did, however, recognise that the inclusion of self-generating enterprises, such as mine sites and tourist resorts, may be considered controversial, particularly if it was assumed that the integration of renewables into these enterprises would actually increase the costs of supply to those commercial enterprises.

After careful consideration of all the available data, we concluded that there was already a significant incentive for self-generating commercial enterprises to consider the integration of renewables into their operations, with a number of sites having completed installation of some renewables (e.g. Yulara). Further to this, it was recognised that under scenarios considered, it was highly probable that the cost of renewables will continue to diminish relative to the alternatives. Therefore, we concluded that it is not unreasonable to require that future self-generating enterprises be included in the 2030 target. Monitoring of the uptake of renewables in these entities could be facilitated by the Utilities Commission through its role in licencing generators (including those self-generating enterprises).

Similarly, while the government has very little capacity to mandate the actions of the Commonwealth with respect to self-generating Defence establishments such as Pine Gap and Jindalee, it was recognised that the Defence department already had programs for integration of renewables underway in various forms at these locations.

THE TARGET (calculations for guidance only): Current demand is approx. 1800GWh pa and based on current forecasts assuming limited growth in energy consumption, a 50 per cent renewable energy contribution by 2030 would equate to approximately 900GWh within the regulated networks (Darwin–Katherine, Alice Springs and Tennant Creek).

Estimates of the future generation requirements in the non-regulated areas, including off grid and self-generating enterprises, are difficult to make with high

degrees of reliability, as consumption in many of those locations is premised on future resource extraction, tourism volumes and other external variables. Based on existing known data sets, however, including self-reported data, indicates that existing non-regulated generation is in the order of 1300-1700GWh's per annum (excluding Inpex, Alcan).

Based on current technologies, around 450MW peak of single axis tracking solar PV installations would be required to meet the regulated portion of the target. A further 300-400MW of single axis tracking solar installations would be required to provide 50% of the existing unregulated generation.

To place this in context, 450MW of flat plate solar PV will use around 700 hectares of land. A tiny fraction of the NT.

Appendix 4: Renewable Technology Summary

In 2010, the Green Energy Taskforce produced two reports for the Northern Territory Government. The first was the 'Roadmap to Renewable and Low Emission Energy in Remote Communities', and the second was 'An Evaluation of the Relative Merits, Feasibility and Likely Costs of the Potentially Available Renewable Energy Technologies to be used in the NT, including geothermal, Solar, Biomass and Tidal'. These reports provide a comprehensive overview of the renewable energy technology of the day and its application in remote communities.

Little has changed in several of the technologies over the intervening years; however, dramatic cost reductions have been made in solar PV systems^{54,55}. For this reason, a review of technologies was not included in the terms of reference for the Panel.

The table below is a summary of the current state of each of the technologies reviewed by the Green Energy Taskforce, and in particular, whether there has been any material change in the state of the technology.

Generation technology	Green Energy Taskforce assessment	Current status
Wind	Although relatively mature, wind power is likely to be of marginal value due to the relatively low quality of the wind resource in the NT.	No change
Geothermal	Geothermal has the significant long-term potential for the NT but is relatively immature, and it is considered unlikely that this status will change sufficiently in the medium term to allow geothermal power to make a material contribution toward the 2030 target.	No change
Freshwater hydro	Even if the environmental implications could be managed, hydropower would, due to both terrain and the seasonal variability in rainfall, be a marginal technology for NT at best.	No change
Tidal	Despite the efforts being undertaken to develop tidal power, including demonstration sites in the NT, it is considered unlikely that it will become viable in the medium term.	No change
Ocean	Despite the efforts being undertaken to develop wave power, it is considered unlikely that it will become viable in the medium term.	No change
Liquid biofuels	Although power generation with biofuel is relatively mature, the key challenge for the NT will be the development of sufficient feedstock, and it is considered unlikely that this will be achievable in the medium term.	No change
Biomass	The key challenge facing bio-gasification is the lack of available data to support the assessment of the biomass resource.	No change

⁵⁴ Refer to Lazards Levelized Cost Of Energy analysis – Version 10.0 December 2016

⁵⁵ Fraunhofer ISE (2015): Current and Future Cost of Photovoltaics. Long-term Scenarios for Market Development, System Prices and LCOE of Utility-Scale PV Systems. Study on behalf of Agora Energiewende. 2015

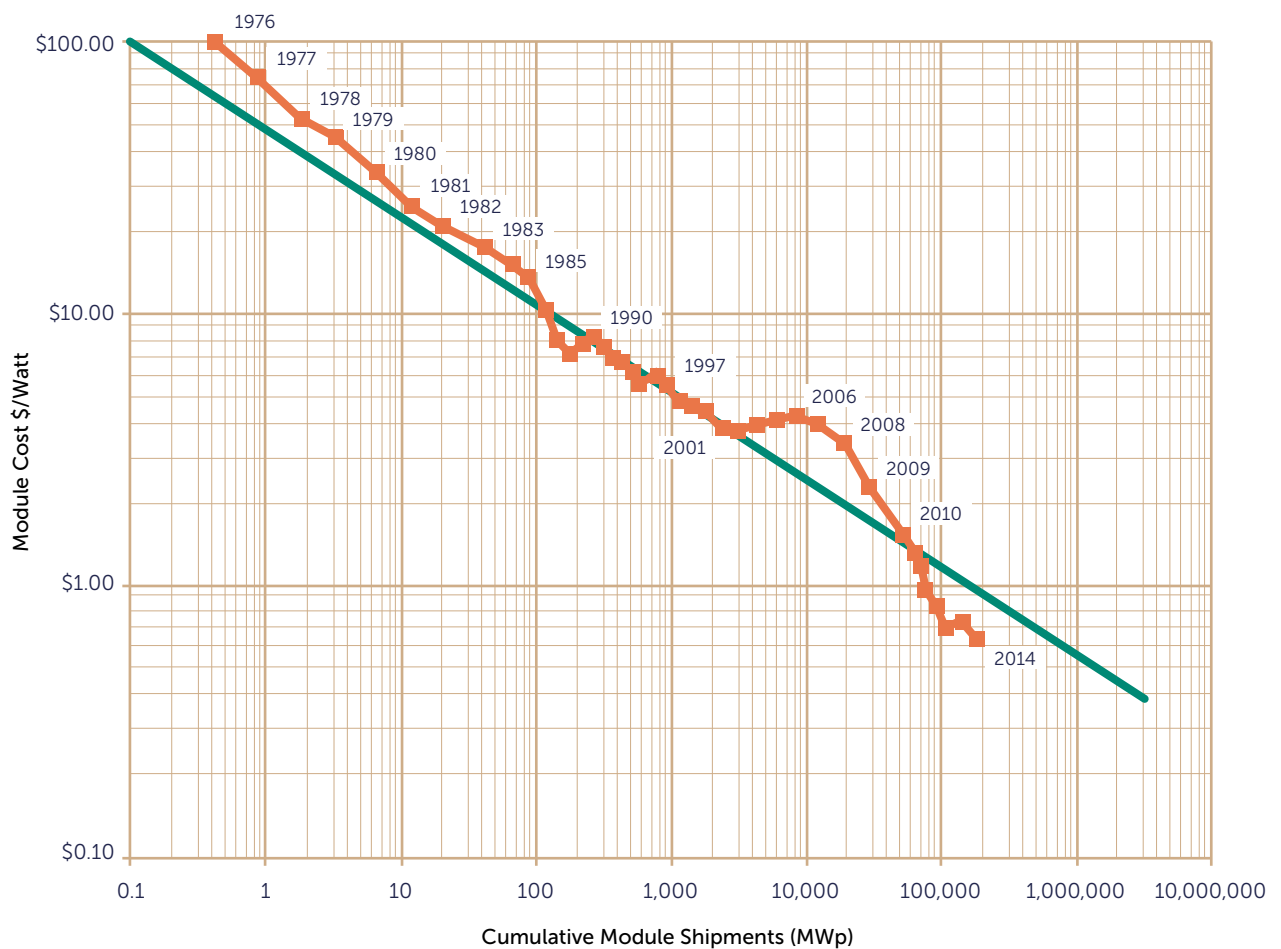
Generation technology	Green Energy Taskforce assessment	Current status
Solar thermal	While the costs for solar thermal are still high and the commercial scale is currently too big for the Territory to accommodate, it is approaching a stage where it could be deployed in the NT. It is considered that the best prospects would be in combination with gas generation (to overcome the intermittency).	Solar thermal price and modularity have not achieved the levels that had been forecast and do not present a short or medium-term opportunity; however, ongoing research suggests this may still emerge as an opportunity for the NT. Small scale CSP is moving fast toward lower CAPEX costs. A recent project has been approved in SA where the PPA cost has been quoted as \$78/MWh
Solar PV	Solar PV is relatively well developed, and the NT has an abundance of the solar resource. Intermittency and cost remain the major barriers to widespread uptake in the short term. This can be solved with further research and development of integration methods.	Solar PV has undergone a rapid reduction in cost that has far exceeded most reported predictions, with construction costs nearing \$1/Wp at large scale and predicted to drop further, resulting in 20–25MW plants being contracted at values ranging from \$75–\$95/MWh in 2017.

