Developing Alice Springs & Central Australia as a World-leading Solar Centre

Report to Northern Territory Government by

The Australian PV Association

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July 2012

The Australian Photovoltaics Association

The objective of the APVA is to encourage participation of Australian organisations in PV industry development, policy analysis, standards and accreditation, advocacy and collaborative research and development projects concerning solar photovoltaic electricity.

APVA provides:

- Up to date information on PV developments around the world (research, product development, policy, marketing strategies) as well as issues arising.
- A network of PV industry, government and researchers which undertake local and international PV projects, with associated shared knowledge and understanding.
- Australian input to PV guidelines and standards development.
- Management of Australian participation in the IEA-PVPS, with funding from the Australian Solar Institute.

Acronyms

AC	Alternating Current
AEMO	Australian Energy Market Operator
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
EPCC	Energy Policy and Climate Change Unit of the Department of Chief Minister
ETS	Emissions Trading Scheme
FIT	Feed in Tariff
GETF	Green Energy Taskforce
LCOE	Levelised Cost of Energy
LGC	Large Generation Certificates
NEM	National Electricity Market
NG	Natural Gas
NTG	Northern Territory Government
ORER	Office of Renewable Energy Regulator
PPA	Power Purchase Agreement
PV	Photo Voltaic
PWC	Power Water Corporation
RE	Renewable Energy
RET	Renewable Energy Target
RRPGP	Renewable Remote Power Generation Program
SHW	Solar Hot Water
SRES	Small-scale Renewable Energy Scheme
STC	Small Technology Certificates
TOR	Terms of Reference
WACC	Weighted Average Cost of Capital

Executive Summary

Introduction

The Northern Territory Climate Change Policy is effectively an action plan that will ensure the Territory plays its part in national and international efforts to control climate change. Target 13 of the NT Climate Change Policy is a commitment to: *By 2020, develop Alice Springs and Central Australia as a world-leading solar energy centre*. The progression of Target 13 is an opportunity to achieve a number of objectives:

- Identify and trial innovative financing options.
- Contribute toward the NT's achievement of the Australian Government's 20% renewable electricity target.
- Implement the recommendations from the NT Green Energy Taskforce reports.
- Develop innovation, knowledge and business opportunities beyond the focus of hardware and project development.
- Align with and build on existing research and innovation projects.
- Position Alice Springs and Central Australia favourably for Australian Government funding under the Clean Energy Future package.

This Briefing Report identifies issues and opportunities associated with Target 13, so as to inform the NT Department of Natural Resources, Environment, The Arts and Sport, in preparation for public consultation. This report focuses on solar electricity, although solar heating for water and other end uses, such as cooling, will also play an important role in increasing solar penetration levels. Similarly, energy efficiency and demand management, along with energy storage and smart control systems, will be crucial. This report has been developed in consultation with a number of key stakeholders who will necessarily be involved in future implementation.

Section 3 of this report firstly defines a World-leading Solar Centre and provides examples of solar centres, both in Australian and internationally. It then discusses in some detail the five desirable characteristics of a World-leading Solar Centre, which are divided into: levels of deployment; test and demonstration facilities; community and stakeholder engagement; education and training; and financial and market mechanisms.

Section 4 describes the Central Australian region, focussing on the current energy supply and existing solar installations – both grid-connected and off-grid.

Section 5 describes the various technology options that could be deployed in a Solar Centre, ranging from batteries and smart meters to large-scale PV and solar thermal as well as integrated solar combined cycle and solar gas.

Section 6 defines three possible scenarios for solar deployment: 'BAU', 'Moderate' and 'Stretch'. It describes in detail how each of the scenarios would develop in terms of the five characteristics required for a World-leading Solar Centre.

Section 7 then concludes with a discussion and recommendations.

The Appendices contain more detailed assessments of Solar Centres, technology performance, and consultations.

Definition of a World-leading Solar Centre

The definition chosen for a Central Australian Solar Centre will determine what is to be achieved, how it will be achieved, and the stakeholders that will be involved in achieving it. The proposed definition includes five criteria. By 2020, it is suggested that a world-leading Solar Centre may perform better in some of these areas, but should not perform poorly in any of them.

Definition of a world leading solar centre

A Solar Centre should provide an appropriate supportive environment for the private sector and government agencies to promote and install solar energy according to the relevant scenarios, and also act as a live research centre for assessing and demonstrating new technologies and systems. It should also actively explore issues related to the integration of different solar technology options at high penetration. Thus, a world-leading Solar Centre would ideally have the following:

1. Levels of deployment of all relevant Solar Energy technologies at close to the highest levels of penetration world wide.
2. One or more highly visible Solar Energy Technology test and demonstration facilities, especially relevant to remote locations and desert climates, which are respected by researchers and commercial operators globally.
3. A continuation of the high level of support and engagement with the local community and key stakeholders, including indigenous communities, relevant energy retail and generation companies and local government.
4. Significant supporting activities in solar energy education and training at tertiary, secondary, trades and community levels.
5. World's best practice financial and market mechanisms to facilitate ongoing deployment of solar technologies and ensure that supporting action on best practice outcomes in Energy Efficiency and demand side management deliver a high level of solar contribution in an overall least cost manner.

The criteria above have been used in the report to guide the requirements under each future scenario examined. The main report includes brief descriptions of relevant International and Australian examples and activities of Solar Cities and Centres. These include the Australian Solar Cities Program, the USA Solar Cities program, the International Solar Cities Congress, the International Council for Local Environmental Initiatives, Freiburg Eco-city, and Dezhou in China.

The Central Australian region in 2012 – the baseline

Alice Springs Energy supply

Alice Springs has a gas connection to Darwin and an electricity network operated by PWC that is one of the NTs "regulated systems". Table 1 lists key load statistics. Total generation capacity exceeds the estimated requirements through to 2020.

Table 1: Alice Springs Electricity Load Summary

Maximum Load	55 MW
Minimum Load	15 MW
Average Load	26 MW
Annual Load	230 GWh
Central Generation Capacity	100 MW

Electricity on the network comes from three gas-fired power stations: the Ron Goodin power station operated by PWC; the Brewer power station under contract to PWC; the new Owen Springs power station also under contract to PWC; and grid-connected PV systems, both large iconic and small private systems. Of the three fossil fuel-fired power stations, the newest is Owen Springs. This system is still being progressively established, but is intended to be the main location for generation on the network moving into the future.

Existing energy prices for residential are currently subsidised as part of the Northern Territory's 'Community Service Obligation' (CSO) and are: $217.7/MWh or $317/MWh peak and $184.8/MWh off peak. Non contestable commercial tariffs are $250.9/MWh or $317/MWh peak and $184.8/MWh off peak, and contestable are likely to be in the range of $210 - $240/MWh.

Alice Solar City

The Alice Springs Solar City[1] has been very successful in raising community awareness of solar options, and of increasing solar uptake rates. At the time of the mid-term review of the Australian Solar Cities program:

- Around half of Alice Springs households had solar hot water systems installed
- There were approximately 1.5MWe of large iconic PV systems
- More than 300 homes and business have roof top PV
- It has the largest concentration of solar energy of all the solar cities
- It initially operated its own solar buy back tariff program, but new customers now have access to an NT wide tariff.

The body of the report includes other statistics on progress as well as observations from the mid term review by Wyld group.

Existing solar installations in Alice Springs

The current installed capacity, location, size and contribution of PV in Alice Springs is shown in the Tables below.[21] An estimated 50% of households also have solar water heaters.