The conclusion of the Green Energy Task Force was that solar PV was the most prospective renewable energy technology for the Northern Territory. This conclusion has been reinforced in recent years by the significant cost reductions achieved by the industry. Wholesale prices for electricity from medium and large-scale solar PV installations are now proving competitive to conventional fossil fuel generation, and prices continue to fall. In remote areas where generation is by diesel plant, the costs are significantly lower than fossil fuel generation.

The 7th edition of the International Roadmap for Photovoltaics, released in late 2016 highlighted that the learning rate for solar PV (the rate at which prices drop as production increases) has continued to drop at a rate of 21% per year. The new edition was produced using input from 31 different solar PV cell + module manufacturers (crystalline, polycrystalline, wafer, etc), PV research facilities, and industry material + equipment suppliers.

The graph below shows the cumulative rates of cost reductions over the preceding 40 years. The relationship that between cost reduction and deployment is commonly known as Swanson's Law.

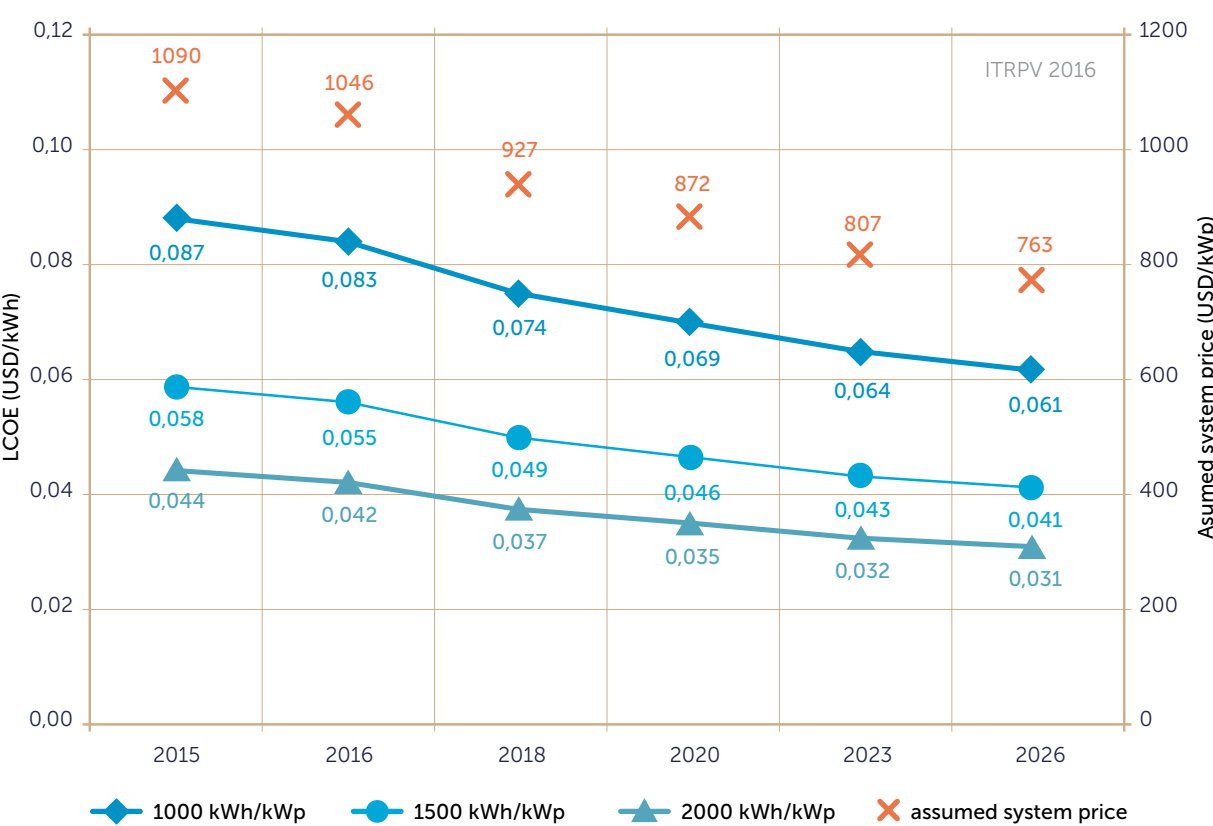
Figure 1: Swanson's Law



The report notes that the average crystalline-silicon PV module price declined to 58¢/Wp in 2015 — from 62¢/Wp in 2014. This corresponds to manufacturing capacities of 50 GWp (in 2015) and 39.3 GWp (in 2014), according to the report.

The graph below provides an estimate of the cost reductions that are projected to occur over the coming years for both modules and systems. Whilst the absolute values indicated may not be achieved within the NT, the relative reductions in price are considered reasonable.

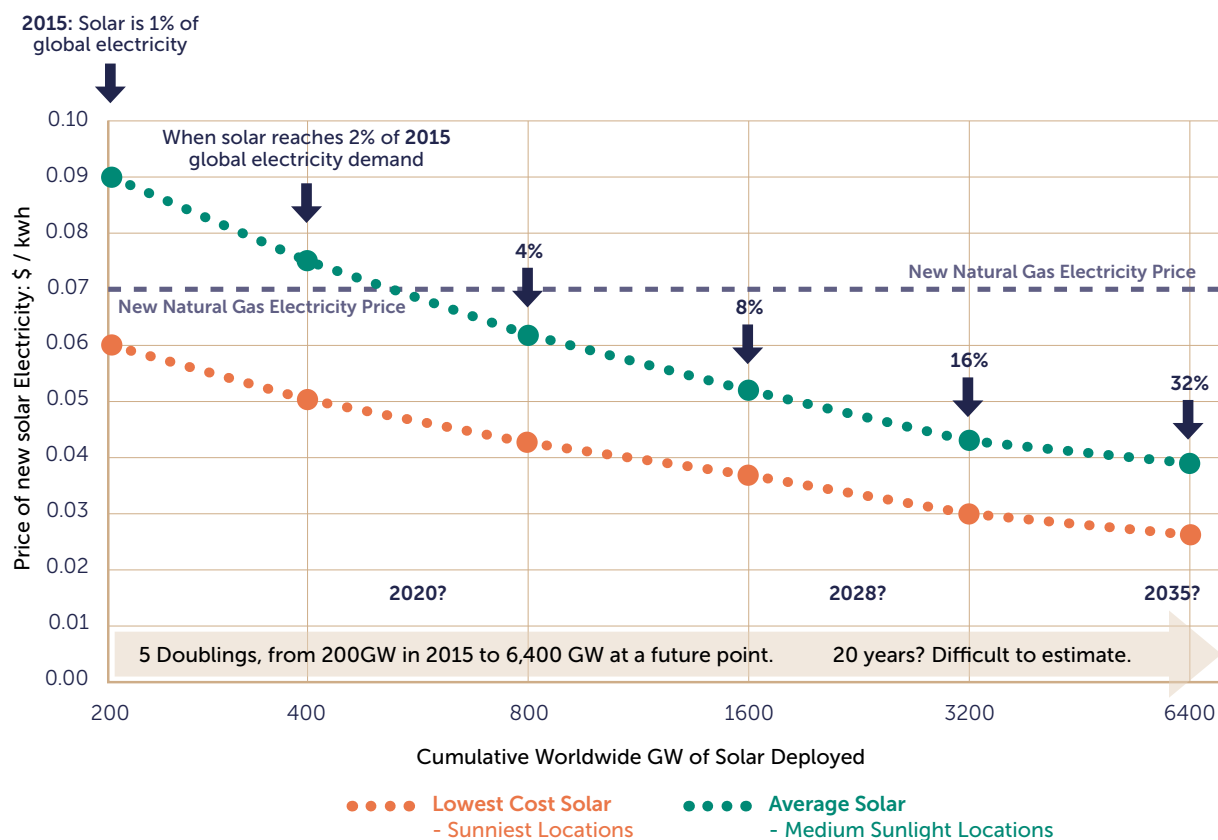
Figure 2: Calculated LCOE Values for Different Insolation Conditions



Financial conditions: 80% debt, 5%/a interest rate, 20-year loan tenor, 2%/a inflation rate, 25 years usable system life.

The graph below indicates the likely cost reductions based on current technology paths over the coming years relative to natural gas generation:

Figure 3: New Solar Electricity Price Projection



Ramez Naam, How Cheap Can Energy Storage Get, 2015.

This is a future model of solar prices. Assumes 16% cost reduction of new solar electricity per doubling of scale.

Solar costs unsubsidised. Natural gas prices do not include carbon externalities.

Appendix 5: Renewable Energy Policies in other Jurisdictions

Australian state and territory governments have been leading the transition to renewable energy, with most now having renewable energy targets of 50per cent by 2030. The ACT has a target of 100 per cent renewable electricity by 2020 that it is on track to meet through a reverse auction scheme. South Australia has seen the greatest increase in its share of renewable energy of Australian states, going from 26per cent renewable energy in 2013 to 40per cent in 2014 and now 50per cent in 2017. Victoria and Queensland are currently in the process of developing their schemes, while NSW has also increased its incentives for renewable energy. States and territories with consistent policy support, renewable energy incentive schemes and effective complementary planning legislation have attracted the bulk of renewable energy investment in Australia to date (IRENA, 2015c).

The table below summarises the actions of the states and territories:

	RE target	Household Feed in Tariff	Procurement process
Victoria	40per cent by 2025	11.3c/kWh	Reverse auction
New South Wales	Net-zero emissions by 2050	6.3c/kWh (avg.)	Tender process
Queensland	50per cent by 2030	7.5c/kWh (regional only)	Reverse auction
South Australia	50per cent by 2025	16c/kWh	Tender process
Western Australia	N/A	7.1c/kWh	TBC
Tasmania	100per cent by 2020	6.8c/kWh	TBC
Australian Capital Territory	100per cent by 2020	8c/kWh	Reverse Auction
Northern Territory	50per cent by 2030	25.67c/kWh	N/A

Whilst there are notable differences in the technical, regulatory and financial structures of the other states, the experiences of ACT in achieving substantial reductions in the provision of renewable energy through mechanisms such as reverse auctions for PPA's and/or Contracts for Differences (CFD's), and in particular the instruments developed by government to give effect to these are worth consideration for the NT.

Appendix 6: Northern Territory Renewable Energy Deployment

With its near total reliance on diesel generation for much of its early development, the Northern Territory has a long history of innovation with renewable energy systems. It developed the earliest solar thermal systems in Australia and more recently implemented internationally recognised programs such as Bushlight, Alice Solar City and the Desert Knowledge Australian Solar Centre.

The table below details the number of renewable energy systems currently installed across the regulated and unregulated networks and their contribution to consumption (energy) and demand (power) on a per cent basis.

Current State: Renewable Energy Installations – Regulated Networks

Item	Units	Darwin–Katherine	Tennant Creek	Alice Springs	Comments
2015–16 completed (consumer PV)	Number of installations	698	24	166	
	MW	10.554	0.099	0.850	
Total PV up to 30 Jun 2016 (consumer PV)	Installs	3,564	68	1,431	
	MW	24.810	0.311	7.190	
Other renewables	MW	1.003	0	4	LMS, Manton hydro, Uterne
Total customers	Number of installations	69,482	1,726	12,988	Taken from Annual Internal Statistics 2015–16 D2016/341294 CO1 Major + minor, assumed southern region is Alice Springs, Barkly is Tennant Creek
Customer penetration	per cent	5per cent	4per cent	11per cent	
Annual consumption	MWhr	1,671,360	29,583	212,422	
Estimated annual renewable generation (4kWhr)	MWhr	43,252	454	16,337	Assumed 4kWhr daily per kW installed PV (D2016/251467 average 18.2kWhr/4.5kW), Assume Hydro/LMS 0.8MWhr per MW installed per hr 24/7
Estimated annual renewable generation (5kWhr)	MWhr	52,307	568	20,422	Assumed 5kWhr daily per kW installed PV, Assume Hydro/LMS 0.8MWhr per MW installed per hr 24/7
TOTAL per cent contribution of renewables to consumption	per cent	3per cent	2per cent	8per cent	

Item	Units	Darwin–Katherine	Tennant Creek	Alice Springs	Comments
Dry season maximum demand	MW	260		47	Assumed 2 pm, 2014–15 from NMP, Tennant Creek was taken from ZSS data sheet daily profile
TOTAL per cent contribution of renewables to demand	per cent	6per cent		14per cent	Assumed Darwin 0.611 of generation capacity actually producing (angles, clouds, etc.)
Wet season maximum demand	MW	290	6.9	49	Assume Tennant Creek/Alice Springs 0.595 of generation capacity actually producing (angles, clouds, etc.)
TOTAL per cent contribution of renewables to demand	per cent	5per cent	3per cent	14per cent	
Dry season minimum demand	MW	140	2.3	16	
TOTAL per cent contribution of renewables to demand	per cent	11per cent	8per cent	42per cent	
Wet season minimum demand	MW	150	2.3	17	
TOTAL per cent contribution of renewables to demand	per cent	11per cent	8per cent	39per cent	
Annual maximum demand	MW	293	7	52	Maximum hr, Darwin value taken from D2016/532374 "Historical Forecast" worksheet 2015–16 MD raw
TOTAL per cent contribution of renewables to demand	per cent	5per cent	3per cent	13per cent	
Estimated 2017–18 renewable totals	MW	65.0			Based on 25MW major solar, and 7.1MW per year (7.1 from D2016/532374 "Solar" worksheet contribution value).