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[1] http://www.alicesolarcity.com.au

Table 2: PV installations in Alice Springs in 2011-12

Category	#	Capacity (kWp)	% Inst. Cap	Comments
Residential Systems				
Installed under ASC program	277	530	17%	Mostly 2kW (some 1 & 1.5kW)
Installed outside ASC program	183	464	15%	1.5kW to 5kW systems
Total Residential	**460**	**994**	**32%**	
Commercial Systems				3kW to 40kW systems
Installed under ASC program	35	367	12%	
Installed outside ASC program	4	14	0%	
Total Commercial	**39**	**381**	**12%**	
Iconic/Showcase Systems				
Desert Knowledge Solar Centre	27	220	7%	Showcase (2008)
Crowne Plaza Hotel	1	305	10%	ASC Iconic (early 2009)
Alice Springs Airport	1	235	8%	ASC Iconic (Nov 2010)
Uterne Solar System	1	969	31%	ASC Iconic (July 2011)
Total Installed Iconic/Showcase	**30**	**1,729**	**56%**	
CURRENTLY INSTALLED PV SYSTEMS	**529**	**3,104**	**100%**	

Table 3: PV capacity and penetration levels – Alice Springs 2011-12

PV Penetration Measure	PV Measure	Value	System Measure	Value	% PV Pen.
PV Capacity Penetration	Installed Nominal PV Capacity	3.1 MW	Peak Load	55 MW	5.6%
PV Peak Power Penetration - Summer	Est. Summer Midday PV Peak Power	2.6 MW	Ave. Summer Midday Load Demand	40 MW	6.5%
PV Peak Power Penetration - Winter	Est. Winter Midday PV Peak Power	2.2 MW	Ave. Winter Midday Load Demand	26 MW	8.3%
PV Annual Energy Penetration	Est. Annual PV Energy Generated	5.7 GWh	Annual Gross System Load	230 GWh	2.5%

Off Grid Electricity Supply

The majority of remote communities are supplied by isolated diesel power stations. IES operates 53 diesel power stations at communities not connected to the regulated grids. The total installed generation capacity at the Growth Towns is approximately 46MW, and 25MW at other IES communities. IES also purchases electricity from the Rio Tinto Alcan operated power station on the Nhulunbuy power grid for two communities and from the GEMCO power grid on Groote Eylandt for one community. There are over six hundred small-scale renewable energy systems deployed throughout the Northern Territory, with many of these servicing outstations. There is also approximately 1MW of photovoltaic system capacity deployed across Yuendumu, Hermannsburg, Lajamanu, Kings Canyon, Bulman and Jilkminggan.

The primary issue facing the off-grid market is one of cost, as the majority of off-grid energy generation comes from diesel generators, which is, in turn, driven by the gate price charged for diesel at the primary import hub in Darwin. The marginal cost of generation for most off grid sites is between $280/MWh and $350/MW/MWh. This price is higher for more remote sites, and anecdotal data suggests that some locations may have marginal costs of generation exceeding $450/MWh.

Technology Options

The body of the report summarises the characteristics of the following technologies, with a focus on their relevance for a World Leading Solar Centre. Key metrics for selected technologies are summarised in Table 4.

- Photovoltaics
- Advanced batteries
- Smart Meters
- Solar Water Heating
- Solar Cooling
- Concentrating Solar Thermal Power technologies
- Solar Gas

Table 4: Key metrics for different Solar options at Alice Springs

Technology	Flat plate PV, no tracking[2]	Trough no storage	Tower with 6 hours storage	Tower with 40 hours storage
Annual generation (kWh/kW)	2074	1983	3773	6526
Average daily generation (kWh/kW)	5.68	5.4	10.34	17.88
Average Capacity factor	24%	23%	43%	74%
Land requirement (ha/MW)	2.56	2.18	5.20	10.39

Possible Future Scenarios

Scenario Descriptions

For this report, three scenarios are defined: 'Business as Usual' (BAU), 'Moderate' and 'Stretch', to analyse possible solar futures. These scenarios are simply examples of the development that may occur from across the full spectrum of possibilities.

- The "BAU" scenario builds on the current situation with a projection out to 2020.
- The "Moderate" scenario limits solar energy use to that which is predicted to be compatible with the economic and social constraints expected for the region in the short term.
- The "Stretch" scenario is defined as the highest level of solar energy use that is predicted to be technically possible using commercially available technology out to 2020.

Electricity demand for all scenarios is assumed to have been 186.7GWh in 2010 and projected to be 230GWh for 2020, a growth rate of about a 2.1% per annum.

Within each scenario, the levels of solar penetration will differ for each of the two different markets:

- Alice Springs
- Off-grid – Central Australia.

[2] Metrics for the PV option are expressed per high voltage AC kW rather than per nominal DC capacity.

The off-grid market has then been broken down to a number of smaller levels, based on the unique characteristics of mine sites, pastoral stations and remote communities, including outstations, homelands and gazetted communities.

Each of these markets currently has very different levels of solar penetration, and importantly, very different characteristics (barriers, issues and opportunities) and so will require different approaches to achieve the scenario targets.

In addition to being based on the percentage of energy provided by solar sources, the scenarios are defined according to the activities identified previously as being required for a world leading "Solar Centre":

- Test & demonstration facilities
- Community and stakeholder engagement
- Education and training
- Financial and market mechanisms.

Alice Springs

Business as Usual

For the business as usual scenario it is assumed the existing level of community engagement and institutional support is at least passively maintained within a broader financial environment that supports continued development without being subject to major external shocks, such as the global financial crisis. Whilst the BAU scenario is anticipated to result in some significant levels of solar deployment based on present trends, it would not be world leading.

Levels of deployment

It has been assumed that the BAU scenario involves around 9MWp of PV and no CSP. Table 5 shows the assumed level of PV deployment within the Business As Usual scenario. The BAU scenario would result in about 20% peak solar contribution in summer and as high as 35% during lower demand months, with a total generation contribution of 14.2GWh out of an overall 230GWh annual load (7% total energy). The body of the report describes the underlying assumptions leading to the proposed deployment rates.

BAU includes no uptake of CSP because the minimum practical system size is large and capital intensive. They would also only be approaching economic viability under a realistic PPA in 2020 or later in the absence of a major grant or other financial support mechanism.

Test & demonstration facilities

The BAU scenario presumes that the existing DKASC facilities would be maintained and some organic growth would occur, but no further development of the facilities would occur. Data-mining activities and research projects using data from the DKASC, ie. ASI research projects, may continue but would not likely extend beyond 2016.

Community and stakeholder engagement

The BAU scenario relies on an existing high level of engagement from members of the community and businesses as well as from organisations such as the Arid Lands Environment Centre (ALEC). Within the BAU model it is assumed that Alice Solar City receives a small amount of ongoing funding to maintain its activities, but has no capacity to grow the program. This reduces the rate of takeup because the high level of population turnover means that many residents living in Alice Springs in 2020 will never have heard of, or engaged with, the Alice Solar City.

Education and training

Centralised solar systems are likely to be installed and operated by PWC or private industry with a PPA. Education and training would be limited to up-skilling PWC staff and perhaps specific operational and maintenance training for a few local people, undertaken by the system installer.

Financial and market mechanisms

Within the BAU model, it is assumed that underlying pricing is sufficient to support the deployment of renewables without specific financial incentives.

The Moderate Scenario

The Moderate Scenario can be interpreted as the minimum level of achievement needed to be consistent with a world leading position. Given that it would need to be solar specifically, it would likely put Alice Springs at a level well above the average for solar penetration for regional centres in Australia and many parts of the world at that time. In order to achieve these levels of solar contribution in a sustainable manner, this scenario also requires a range of other activities as defined in the body of the report.