As can be seen, existing contribution to demand by renewable energy (RE) in places such as Alice Springs is already at 50 per cent, with similar levels of contributions from RE at many of the minor centres and Indigenous Essential Services (IES) communities. Many remote outstations are already operating with 100per cent RE, using a combination of solar and batteries for their primary supply with a diesel generator for emergency backup.

The NT currently has 27 accredited RE power stations (>100kW) ranging from 5.5MW at the Darwin Airport solar system to 305kW at Double Tree by Hilton in Alice Springs. A further 35 systems will become accredited through the SETuP deployment.

Appendix 7: Northern Territory Energy System Structure

The Northern Territory energy system consists of a number of different networks and systems, influenced by geography, regulatory framework and size. A summary of these is:

- Regulated grids:
 - Darwin–Katherine interconnected system
 - Tennant Creek
 - Alice Springs.
- Regulated minor centres
 - Yulara
 - Timber Creek
 - Borroloola
 - Nhulunbuy
 - Ti Tree.
- Non-regulated remote communities
- Licensed self-generating commercial centres (mine sites, tourist resorts)
- Small un-licensed isolated power supplies (cattle stations, roadhouses, outstations).

The regulated systems are energised by gas-fired generators either combined cycle gas turbine/steam systems, open cycle turbines or dual-fuel engines. Historically, PWC, as a vertically and horizontally integrated Government Owned Corporation, has been responsible for both electrical and water essential services. Recently this authority has been divided into three bodies separately responsible for electricity generation, electricity retail sales, and electricity transmission/distribution/system control and water and sewerage services.

Elsewhere, the generation is generally provided by diesel generators, with some locations, particularly outstations and remote communities, including increasing portions of renewables. Natural gas is also used in locations such as Yulara and McArthur River.

Generally, the NT networks have relatively low system inertia. This presents some issues for the existing electricity system if not well managed because it could add significant energy without the required inertia. Inertia and reliable capacity are required to maintain system security and reliability.

Figure 5: NT power system



Power and Water Corporation Annual Report, 2009

Darwin–Katherine Interconnected System

Renewable energy capacity growth in the Darwin–Katherine Interconnected System (DKIS) increased significantly in 2015–16 by 60 per cent. However, this growth consisted entirely of ‘behind the meter’ consumer PV, with system sizes ranging from 1kW (household) to 5500kW (Darwin Airport).

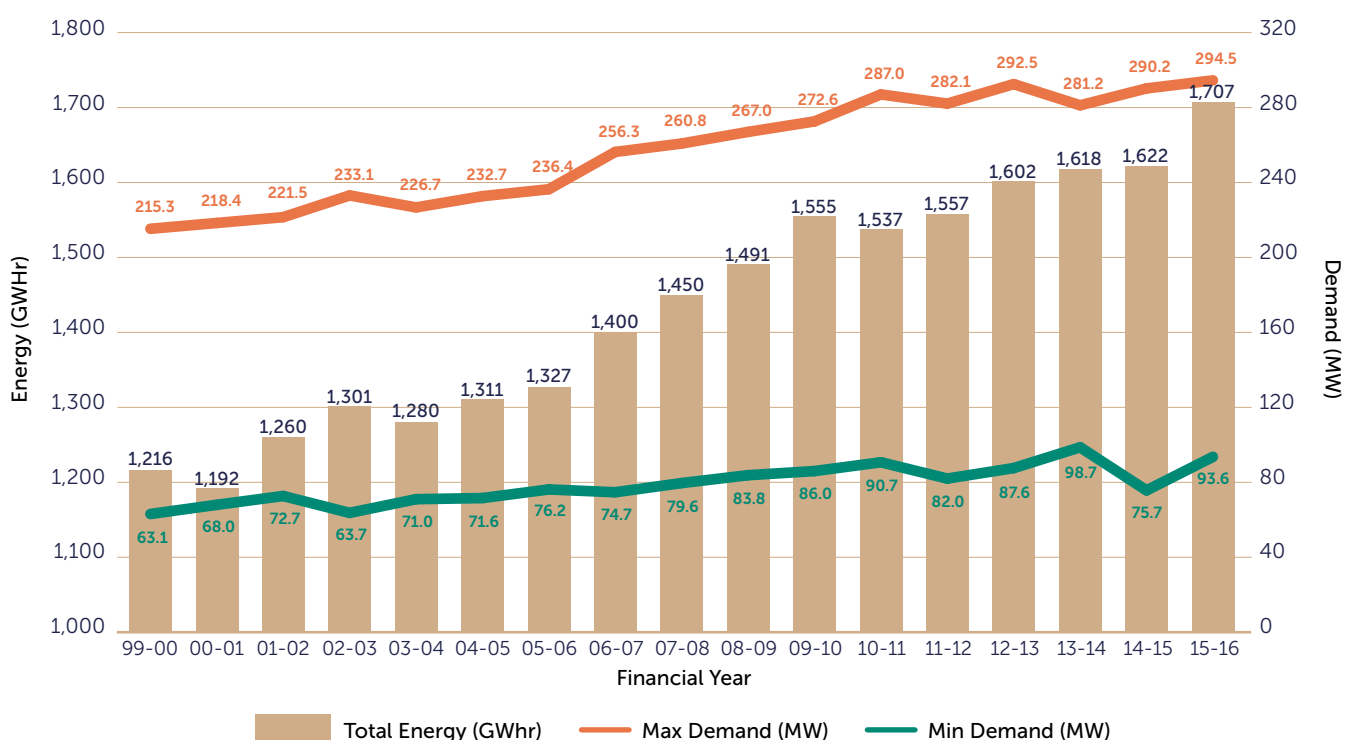
The total renewable energy contribution to consumption in the Darwin–Katherine system is approximately 3 per cent. There are currently seven network access applications for large-scale solar PV being reviewed for DKIS—the total capacity of 130MW. One proponent is planning for connection of a 25MW system in 2018.

In addition to large-scale solar, consumer solar systems are being installed in the DKIS

at a rate of approximately 8MW of connections per annum. This rate is set to increase, with two significant consumer applications currently under consideration that total 20.7MW. The rate of small system applications is expected to continue in line with the system cost curve and not decline because of the current low level of small system penetration, increased financial incentive packages being offered by installers and the feed-in-tariff offered by the retailer (Jacana Energy).

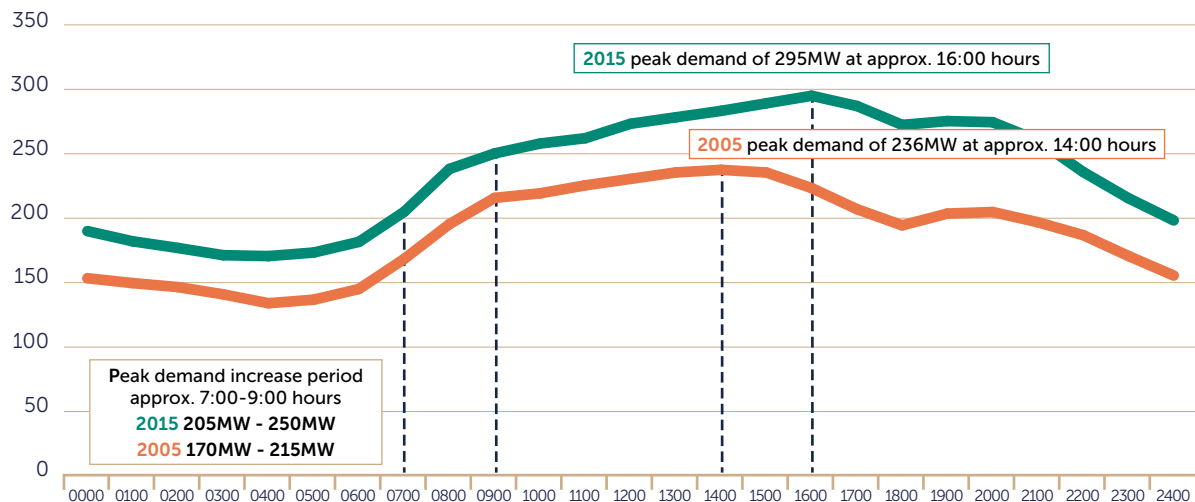
Figures 4 and 5 show the increasing consumption over the past few years for DKIS and the demand peak moving to later in the day. The change of time of the peak is attributable to the contribution of solar PV.

Figure 6: Darwin-Katherine Annual Energy and Demand



Power and Water Corporation, 2017

Figure 7: Darwin–Katherine demand profile comparison



Power and Water Corporation, 2017

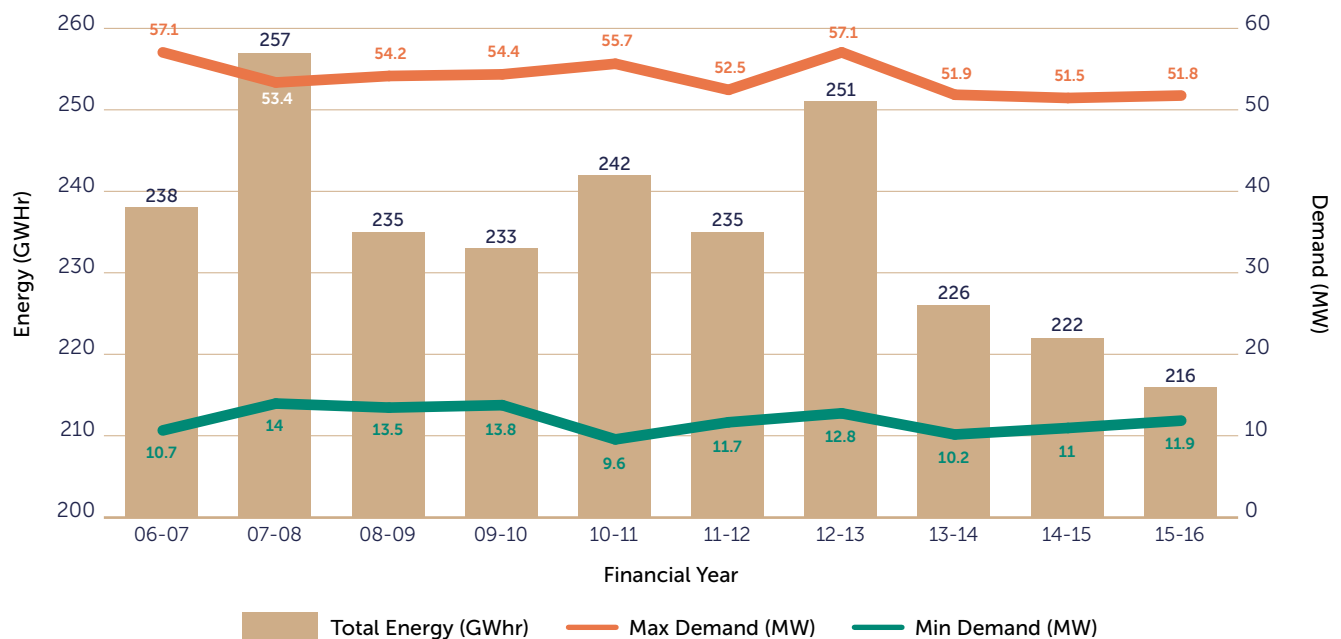
Alice Springs system

Renewable energy capacity in Alice Springs increased in 2015–16 by 52 per cent, from 7.34MW to 11.19MW. The bulk of this was 3MW Uterne solar power station expansion. Growth in consumer PV connections is significantly lower than seen in the Darwin–Katherine grid (11 per cent in Alice Springs compared to 60 per cent in Darwin–Katherine). There is currently no large-scale solar generator network connection applications being processed. Consumer solar system installations

are continuing at a rate of approximately 0.86MW of connections per annum. The total renewable energy contribution to consumption in the Alice Springs system is approximately 8 per cent.

Figure 6 shows the change in consumption over the past few years for Alice Springs. Total energy consumption is reducing, while the maximum and minimum demand are relatively stable.

Figure 8: Alice Springs Annual Energy and Demand



Power and Water Corporation, 2017

Remote and regional isolated systems

The NT Power and Water Corporation (PWC) owns and operates 57 isolated mini-grid power systems across the NT (52 servicing remote Indigenous communities and five servicing minor centres). Of these 57 power stations:

- One has a 'large-scale' solar system (266kW) operating in parallel with the diesel power station and a small wind system (45kW) (IPP model).
- Two have 'large-scale' solar systems (324kW, 402kW) operating in parallel with the diesel power station (control system integration) (IPP model).
- One has a 'small scale' solar system (55kW) operating in parallel with the diesel power station (control system integration) (PWC owned).
- Almost 30 have privately owned rooftop solar systems, varying in size from 5kW to almost 100kW.

The table below gives more detail on the current deployment of renewables in remote communities:

Item	Units	IES communities	Minor centres	Comments
Large PV installed - TKLN	kW	668	324	Installed at Ti Tree, Kalkarindji, Lake Nash under a PPA in 2012
Large PV installed	kW	3380		Installed at Bulman (2002), Arlparra (2017), Kintore (2017), Nyirripi (2017), Docker River (2017), Areyonga (2017), Mt Liebig (2017), Maningrida (2017), Ramingining (2017), Yuendumu (2017), Lajamanu (2017).
Customer installed PV	kW	642		Majority of capacity installed under the Solar Schools Program
Total PV & wind energy generated	MWh	200,000		Data re energy generated is from the utility-scale systems only, i.e. Kalkarindji and Lake Nash. Does not include Ti Tree (not IES)
Total PV & wind energy penetration	per cent	0.16per cent		PV and wind energy generated/total electricity sent out ($0.2/128.91 = 0.16\text{per cent}$)
Customer PV capacity rate install per month 2014–15	number	Approximately 4–6 applications received over the year		
Customer PV capacity rate install per month 2015–16	number	12 applications received over the year		
PV new capacity rate total install 2010–2016	kW	1679		There was also 742kW capacity decommissioned (Hermannsburg, Lajamanu, Yuendumu and Jilkminggan)

Other Areas

The township of Yulara is currently supplied by a combination of natural gas/diesel-powered engines operated by Territory Generation, coupled with a 1.8MW PV system installed by the operators of Ayers Rock Resort, Voyages Indigenous Tourism Australia.