Levels of deployment

We have assumed the Moderate scenario is achieved using around 13MWp of PV, a CSP demonstration centre, together with the existing 35MW of gas-fired generation systems at Owen Springs and the retirement of other units as possible. Table 6 shows the assumed level of PV deployment within the Moderate scenario. The body of the report describes the underlying assumptions leading to the proposed deployment rates

The moderate scenario assumes the development of a Solar Thermal demonstration centre building on DKASC that would allow for the installation of around four different solar thermal technologies. The demonstration CSP plants would operate at a lower capacity factor than would commercial plants, depending on the level of R&D activity involved, and have been assumed to generate 3.5kWh/kW.

The various measures assumed within the moderate scenario would provide for around 22% of the forecast energy demand by 2020 from a combination of PV and CSP, with peak penetration of PV reaching 50% of the midday peak in winter.

Test & demonstration facilities

A world-leading demonstration facility would need to allow access to local and international researchers for these trials and also to cater for visitors from other jurisdictions, including other utilities, politicians, solar industry, financiers and the public, wishing to inspect the site and gain detailed information. This would require specific engagement by the NT Government to support new research activities that build on and develop the profile of the DKASC and the broader activities in Alice Springs. Additionally it would, as noted above, require the development, with support from ARENA, of a specific Solar Thermal testing and demonstration facility.

The likely high levels of penetration of distributed PV would provide a very useful opportunity to test and demonstrate the different possible approaches to minimise any negative grid impacts as well as capitalize on any positive impacts.

Community and stakeholder engagement

The moderate scenario relies on an active level of engagement with a variety of agencies and bodies including PWC and departments of the NT, although it is likely that some uptake of PV at the residential and commercial-scale will occur regardless.

Education and training

In order to achieve the moderate scenario, active engagement by PWC for staff training would be required, both for system operation and public and other stakeholder information. Additionally, a broader group of suppliers and installers would need to be developed to ensure that the long term needs of the market can be sustained.

Financial and market mechanisms

Depending on the level and structure of retail electricity tariffs, 'moderate' levels of uptake in the distributed generation market may occur in the absence of external funding. Storage and/or enhanced control systems may be needed to increase penetration levels and, in this case, consideration should be given to applications for funding from ARENA or the CEFC to assist with establishing the necessary BOS infrastructure. It is assumed that the level of penetration in the moderate scenario does not negatively affect PWC's ability to either pay off existing infrastructure or manage existing gas contracts.

Some level of external funding support would likely be necessary for central power stations, particularly if storage or enhanced control systems are needed to increase penetration levels. Any of the three loan types discussed above could be considered (loan guarantees, concessional loans, subordinated loans), as may CfDs and put options on LGCs.

The Stretch Scenario

The stretch target is taken to be the maximum that is practically technically possible with the technology mix that is likely to be available at any particular time – which here is taken to be a total of 70% electricity contribution from Solar sources by 2020. Achieving the stretch target is likely to require the same additional measures and outcomes listed above for the moderate scenario, with the modification such that a gradual transition is now an accelerated transition, introducing new solar options on a progressive basis to meet the 2020 target, with early retirement of existing assets as required.

Levels of deployment

We have assumed the Stretch scenario is achieved using around 22MWp of PV, a 20MW high capacity factor CSP plant with 40 hours of molten salt storage, together with the existing 35MW of gas-fired generation systems at Owen Springs and the retirement of all units in the Ron Goodin Power station.

Table 7 shows the assumed level of PV deployment within the Stretch scenario. The body of the report describes the underlying assumptions leading to the proposed deployment rates. The stretch objective results in a total PV peak contribution of approximately 90% of peak midday winter demand and around 20% of total annual consumption. Higher level integration of PV beyond this point is not considered as necessarily desirable or viable without the integration of localised storage.

In this case study, it is suggested that a 20MW CSP system with 40hours of storage could run essentially as baseload for all days of good sun. On such days, a further 20MWp of PV (either centralised or distributed) could be added to come close to meeting midday peak demand from the combined solar options. Gas engines to a combined capacity of around 20MW would still be required for filling in, and these would need to be used at a low capacity factor. On days of no sun in Summer, peak load presumably also drops, if a function of air-conditioning. The CSP system could be managed to carry over stored energy to continue generation at a lower level and the gas systems would need to carry the bulk of the load.

In Winter, the average output of the CSP plant would be about 30% less than in Summer. For the sake of this simplistic analysis, it could be considered to operate at a reduced level for most hours, but shut down at periods when the PV output was a maximum. The gas engines would again need to contribute at up to 20MW to meet demand. On non-solar days in Winter, CSP energy could be managed such that operation for at least some hours in the morning and evening peak was achieved. In this way the peak capacity needed from the gas engines could be kept to a level below 30 MW.

As discussed in the body of the report, there are two complicating issues that are especially relevant for the Stretch scenario. The first is that it is understood that PWC has a 'take or pay' contract for gas out to 2030, that includes an increased volume for each year between now and 2030. Thus installing solar may not necessarily realise the apparent fuel saving. The second is that according to the RET Rules, if installed capacity rises above 100MW in a particular grid, all purchases of electricity from that grid become liable under the renewable energy target. Alice Springs is close to that limit and so adding low capacity factor solar systems could increase the likelihood of passing it.

Test & demonstration facilities

At least one of each type of CSP system installed would need to monitored in detail and made available for testing and demonstration purposes, as in the moderate scenario. In this case it would probably make sense to co-locate with the main commercial CSP system at Owen Springs. It may well be possible to facilitate small test systems by accepting steam into the main power block.

As for the Moderate scenario, grid impacts due to high penetration PV provide an opportunity to test and demonstrate the different possible approaches to managing such impacts.

Community and stakeholder engagement

Within the stretch objectives, the high level of takeup of both PV and CSP would require significant levels of community and stakeholder engagement: advocating on behalf of residents and businesses with PWC for connections, as well as working with suppliers and installers to develop cost effective solutions for Alice Springs. This would necessarily be achieved through the continued active support of Alice Solar City – which would require the Northern Territory Government to provide ongoing funding support

Education and training

It will not be feasible to aim for a stretch target without significant commitment to the development and maintenance of a pool of locally based, trained technical support personnel. If a long-term target is set, there will be time to establish relevant programs from school through to TAFE and tertiary education, which will provide jobs for locals, and attract new residents to the area, including experienced trainers. Active consideration may then need to be given to different mechanisms that could be used to build local capacity, including employment sponsorships, small business grants etc. It can take a decade or more to establish a successful university research centre, and continued resourcing will be necessary in order to attract top academics and research students. Nevertheless, an active solar centre with resources to facilitate trade and professional training in solar energy and related technology would provide a compelling case for establishing courses through CDU for local and international students. The existing model of online delivery already adopted by CDU, combined with the campus facilities and accommodation available in Alice Springs would make short courses and professional development an achievable option even in the short term. Full degree courses will take longer to establish.