Some large mine sites, such as the Tanami gold mine operated by Newmont, are considering renewable integration but have not yet proceeded.

Appendix 8: Regulated System Information

Regulated system	Load range	Generation mix (capacity)
Darwin–Katherine Interconnected System (DKIS)	Min: 83.1 – 176.5 MW Max: 128.1 – 294.2 MW Avg: 185.8 MW *Data between 10/2011 and 12/2016	Conventional (95per cent, 509MW) Gas (34per cent, 180MW) Steam (7per cent, 39MW) Dual fuel (54per cent, 290MW) Renewable (5per cent, 25MW)
Alice Springs (AS)	Min: 10.2 – 27.3 MW Max: 14.7 – 52.5 MW Avg: 23.3 MW *Data between 10/2011 and 12/2016	Conventional (89per cent, 88MW) Gas (8per cent, 8MW) Steam (3per cent, 3MW) Dual fuel (78per cent, 77MW) Renewable (11per cent, 11MW)
Tennant Creek (TC)	Min: 0.7 – 4.0 MW Max: 2.2 – 7.0 MW Avg: 3.2 MW *Data between 10/2011 and 12/2016	Conventional (98per cent, 17MW) Gas (28per cent, 5MW) Steam (49per cent, 8MW) Dual fuel (24per cent, 4MW) Renewable (2per cent, 0.3MW)

Power and Water Corporation, Update for Roadmap to Renewable Taskforce, 2017

Appendix 9: Energy Storage

Energy storage will be a key component in transforming electricity supply systems to accommodate renewable energy technologies that generate energy intermittently. In the Northern Territory, the most likely renewable technology (at least in the next decade) will be solar photovoltaics (PV), which generates for a maximum of eight hours per day and even less during adverse weather conditions.

There are many types of energy storage. The following are the most likely contenders for long-term (many hours as opposed to seconds or minutes) storage:

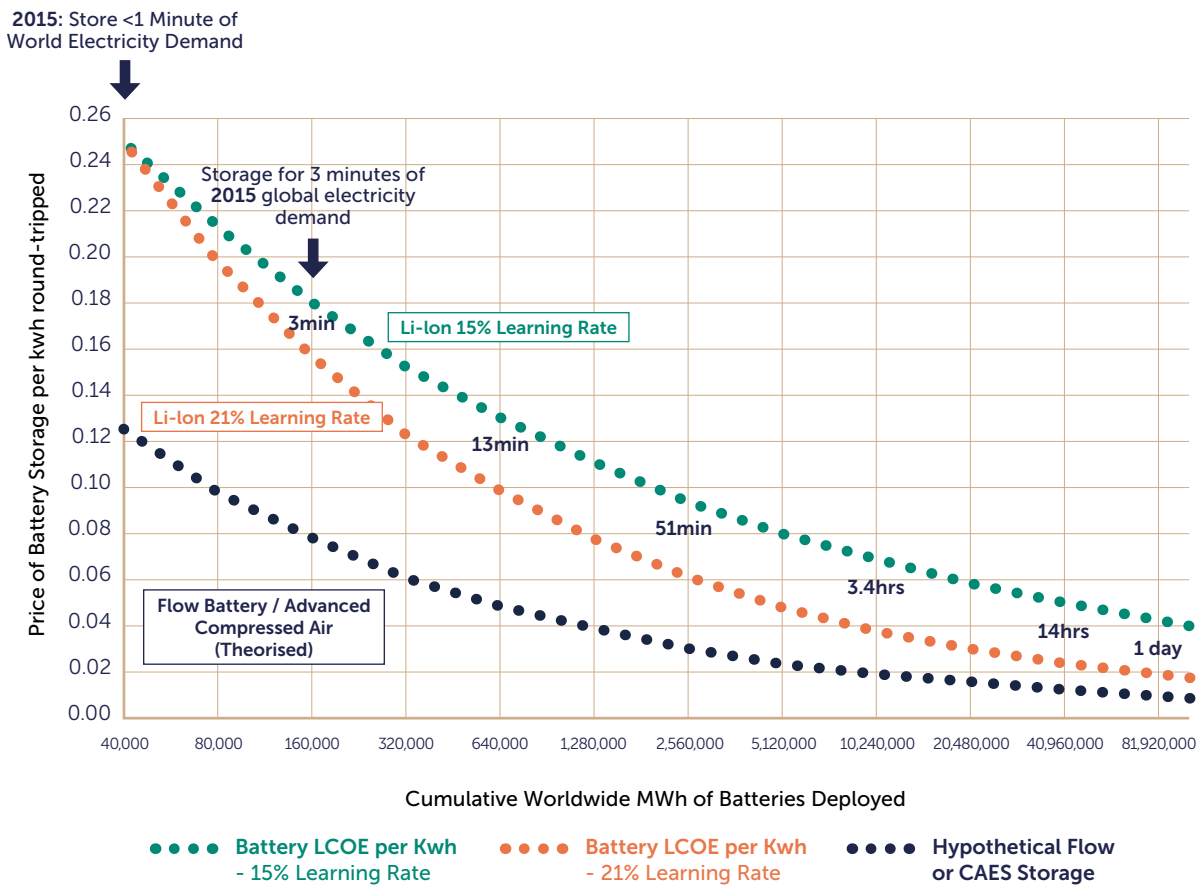
- Electricity storage in **non-flow type batteries**: chemical storage medium inside the battery
- Electricity storage in **flow type batteries**: chemical storage medium outside the battery
- **Thermal storage of heat** in a heat transfer medium whereby the stored energy can later be used to generate steam to drive a conventional steam turbine (thermal energy storage). Note that this form of storage can be used in association with solar thermal power plants to provide dispatchable electricity output
- **Pumped storage** hydro electric schemes: physical storage of potential energy in the form of water in a high reservoir, using conventional hydroelectric generators to recover the energy in the form of electricity, with the same machinery being used to pump the water back up to the high reservoir at times of limited electrical demand
- **Storage of compressed air** in underground caverns: physical storage of kinetic energy in the form of compressed air, using turbine generators to recover the energy in the form of electricity, with the same machinery being used to pump air into the reservoir at times of limited electrical demand.

Global benchmarking completed by firms such as Lazard has highlighted significant progress in the application and implementation of large-scale storage, with cost dramatically reducing in some areas. There remain relatively low levels of experience in Australia at utility scale of battery technologies at present. This situation is expected to change during the period leading up to 2030, with both Victoria and South Australia providing incentives for large-scale battery projects. The South Australian Government has indicated that the 100MW battery will be built at the end of 2017, suggesting that utility scale experience in Australia will soon exist.

In the context of the NT, we concluded that neither pumped storage nor compressed air storage was likely to be viable in the near term due to the physical topology and geology of the NT. The potential of solar thermal storage, however, is more aligned to end use of electricity rather than as a conversion medium, for example, thermal storage of hot water or chilled water for air-conditioning.