Table 5: PV Deployment in Alice Springs under a BAU Scenario

				2012		2013		2014		2015		2016		2017		2018		2019		2020		Total	
	GWh/A	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW
Installed under ASC program	1.70	283	566		0		0		0		0		0		0		0		0		0	283	566
Installed outside ASC program	1.65	177	428	50	100	50	100	75	150	75	150	100	200	100	200	100	200	100	200	200	400	1027	2,128
Total Residential		**460**	**994**	**50**	**100**	**50**	**100**	**75**	**150**	**75**	**150**	**100**	**200**	**100**	**200**	**100**	**200**	**100**	**200**	**200**	**400**	**1310**	**2,694**
Commercial Systems																							
Installed under ASC program	1.75	35	367		0		0		0		0		0		0		0		0		0	35	367
Installed outside ASC program	1.7	4	14	3	30	3	30	5	50	7	70	10	100	7	70	5	50	3	30	3	30	50	474
Total Commercial		**39**	**381**	**3**	**30**	**3**	**30**	**5**	**50**	**7**	**70**	**10**	**100**	**7**	**70**	**5**	**50**	**3**	**30**	**3**	**30**	**85**	**841**
Iconic/Showcase Systems																							0
Desert Knowledge Solar Centre	1.77	27	220		30																		250
Crowne Plaza Hotel	1.75	1	305																				305
Alice Springs Airport	2.2	1	235				250		250														735
Uterne	2.2		969																				969
Araluen	1.75				165																		165
Large (>100kW) Com Roof Top	1.7								200		150		150		100		100		100		100		900
Large (>100kW) Com Ground	1.75												1,000								1,000		2000
																							0
Total Iconic Showcase			**1,729**		**195**		**250**		**450**		**150**		**1,150**		**100**		**100**		**100**		**1,100**		**5,324**
TOTAL		**499**	**3,104**		**325**		**380**		**650**		**370**		**1,450**		**370**		**350**		**330**		**1,530**		**8,859**

Table 6: Levels of PV deployment under the Moderate Scenario

				2012		2013		2014		2015		2016		2017		2018		2019		2020		Total	
	GWh/A	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW
Installed under ASC program	1.7	283	566		0		0		0		0		0		0		0		0		0	283	566
Installed outside ASC program	1.65	177	428	50	100	75	150	100	200	150	300	150	300	200	400	200	400	300	600	300	600	1702	3,478
Total Residential		**460**	**994**	**50**	**100**	**75**	**150**	**100**	**200**	**150**	**300**	**150**	**300**	**200**	**400**	**200**	**400**	**300**	**600**	**300**	**600**	**1985**	**4,044**
Commercial Systems																							
Installed under ASC program	1.75	35	367		0		0		0		0		0		0		0		0		0	35	367
Installed outside ASC program	1.7	4	14	3	30	3	30	5	50	7	70	10	100	10	100	10	100	10	100	7	70	69	664
Total Commercial		**39**	**381**	**3**	**30**	**3**	**30**	**5**	**50**	**7**	**70**	**10**	**100**	**10**	**100**	**10**	**100**	**10**	**100**	**7**	**70**	**104**	**1,031**
Iconic/Showcase Systems																							0
Desert Knowledge Solar Centre	1.77	27	220		30																		250
Crowne Plaza Hotel	1.75	1	305																				305
Alice Springs Airport	2.2	1	235				250		250														735
Uterne	2.2		969																				969
Araluen	1.75				165																		165
Large (>100kW) Com Roof Top	1.7								200		150		150		100		300		200		150		1,250
Large (>100kW) Com Ground	1.75												500		1,500		500		500		1,000		4000
																							0
Total Iconic Showcase			**1,729**		**195**		**250**		**450**		**150**		**650**		**1,600**		**800**		**700**		**1,150**		**7,674**
TOTAL		**499**	**3,104**		**325**		**430**		**700**		**520**		**1,050**		**2,100**		**1,300**		**1,400**		**1,820**		**12,749**

Table 7: PV Deployment under the Stretch Scenario

				2012		2013		2014		2015		2016		2017		2018		2019		2020		Total	
	GWh/A	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW
Installed under ASC program	1.7	283	566		0		0		0		0		0		0		0		0		0	283	566
Installed outside ASC program	1.65	177	428	50	100	##	200	##	300	##	300	200	400	200	400	200	400	300	600	300	600	1827	3,728
Total Residential		**460**	**994**	**50**	**100**	**##**	**200**	**##**	**300**	**##**	**300**	**200**	**400**	**200**	**400**	**200**	**400**	**300**	**600**	**300**	**600**	**2110**	**4,294**
Commercial Systems																							
Installed under ASC program	1.75	35	367		0		0		0		0		0		0		0		0		0	35	367
Installed outside ASC program	1.7	4	14	3	30	3	30	5	50	7	70	10	100	10	100	15	150	15	150	10	100	82	794
Total Commercial		**39**	**381**	**3**	**30**	**3**	**30**	**5**	**50**	**7**	**70**	**10**	**100**	**10**	**100**	**15**	**150**	**15**	**150**	**10**	**100**	**117**	**1,161**
Iconic/Showcase Systems																							0
Desert Knowledge Solar Centre	1.77	27	220		30																		250
Crowne Plaza Hotel	1.75	1	305																				305
Alice Springs Airport	2.2	1	235				250		250														735
Uterne	2.2		969																				969
Araluen	1.75				165																		165
Large (>100kW) Com Roof Top	1.7								200		150		150		100		300		300		500		1,700
Large (>100kW) Com Ground	1.75												1,000		1,500		2,500		2,500		5,000		12500
																							0
Total Iconic Showcase			**1,729**		**195**		**250**		**450**		**150**		**1,150**		**1,600**		**2,800**		**2,800**		**5,500**		**16,624**
TOTAL		**499**	**3,104**		**325**		**480**		**800**		**520**		**1,650**		**2,100**		**3,350**		**3,550**		**6,200**		**22,079**

Financial and market mechanisms

The existing and forecast pricing of PV systems both at the residential level and the medium and large commercial level is such that it is not anticipated that direct financial subsidies would be required to stimulate this higher level of PV uptake. As for the moderate scenario, the establishment of a Distributed Energy market is likely to be necessary. The deployment of large-scale PV participating in the wholesale market is assumed to be financed through long term PPA's with PWC, but would need additional financial assistance. A low interest loan from the CEFC or a subsidy (of around 25%) from ARENA could be sufficient to make large-scale PV financially viable.

If the installation of the CSP system was delayed until 2018, it is possible that a PPA that reflected costs of new gas driven generation at that time, plus attractive debt finance, would allow such a plant to be built. However there is merit in attempting to act sooner. With the CSP project in round 1 of Solar Flagships in doubt and round 2 now rolled into ARENA, a good case could be made for making Alice Springs the site for an alternative flagship project. A 30% capital grant, together with favourable finance through the CEFC and with a PPA from PWC that recognised the full avoided costs of new gas generation and the value of LGC's, should come close to making such a project viable.

In addition, two critical financial market interventions would be required:

- There is little to no incentive for individual building managers or government tenants to engage in energy saving activities or to invest in assets such as PV, as the capital costs are borne from their local budget, but the savings are yielded back to the parent department or agency. At the very least, savings should accrue to whoever pays for them.
- Finance may need to be provided to allow for the absorption of costs associated with acquitting the contractual obligations of the "take or pay" gas contract.

Electricity supply in Remote communities

As many of the pastoral stations, remote communities and mines draw on the same pool of technical suppliers and contractors, for all the criteria other than "Level of deployment" the end-use categories have been combined for discussion.

Business as usual

Levels of deployment

For outstations, IES communities, pastoral stations, ranger stations and mine sites, it is assumed that significantly higher levels of PV is constrained within the BAU scenario.

Test and demonstration facilities

There are currently no formal test or demonstration facilities in remote communities, although many systems, such as those installed by Bushlight, are monitored. This situation is likely to remain under a BAU scenario.

Community and stakeholder engagement

Under a business as usual scenario, the existing programs for engaging with local communities would be maintained and, other than through Bushlight, there would be no specific community engagement activities targeted at energy management or reduction.

Education and training

The business as usual model would require the ongoing support of the local education supply base. Trade training in system operation and maintenance, as well as initial installation would provide new jobs and opportunities in remote area. Such training would also be of interest to the wider Australian and Asia-Pacific communities.

Financial and market mechanisms

The BAU scenario assumes that the existing marginal costs of generation in most areas are sufficient to support the broad-scale deployment of low penetration renewables.

The Moderate Scenario

Levels of Deployment

The moderate scenario would involve a more rapid uptake of PV within the IES communities, resulting in a total of approximately 5MW installed through to 2020, and no additional uptake in remote outstations or pastoral stations. The moderate scenario includes a 1MW PV power plant for the Tanami mine.

Test and demonstration facilities

Under this scenario, test and demonstration would most likely be limited to expansion of the approach taken through existing facilities.

Community and stakeholder engagement

A moderate scenario would require the deployment of reasonably proactive community engagement strategies to work with residents within remote Aboriginal communities regarding energy consumption patterns and incentives to drive behaviour changes. The replacement of existing prepayment metering systems may provide the opportunity for in-house metering and active demand management to be trialed.

Education and training

Programs like Bushlight have developed valuable processes and experience in delivery of sustainable energy systems to remote communities, but this approach has required significant external funding. Maintaining this level of support will almost certainly be necessary if high levels of solar uptake are to be achieved. Training of local maintenance staff will certainly be required, as will supply channels for spare parts. Both of these will likely have different requirements from those established for Alice Springs.

Financial and market mechanisms

The moderate scenario does not require any additional direct financial support for system installation, but would require funding for expansion of the necessary test and demonstration facilities, community and stakeholder engagement and education and training. Removal of existing cross-subsidies would be required in order to provide greater and more transparent arguments for generating cost reductions.

The Stretch Scenario

Levels of Deployment

A stretch scenario for the off-grid market would see 20% of the IES communities with high penetration PV, with battery storage operating as full hybrid systems, resulting in deployment of a combined 8MW of PV. No additional uptake in outstations or pastoral stations is assumed, nor is there an increase in the penetration of renewables in the ranger stations. The primary opportunities that exist for a significant CSP project are at either the Tanami Mine or at the Yulara resort adjacent to Uluru.

Test and demonstration facilities

Under this scenario, test and demonstration would be highly desirable and could be expanded to not only technical monitoring (including the development of a storage technology test and evaluation centre) but also the social aspects of such high penetration in remote communities. It is likely however that the most effective location for much of this test and demonstration role would be at the Alice Springs sites.

Community and stakeholder engagement

For the stretch objective, extremely active, targeted community engagement would need to be undertaken to work with remote communities, to challenge existing patterns of energy consumption and presumptions regarding equality of service expectations within remote communities versus that available in regulated markets. This may include changes to the structures of existing CSO support processes that are 'invisible' to the consumer. A suggested change is provided in the body of the report.

Education and training

Under a stretch scenario, the same level of activity in education and training as the moderate scenario would be expected. However, the interest generated by having a world-leading solar centre would provide added opportunities to target education and training in off-grid solar applications to the wider Australian and international communities. The online course delivery already established in CDU provides an excellent base on which to develop this education market.

Financial and market mechanisms

As noted previously, the existing pricing of diesel is sufficient to support much of the proposed stretch activities in all markets other than mining. Again, additional funding would be required for expansion of the necessary test and demonstration facilities, community and stakeholder engagement and education and training. An important issue for the mining sector is the typical financial planning need for an asset life that is equal to, or less than, their advertised mine life. As for the primary Alice Springs market, any of the three loan types discussed above could be considered (loan guarantees, concessional loans, subordinated loans), as could CfDs and put options on LGCs. Direct capital subsidies may be available through the CEFC or ARENA. Proactive intervention from the NT government may be needed regarding the treatment of diesel fuel subsidies, the depreciation period for solar equipment, tax pass-through arrangements and other such support mechanisms in order to accelerate solar uptake in this sector.

Discussion and Recommendations

The NT has high energy generation costs and a substantial Community Service Obligation (CSO) budget commitment, thus providing significant incentive to reduce energy consumption and deploy alternative generation sources. Nevertheless, there are many consequences of increased uptake of solar. The most significant will be the impact on the existing electricity generation and transmission/distribution assets, and how those assets are paid for. Uncontrolled expansion of solar without storage can reduce power quality, and can increase the cycling rate and spinning reserve requirements of conventional generators as well as the strain placed on the network due to, for example, reverse power flow and power fluctuations. Significant reductions in the amount of electricity bought from the network because of DG can also negatively affect the financial viability of generators and network operators, depending on their regulatory environment. The need to pay for stranded assets may be passed onto end users, and if this occurs through higher electricity usage prices, it will act as a driver for increased uptake of DG, further exacerbating the problem.

Conversely, through appropriately configured grid-interactive inverters, solar PV can improve power quality, and concentrating solar thermal with storage, as well as distributed storage options, can provide dispatchable power. Integrating these various generation options with demand side management and energy efficiency can improve the operation of the entire energy network – although such approaches result in higher complexity and associated management requirements. How well these various issues are managed will in turn have a significant impact on the final level of uptake.

The higher levels of solar penetration discussed in this report provide an enhanced opportunity for the Desert Knowledge Australia (DKA) Solar Centre to extend its current role to monitor and analyse grid impacts, and to undertake underlying solar research which will consolidate its status as a world leading solar research centre. The lessons learned from implementing a range of solar strategies in the Central Australian Solar Centre will be internationally valuable. Having such a facility in Central Australia will encourage local and international researchers to undertake further research in Alice Springs and the surrounding areas, with implications for educational and tourist potential.

There is a strong case for a major expansion of the role played by the DKA centre to encompass larger demonstration systems and CSP activities. Alice Springs is blessed with excellent solar resources, it has good supporting infrastructure and it can be visited easily via an airport conveniently located near likely sites and serviced by regular flights from all capital cities. It is the best location for such a Centre in Australia. It could also offer a very attractive opportunity for international collaboration with researchers and companies from the Asia-Pacific region. Associated education and training opportunities would also be viewed with keen interest in the region, providing another valuable employment income and stream.

The following recommendations are therefore proposed:

- The 'moderate' scenario be adopted as the starting point for Central Australia and Alice Springs as it represents a no regrets overall least-cost approach that best capitalises on the infrastructure and capacity developed as a result of the Alice Springs Solar City, Desert Knowledge Australia Solar Centre, Bushlight and other recent programs. Without a pro-active program in place to maintain and enhance them, these established facilities, the expertise associated with them and the profile created, will be dissipated.
- Some version of the 'stretch' scenario is highly plausible and consistent with a goal of a world leading position. It should be analysed in more detail to select at least some components which can be pursued via ARENA, the CEFC, education or other budgets in the short term.
- Existing plans to extend the Owen Springs power station and retire the Ron Goodin Power station, together with forward planning around gas contracts and network augmentation, should be reviewed in detail to seek savings and least-cost solutions that could accompany a move to high solar contributions.
- The policy frameworks underlying energy supply and demand should be examined to ensure that decisions taken by government agencies are consistent with achieving the 'moderate' scenario goals. As cost gaps reduce, regulatory aspects of energy sector operation, including reliability criteria and supply side preferences, will become more significant barriers and regulations may need to be revised.
- Government-owned buildings currently benefit from a bulk purchase contract with PWC for low-cost electricity. In addition, the occupiers of these buildings don't pay for their electricity use. As such, the financial incentive for uptake of energy efficiency and solar is significantly reduced, and the low-cost electricity provides no net benefit to the NT government as a whole. Consideration should be given to providing appropriate signals and mechanisms to encourage uptake of EE and solar, with those responsible for taking action benefiting from the savings.
- Government procurement procedures should be examined so that planning is consistent with the agreed targets and so that decisions are made in light of the actual costs incurred for energy supply, not the cross-subsidised cost.
- Long-term commitments should be made to educational outcomes at all levels, since the availability of local personnel with training and expertise in solar will be an essential component of maintaining and expanding on current levels of solar use and ensuring quality installations and O&M availability. It will also facilitate the establishment of more local solar businesses as well as expanded research and development capabilities.
- The Alice Springs Solar City should continue to be supported so that it can maintain and extend its activities, especially with regard to information dissemination and advice. As penetration levels of solar extend from early adopters through to mainstream consumers, the marketing needed will increase.
- Resources should be provided to the Solar City to enable it to be pro-active in promotion of the Solar Centre for educational purposes, energy events and relevant sectors of the tourist market.