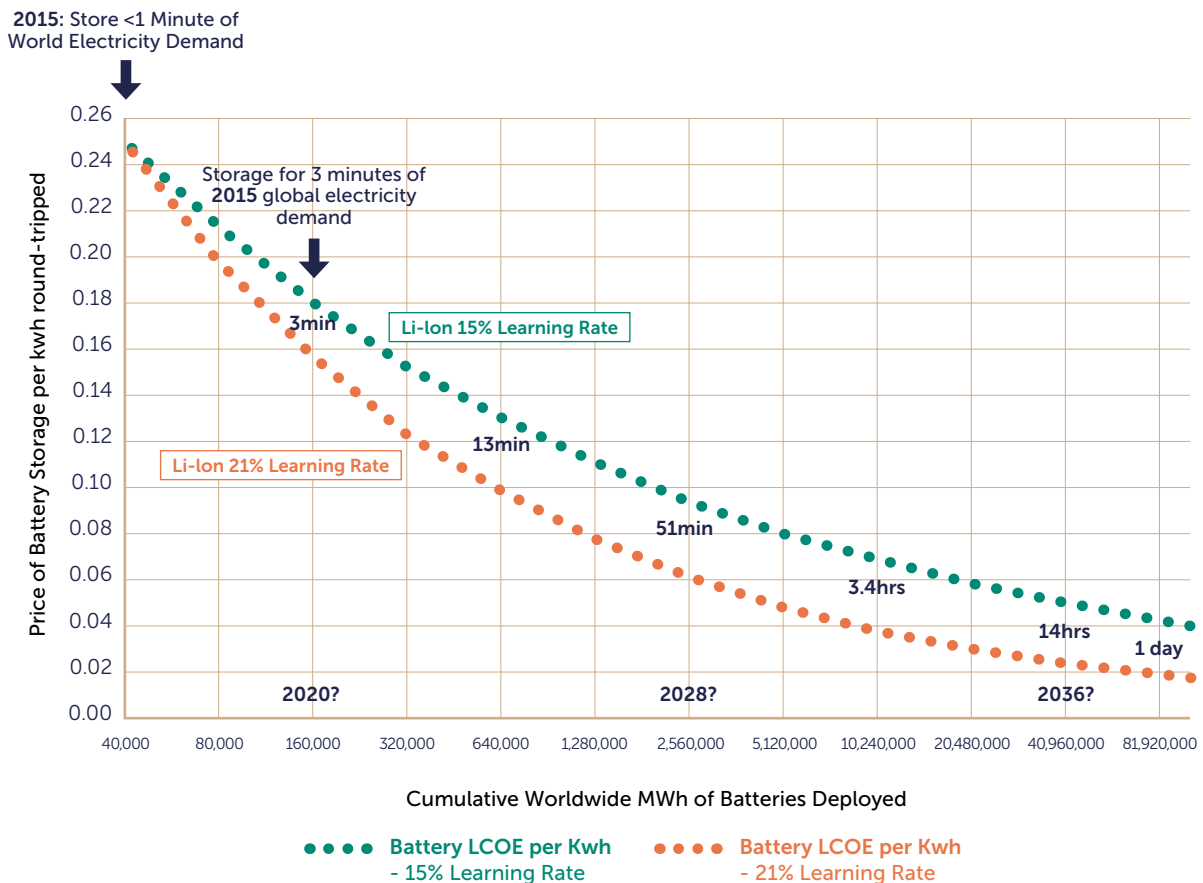
The graphs below indicate the likely price trends for energy storage based on current known technology development pathways.

Figure 9: Energy storage learning curve



Ramez Naam, How Cheap Can Energy Storage Get, 2015.
 This is a future model of enery storage prices. Assumes 15-21% cost reduction of new battery storage per doubling of scale. Costs Unsubsidised. Costs do not include the cost of generating the electricity to store.

Figure 10: Li-Ion price projection



Ramez Naam, How Cheap Can Energy Storage Get, 2015.

This is a future model of lithium-ion battery prices. Assumes 15-21% cost reduction of new battery storage per doubling of scale. Costs Unsubsidised. Costs do not include the cost of generating the electricity to store.

Notwithstanding the challenges that remain in the battery market, the rapid rate of change and the scaling up of global supply chains to support battery development and deployment gives confidence to the assertions that chemical batteries, either flow or non-flow, will be economically viable in the medium term.

The increased economic viability of batteries coupled with low-cost generating technologies such as PV is therefore considered likely to become more evident in the electricity system within the next five to seven years.

Appendix 10: Intermittency of Renewable Energy in the Northern Territory

The Northern Territory has developed significant expertise in the integration of renewables into the various energy systems, including modelling the impact of variability and intermittency that are inherent within renewable technologies such as solar PV.

While the assumed impact of variability and intermittency has been over- and under-estimated by detractors and proponents of renewable energy respectively, it is clear that the management of this variability is non-trivial. Figure 9 shows system and individual generator load profile curve for a particular day in Alice Springs that shows the impact of variable output renewable energy systems is having on the system profile and relative loading on the respective engines.

Without negating the potential significance of the management challenges associated with accommodating a variable load as highlighted in the figure above, it should also be noted that this impact is amplified due to the quite variable nature of the system load. For example, in the figure above, the maximum

load is 25MVA; however, during summer, the maximum load is approximately 57MVA. Consequently, it can be concluded that the challenges posed by variability are significantly influenced by seasonality as well as the time of day/week (weekend loads are substantially lower than weekday loads in Alice Springs).

On the network side, the increase in consumer PV is creating low-voltage regulation issues and affecting the quality of supply. Customers expect to be able to generate PV and for PWC to ensure the reliability and quality of supply. Residential installations of PV currently use the Network as their battery and are not consuming the solar energy they are producing. The daily customer profile in Figure 10 shows how much an average customer exports to the grid during the day. The push of PV onto the grid increases voltages, and the evening usage causes the voltage to drop. This large swing is expected to increase unless customers are incentivised to change their consumption patterns.