- A detailed feasibility study into establishing an expanded solar test centre should be carried out that includes preferred site selection, cost analysis and negotiation with federal government and possible international stakeholders should be considered.

TABLE OF CONTENTS

1 Introduction

The Northern Territory Climate Change Policy was released in December 2009. The policy contains 40 targets and 118 associated actions and incorporates commitments from all NT Government agencies. The Climate Change Policy is effectively an action plan that will ensure the Territory plays its part in national and international efforts to control climate change.

Target 13 of the NT Climate Change Policy is a commitment to: *By 2020, develop Alice Springs and Central Australia as a world-leading solar energy centre*. A previous issues paper on Target 13[3] suggests that in order to realise this goal a 10 year Action Plan needs to be developed and implemented. It has been proposed such an Action Plan build on the considerable achievements and continue on the work of the Alice Solar City Consortium, the Bushlight program, and Power and Water Corporation through the provision of essential services to Alice Springs and to remote communities. In the context of the current activity and achievements to date, Target 13 should be more focussed on co-ordinating and guiding activities rather than sponsoring development. This will require innovative thinking and action to creating investment environments that will allow for a truly sustainable business model.

The progression of Target 13 is an opportunity to achieve a number of objectives, not only as a commitment under the NT Climate Change Policy but also to:

- Identify and trial innovative financing options in order to leverage private and public investment, as a move away from a government grant model to more sustainable business models.
- Contribute toward the NT's achievement of the Australian Government's 20% renewable electricity target.
- Implement the recommendations from the NT Green Energy Taskforce reports.
- Develop innovation, knowledge and business opportunities beyond the focus of hardware and project development.
- Align with and build on existing research and innovation projects, such as the Desert Knowledge Australia Solar Centre and other existing research projects in central Australia.
- Position Alice Springs and Central Australia favourably for Australian Government funding under the Clean Energy Future package.

This Briefing Report identifies issues and opportunities associated with Target 13, so as to inform the NT Department of Natural Resources, Environment, The Arts and Sport, in preparation for public consultation. It builds on the work previously undertaken by the Alice Springs Solar City and through the Green Energy Taskforce reports 'Roadmap to Renewable and Low Emission Energy in Remote Communities' and '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, Sola, Biomass and Tidal'.

The previous Green Energy Taskforce papers have surveyed renewable energy sources in the NT and come to the valid conclusion that Solar is essentially the only medium term sensible option for the NT. There are no high quality wind resources or significant opportunities for biomass that have been identified. Geothermal is flagged as a significant longer term prospect. In Alice Springs it appears very much the case that the renewable energy opportunity for the near future is solar and indeed

[3], Alice Springs Solar Cities, Desert Knowledge Australia, Power and Water Corporation, Energy & Climate Change Unit, Department of NRETAS, 2012, *Target 13 – By 2020, develop Alice Springs and Central Australia as a world-leading solar energy centre*, Version 2: 21 FEB 2012

Task 13 is specifically about solar. This report focuses on solar electricity, although solar heating for water and other end uses, such as cooling, will also play an important role in increasing solar penetration levels. Similarly, energy efficiency and demand management, along with energy storage and smart control systems, will be crucial.

Section 3 of this report firstly defines a World-leading Solar Centre and provides examples of solar centres, both in Australian and internationally. It then discusses in some detail the five desirable characteristics of a World-leading Solar Centre, which are divided into: levels of deployment; test and demonstration facilities; community and stakeholder engagement; education and training; and financial and market mechanisms.

Section 4 describes the Central Australian region, focussing on the current energy supply and existing solar installations – both grid-connected and off-grid.

Section 5 describes the various technology options that could be deployed in a Solar Centre, ranging from batteries and smart meters to large-scale PV and solar thermal as well as integrated solar combined cycle and solar gas.

Section 6 defines three possible scenarios for solar deployment: 'BAU', 'Moderate' and 'Stretch'. It describes in detail how each of the scenarios would develop in terms of the five characteristics required for a World-leading Solar Centre.

Section 7 then concludes with a discussion and recommendations.

The Appendices provide detailed information on international solar centres, solar performance and consultations undertaken.

2 Scope of Work

The Scope of work for this report was to:

1. Inform "Target 13 NT Climate Change Policy: 10 year Action Plan for ASP (Central Australia) to be a world Solar City (T13)".
2. Undertake a Reference search.
3. Draft a definition of a world leading solar city and identify critical participants.
4. Define the dimensions of the task and identify key – technical, financial, etc - barriers and issues
5. In discussion with the consultancy proponent identify two scenarios two (renewable energy rollout / contribution scenarios) for consideration, for example:
   - Conservative Target - achieving 20% renewable energy by 2020
   - Stretch Target - 100% renewable energy by 2020.
6. Identify potential policy overlays and potential cost implications. Identify and prioritise short, medium and long-term risks and opportunities and their impact on T13 scenarios and compared to BAU baseline.
7. Undertake a desktop study around cost sensitivity around the BAU baseline case and two action plan scenario cases, taking into account current and emerging energy efficiency and renewable energy technologies etc.
8. Develop draft action plan recommendations for public and government consultation, identifying assumptions and threshold issues for resolution.
9. Submit draft report for comment prior to final acceptance.

This report has been developed in consultation with a number of key stakeholders. Details of the consultation process are included in Appendix 7.

3 Definition of a World-leading Solar Centre

There are many types of Solar Centre around the world. The definition chosen for a Central Australian Solar Centre will determine what is to be achieved, how it will be achieved, and the stakeholders that will be involved in achieving it.

The project team has developed a working definition of a World-leading Solar Centre by drawing on national and international experience, summarised below, and in consultation with key stakeholders. A key difference to both international and other Australian solar city / centre concepts is the geographically dispersed nature of Central Australia, incorporating not only Alice Springs Solar City but also the remote communities in the surrounding region in the Southern part of the Northern Territory.

The proposed definition addresses 5 criteria. By 2020, it is suggested that a world-leading Solar Centre may perform better in some of these areas, but should not perform poorly in any of them.

Definition of a world leading solar centre

A Solar Centre should provide an appropriate supportive environment for the private sector and government agencies to promote and install solar energy according to the relevant scenarios, and also act as a live research centre for assessing and demonstrating new technologies and systems. It should also actively explore issues related to the integration of different solar technology options at high penetration. Thus, a world-leading Solar Centre would ideally have the following:

6. Levels of deployment of all relevant Solar Energy technologies at close to the highest levels of penetration world wide.
7. One or more highly visible Solar Energy Technology test and demonstration facilities, especially relevant to remote locations and desert climates, which are respected by researchers and commercial operators globally.
8. A continuation of the high level of support and engagement with the local community and key stakeholders, including indigenous communities, relevant energy retail and generation companies and local government.
9. Significant supporting activities in solar energy education and training at tertiary, secondary, trades and community levels.
10. World's best practice financial and market mechanisms to facilitate ongoing deployment of solar technologies and ensure that supporting action on best practice outcomes in Energy Efficiency and demand side management deliver a high level of solar contribution in an overall least cost manner.

Through the Solar Cities initiative, the associated deployment of solar systems and the presence of the Desert Knowledge Australia demonstration precinct, Alice Springs can already legitimately claim a significant role as a Solar Energy Centre. The real significance of Target 13 is the aspiration to be world leading by 2020. This does not simply involve a timeline to achieve a certain concrete target, but an aspiration to progress in relevant areas, faster than other worldwide rates of development and so emerge in a leading position by that time.