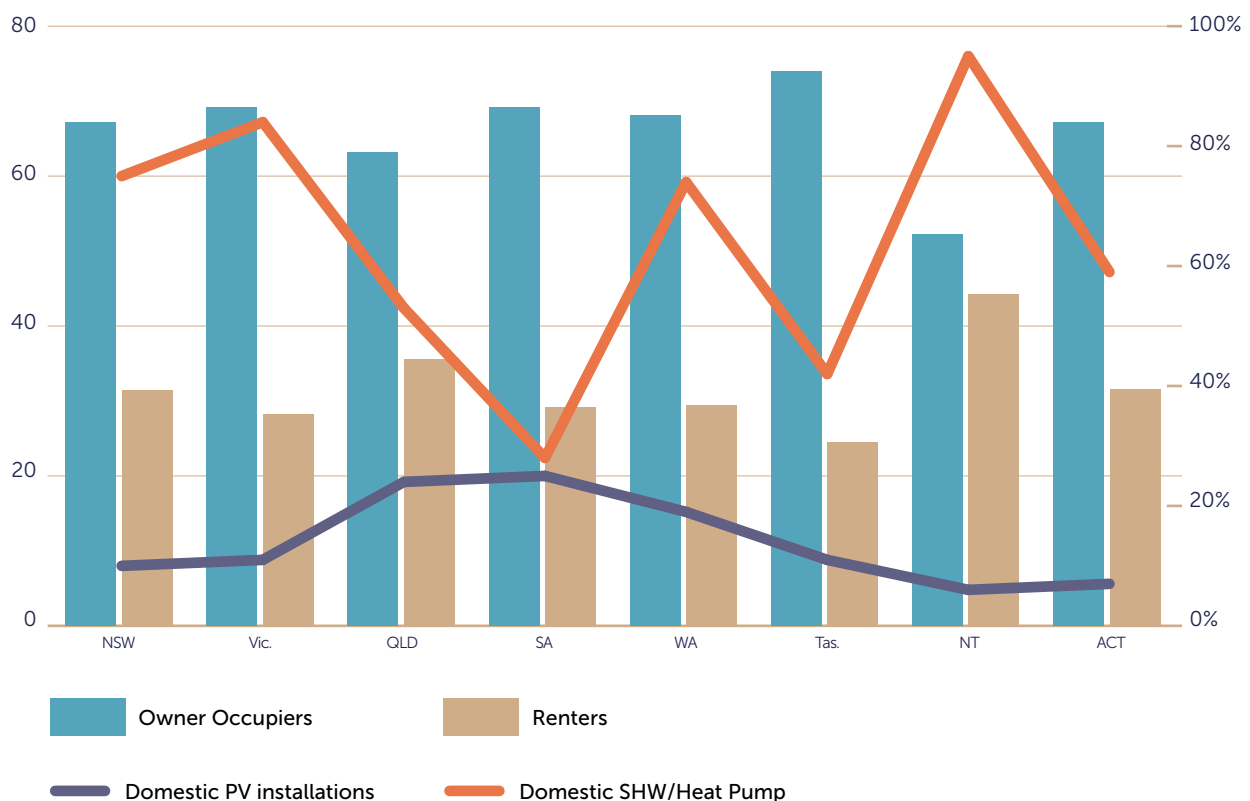
Appendix 11: Household Solar

Domestic PV installations are relatively low compared to elsewhere in the country, with only 6 per cent of households with PV compared with a national average of 14 per cent. This difference is explained by the characteristics of the NT:

1. **Household Ownership:** NT owner occupiers represent a smaller portion of the total housing stock compared with the rest of the country, principally due to the population's higher level of mobility in the population and the higher proportion of the population relying on public housing.
2. **Solar water heaters:** the NT has historically had the highest uptake of solar water heaters (and to a lesser degree, heat pumps) of anywhere in Australia. This investment has generally taken precedence of solar PV, with solar hot water units being replaced, on average, every 10 years and close to 100 per cent of households, including units, having some form of solar hot water. It is interesting to note that solar and high efficiency electric hot water systems can now be more economical than solar thermal systems.

This graph shows this relationship more clearly:

Figure 11: Owner occupier vs renter and solar PV and solar hot water installations



There is a high value in this distortion as it can be used to drive investment in large grid connected PV plants in order to supply a renewable energy alternative for this sector of the consumer market.

Appendix 12: Investment in Renewable Energy

Nearly all of these successful Australian Renewable Energy Agency ARENA projects have long-term offtake agreements of 10 years or more. Four Queensland projects benefitted from the Solar 150 program, providing a 20-year contract for the difference (similar to the successful ACT auction programs). The ARENA and ACT programs also demonstrated the strong domestic and international interest in projects by developers and financiers (equity and debt) providing competitively priced financing. There was, however, limited appetite for merchant price-exposed projects in the ARENA competitive round and the Clean Energy Finance Corporation (CEFC) was the only financier in this program to support merchant financing models. Whereas the ACT Government auction program had determined in its design and has demonstrated that the most cost-competitive model to procure renewable energy was through 20-year contracts for difference (CFDs), which provided optimal risk allocation, and due to debt sizing parameters and equity return differentials, delivered a saving of approximately 40 per cent compared to merchant pricing models.

Within the regulated portion of the NT electricity system, the NT does not currently have a merchant energy market like the National Electricity Market (NEM) with either market maturity or depth of market trading activity that is sufficient to facilitate a merchant market for investment in a generation or ancillary services. While a market structure is to be established, this structure will not facilitate either a spot merchant pricing market or provide the transparency of market pricing models and assumptions required to enable long-term forecasting of the pricing of energy and ancillary services. As a result, merchant pricing financing models for private sector financing are not available and would not be bankable for either equity or debt providers.

Therefore, to encourage the long-term investment in RE in the NT, long-term offtake agreements (also called power purchase agreements or PPAs) are required. CFDs

require a spot market mechanism and therefore are not an option for the NT. For these offtake agreements to be financeable or bankable, the PPA contracts need to be with a creditworthy counterparty, such as the NT Government. Pricing structures for PPAs or CFDs can be structured on a CPI or nominal basis.

In the unregulated mining and off-grid portion of the electricity sector, the barriers to further renewable deployment are more complicated than simply the method of contracting. Very often, projects that would normally be deemed to be economically viable do not proceed in the off-grid space. This is often driven by one of more of the following:

- I. **Capital constraints** – although the investment return of a project may be consistent with general industry or government expectations, competition for capital within a proponent (e.g. a mining company) may be such that what would be otherwise considered acceptable is not sufficient to pass the return hurdles for capital allocation to renewable energy projects.
- II. **Assessment of risk** – where external financiers are willing to own/finance a project under a PPA (or similar) framework, the return required will be defined by their assessment of the risk of the proposal (this often creates the perverse situation where the entity best placed to understand and assess the risk is not the entity having to price the risk within the finance package) and the resulting pricing of the project is uneconomic.
- III. **Sunk Cost** – significant capital has already been expended in generation infrastructure that may become stranded as a result of new investment in RE.

Appendix 13: Integration with Existing Generation in the Northern Territory

Significant experience has been developed in the NT on integrating renewables with existing diesel and natural gas generation plant. Many sites in remote areas regularly exceed 60 per cent contribution by renewables, primarily solar PV. One of the critical challenges that exist as part of longer-term planning for 50 per cent energy contribution by renewables is the management of spinning reserve, fault levels, voltage management, standby capacity and peaking capacity, while at the same time considering how to manage the phasing out of older generation plant.

Specifically, given that:

- The NT is likely to rely predominantly on solar PV to meet the target for the foreseeable future
- Solar PV, particularly in the Top End, faces higher levels of intermittency in the wet season
- The peak loads tend to occur later in the afternoon and early evening, principally due to air-conditioning.

There is a significant challenge in being able to reliably 'fill the gaps' in the output of the PV systems.

There is some opportunity to manage this through design, with lower-cost solar PV systems resulting in increased viability of oversizing PV arrays to generate synthetic inertia. However, this will not resolve all the challenges. To that end, there remain two primary solutions:

- Using batteries, either in large modules or distributed throughout the network
- or
- Repurposing existing generation assets to provide support to the network.

The kind of plant presently in the gas-fired system in the NT is very suitable for the 'filling the gaps' role. Most of the capacity is gas turbines plant, and gas turbines can be started quickly, run for short periods and stop again when no longer required with minimal impact on the machinery and relatively low economic cost.

During the next 15 years, gas will be readily available at a predictable price from the existing gas contract. While burning this gas costs money, much of the plant burning it is well into its economic life and therefore has low residual capital value.

In the immediate future, as renewable energy begins to ramp up, the Northern Territory is ideally placed to manage intermittency and plant reallocation from 'prime power' to 'standby' status. As battery technology improves and reduces in cost, it can logically and slowly replace the aged gas plant.

Consequently, existing assets such as the 190MW at Channel Island (due to retire in 2027) may be seen as providing space for the deployment of more renewable energy (RE) as RE is progressively more able to naturally compete with gas-fired plant and simply push at least part of the 190MW retirement out by using the plant much earlier as low merit order support for RE and thus gain more value from the investment.