In the remainder of this Chapter, Section 3.1 firstly reviews some of the relevant International and Australian examples and activities of Solar Cities and Centres. Section 3.2 then briefly discusses each of the five major characteristics of a Solar Centre which we consider should be included in the above definition.

3.1 Examples of Solar Centres

3.1.1 Australian Solar Cities Program

The Australian Government's Solar Cities Program is administered by the Department of Climate Change and Energy Efficiency. It is designed to trial and demonstrate new sustainable models for electricity supply and use[4].

Australia's Solar Cities are Adelaide, Alice Springs, Blacktown, Central Victoria, Moreland, Perth and Townsville, as shown in Figure 1. The publication "Solar Cities: catalyst for change"[5] provides details of the consortia and activities in each of the cities. Activities are summarised in Table 8.

Figure 1: Australian Solar Cities

A mid-term review of the program (Wyld Group, 2011)[6], concludes that it is on track and successfully meeting its goals. It highlights the opportunity presented by collection of data at a higher level than has previously been available in Australia and recommends a higher level of information dissemination so that the wider Australian community can benefit.

Overall, the solar cities program in Australia is about showcasing and trialling good approaches. In all cases they only involve a small subset of the actual city population, although the activities seem well publicised and recognised in the wider community.

They offer a model that could be followed, if the whole city were to adopt the practices of the active participants in the program. It should be noted that at present they all only appear to address the stationary energy sector.

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[4] See: http://www.climatechange.gov.au/government/initiatives/solar-cities.aspx.

[5] http://www.climatechange.gov.au/~/media/government/programs-rebates/solar-cities/SolarCities-CatalystForChange-20111021-PDF.pdf

[6] http://www.climatechange.gov.au/government/initiatives/solar-cities/publications-resources/~/media/publications/solar-cities/mid-term-review-solar-cities-pdf.pdf

Table 8: Activities covered in each of the Australian Solar Cities

TABLE 2: SOLAR CITY ACTIVITIES							
Activity	Adelaide	Alice Springs	Blacktown	Central Victoria	Moreland	Perth	Townsville
Smart meters	✓	✓	✓	✓		✓	✓
Residential PV	✓	✓	✓	✓		✓	✓
Business PV	✓	✓	✓				✓
Iconic PV	✓	✓	✓	✓		✓	✓
Residential energy efficiency	✓	✓	✓	✓	✓	✓	✓
Business energy efficiency	✓	✓	✓	✓	✓		✓
Cost-reflective pricing	✓	✓	✓	✓		✓	✓
Urban development	✓				✓		✓
Community engagement	✓	✓	✓	✓	✓	✓	✓
Finance packages	✓		✓	✓			
Smart grid						✓	
Monitoring and reporting	✓	✓	✓	✓	✓	✓	✓
Co-generation					✓		
Solar hot water	✓	✓	✓	✓		✓	✓
Energy display shopfront		✓			✓		✓

3.1.2 USA solar cities program

The USA previously showcased a solar cities program. The 25 cities selected were:

Ann Arbor, MI, Austin, TX’ Berkeley, CA, Boston, MA, Denver, CO, Houston, TX, Knoxville, TN, Madison, WI, Milwaukee, WI, Minneapolis – St. Paul, MN, New Orleans, LA, New York City, NY, Orlando, FL, Philadelphia, PA, Pittsburgh, PA, Portland, OR, Sacramento, CA Salt Lake City, UT, San Antonio, TX, San Diego, CA, San Francisco, CA, San Jose, CA, Santa Rosa, CA, Seattle, WA, Tucson, AZ.

The program is described as follows and the resources developed by these 25 cities are available through the SunShot Resource Center[7]:

> *“In 2007 and 2008, the U.S. Department of Energy (DOE) selected 25 major U.S. cities as Solar America Cities, the foundation of DOE's Solar America Communities program. Through this effort, these cities have been working to accelerate the adoption of solar energy technologies for a cleaner, more secure energy future. These unique federal-local partnerships have enabled DOE to identify barriers to solar energy use in diverse locations and at various stages of market development, and to collaboratively develop solutions to those barriers.”*[8]

[7] http://www4.eere.energy.gov/solar/sunshot/resource_center/

[8] http://solaramericacommunities.energy.gov/

3.1.3 The International Solar Cities Congress

The International Solar Cities Initiative[9] was established in 2003, prior to much of the recent growth in solar deployments. The International Solar Energy Society was a player in its formation.

It largely functions as a coordinator of a series of International Solar Cities Congresses. The cities that have hosted these have, in the course of doing so, highlighted their own achievements and aspirations to leadership as Solar Centres. So far the host cities have been: Daugu, South Korea in 2004, Oxforn, UK in 2006, Adelaide in 2008, Dexhou, China in 2010 and Buenos-Aires is to host in 2012 or 2013.

3.1.4 International Council for Local Environmental Initiatives

The 'International Council for Local Environmental Initiatives' (ICLEI) was founded in 1990[10]. It claims 1200 towns, counties and association members world wide. Its activities are broad ranging and there is a focus on event organisation, advice and consulting. In Australia, many pro-active local governments joined ICLEI when it was supported by the Australian Government and implemented a range of energy efficiency, renewable energy and greenhouse gas reduction programs. The expertise developed in the participating Councils has seen them continue to lead local actions in renewable energy and greenhouse gas reduction.

3.1.5 Freiburg Eco-city

Even with the high level of solar activity across Germany, Freiberg leads the way as a world-leading solar centre on a number of fronts, including hosting a range of national and international solar organisations, world leading research centres, high levels of solar uptake, solar industries, complete net energy positive solar villages and other innovations[11].

Solar energy is considered in a holistic way, and started in 1992 with the local council adopting low energy and passive solar building requirements.

3.1.6 Dezhou China

According to Wikipedia[12]

“A new industrial zone hailed as the "Solar Valley" is being built for experimenting with clean- energy urban projects and massive use of household utilities such as solar-powered water-heaters.

One of the biggest industries in Dezhou is the solar energy industry, with two main corporations included—Himin Group and its partner Ecco Solar Group. The Himin Group is the world's largest solar water heater manufacturer. Dezhou also houses the world's largest solar-powered office building, covering around 75,000 square meters.

Dezhou increased its international reputation when it was selected to host of the 2010 International Solar City Congress.

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[9] http://www.isci-cities.org/

[10] http://www.iclei.org

[11] http://www.solarregion.freiburg.de/solarregion/freiburg_solar_city.php

[12] http://en.wikipedia.org/wiki/Dezhou

3.2 Major Characteristics of a World-Leading Solar Centre

3.2.1 Solar Deployment

Levels of deployment of all relevant Solar Energy technologies at close to the highest levels of penetration world-wide.

In seeking to identify the attributes of "world leading" that Alice Springs should aspire to, the locations that have so far achieved the highest levels of solar energy uptake / penetration should be considered. Some international examples were provided in Section 3.1. Germany certainly leads the way overall, although some Pacific Islands are converting their entire power systems to renewable energy[13], while countries like Spain and Japan have high solar penetrations in some areas. In considering the penetration fractions of solar or renewables in general, it is important to consider both the fraction of peak demand and fraction of actual energy production encountered. In this regard, items which have recently made the news with some records include:

- In Germany, it has been reported that solar generation peaked at 22.4GW or 30% of demand on Friday 25 May 2012 and that it accounted for 14% of actual electricity production for the day[14].
- In Australia it has recently been reported that South Australia has the highest penetration of both wind and PV generation in terms of market share of all the states[15]. In the March quarter of 2012, 31% of SA's electricity came from wind and 3.5% from PV.
- California's has a mandated 33% by 2020 Renewable Portfolio Obligation of which both domestic scale and utility scale solar is expected to be a significant contributor. As a mandatory target for a contribution to energy generated this is likely to lead to very high peak contributions at times and is resulting in a great deal of attention to the network management implications that will result.

Depending on the nature of the grid, the loads connected to that grid and the types of renewable energy technologies, high penetrations of renewables may require increasing levels of generation and load control, as well as power quality control. While the Moderate scenario described here is unlikely to require such controls, the Stretch scenario certainly would.

Although solar electricity is the focus of this report, Solar Water Heating is a key area for consideration; increased uptake is an obvious part of both scenarios and may displace electricity or gas use. Other innovative solar-driven processes can also be explored, with an obvious one being solar thermal driven cooling applications. This is a well established demonstrated process, but at this stage is not commercially mature.

Transport is the hardest sector to power using solar energy. There is no obvious biofuel option on the horizon in the Alice Springs region. Wider use of electric vehicles can be anticipated in parallel with global / national adoption, however it would seem that this is likely to be limited to vehicles operating in the urban area of Alice Springs. In this regard, an electrified public transport system, such as electric mini-buses, could be considered. The role of the city as a transport / distribution hub for the whole of the southern part of the northern territory, with large distances and remote areas, suggests that vehicle electrification is likely to be harder than in a major capital city. Over the period

[13] http://www.tokelau.org.nz/Tokelau+Government/Government+Departments/Power/Energy.html

[14] http://reneweconomy.com.au/2012/in-depth-the-real-story-behind-germanys-22gw-solar-record-32665

[15] http://reneweconomy.com.au/2012/mixed-greens-wind-and-solar-provide-13-of-power-in-sa-69923

to 2020, innovative options such as application of CSIRO's solar enhancement of natural gas for transport fuel could be considered.

A clear assumption behind the investigation of the Target 13 goal is that, along with higher levels of solar energy use, best practice approaches to energy efficiency are obviously desirable. This should be seen in the areas of:

- Domestic buildings
- Commercial buildings
- Cooling and refrigeration systems
- Street lighting
- Relevant industrial / commercial processes
- Efficiency of Non-renewable power generation

Demand management will also be critical, to make best use of the solar resources, minimise fossil-fuel use and storage requirements.

3.2.2 Research and demonstration centres

One or more highly visible Solar Energy Technology test and demonstration facilities, especially relevant to remote locations and desert climates, which are respected by researchers and commercial operators globally.

There is an increasing number of centres of excellence in research in solar-related fields around the world. Alice Springs is already home to the Desert Knowledge Australia Solar Centre (http://www.dkasolarcentre.com.au/) which showcases and tests a range of PV technologies and systems, as well as the Centre for Appropriate Technology (CAT), which has a longstanding reputation for applied energy research for indigenous communities, including the Bushlight program. Existing research facilities could be enhanced, especially to support remote area solar solutions. Demonstration activities, and activities in support of research, such as testing and experimental platforms, are also a logical possibility given the nature of the city and its high solar resource levels.

In terms of centres for demonstration, CSP activities are physically bigger and make more of an impression on the surrounding region than PV and would be a logical extension of current facilities.

World-leading research and demonstration facilities open up funding opportunities, not only from the energy field, such as the new federal Australian Renewable Energy Agency (ARENA), but also from non-energy sources, such as the Australian Research Council (ARC) and industries. There are associated prospects for international collaborations, conferences and 'solar tourism'.

Appendix 1: International Research and Demonstration Centres provides details on a number of existing examples. They range from a strong R&D focus to incubator / demonstration centres for early stage commercial activities. To highlight one pertinent example; work is underway to establish the Solar Technology Acceleration Centre, (SolarTAC) in Colorado. This new centre occupies a 74 acre (30 ha) site near Denver International Airport. It is a public-private partnership that aims to be an integrated, world-class test facility where the solar industry can research, test, validate, and demonstrate solar technologies. Both CSP and PV technologies are included in its scope, with some major established solar companies identified as foundation partners. Smaller companies in the startup phase are also installing test systems.

The website (www.solartac.org), has a site animation that gives an excellent example of what expanding a concept like DKASC in Alice Springs, could look like.

3.2.3 Community Engagement

> A high level of support and engagement with the local community and key stakeholders including indigenous communities, relevant energy retail and generation companies and local government, with the aim of changing the culture of mainstream businesses

Community engagement has been a key component of the success achieved in the Alice Springs Solar City. This has been achieved at a number of levels, all of which will remain critical as higher levels of penetration are sought, not least because changes to attitudes, behaviour and procedures will be needed:

- Establishment of the Consortium (Unique amongst the various solar cities, in that the seven member consortium was led by a local government entity, the Alice Springs Town Council, with the balance of the executive consisting of Power Water Corporation and the NT Government. Non-executive members of the consortium included the NT Chamber of Commerce, Tangentyere Housing, Arid Lands Environment Centre and the Desert Knowledge CRC)), which prepared the bid and subsequently ensured its programs were implemented. Maintaining these linkages and communication channels will be an important aspect of deployment at higher levels.
- The Alice Solar City Smart Living Centre, which provided a walk-in advisory service, plus brochures and demonstrations. Continued access to unbiased information, as well as dedicated space for industry and service providers to display their promotional material, will continue to be an important component of successful community engagement. This can be leveraged to provide space for information sessions and training, as discussed below.
- The iconic site demonstration systems, which allowed the solar sector to work with local businesses to achieve top quality projects. These projects, in turn provided valuable and visible technology demonstration to the wider community.

3.2.4 Education and Training

> Significant supporting activities in solar energy education and training at tertiary, secondary, trades and community levels.

Education and training will ensure the long term success of ambitious solar targets. Without this, deployment is likely to be undertaken by fly-in fly-out workers, while maintenance levels and the ambition to continue to develop the solar sector will be limited.

Solar education should start at school level, and continue through to tertiary levels. It takes time, facilities, continuous commitment and on-going funding to develop and maintain education levels, and especially to attract and keep high quality teachers and trainers.

This aspect also taps into wider funding sources at all levels of education.

A successful world leading solar centre would also be the focus for educational activities at a national and even international level, via short courses and distance education. It could also provide a location for field work and research activity for undergraduate and postgraduate students from other locations.

Charles Darwin University is well placed to capitalise on the opportunities which would be provided by a world-leading solar centre. It has excellent facilities in Alice Springs, which are currently underutilised, and could work with other stakeholders, and also with other institutions across the country which already offer renewable energy qualifications, to provide trade and tertiary education, as well as associated research, in a relatively short time. This would require the appointment of new teaching staff, since the Centre for Renewable Energy and Low Emissions Technology is limited to research only at present.

Any education and training offered would likely attract keen interest from the Asia-Pacific region, since diesel replacement and renewable energy generally is a high priority and few centres currently offer specific courses or have access to associated facilities.

3.2.5 Financial and Market Mechanisms

> World's best practice financial and market mechanisms to facilitate ongoing deployment of solar technologies and ensure that supporting action on best practice outcomes in Energy Efficiency and demand side management deliver a high level of solar contribution in an overall least cost manner."

In order to attract and encourage investment, long-term Government commitments and frameworks will need to be in place. Neither industry nor financial services are likely to be established specifically to serve the solar sector in Alice Springs or the surrounding region if there is no certainty of a long-term market. As discussed below, there is a range of financial mechanisms that could be used to enable both PV and solar thermal, with some being more suited to large-scale systems and some more suited to distributed generation.[16] Some require a source of funding and some don't. Where funding is required, as well as being sourced from ARENA and the CEFC, consideration could be given to re-allocating savings made in diesel and gas.

In areas where the marginal costs of supply would otherwise be considered to be high enough to support the uptake of renewable energy, such as mine sites or large commercial buildings, other constraints exist, including access to capital and overall project risk, that have limited the uptake of renewable energy. Government involvement through some of the following could help address both these issues. The options for support via ARENA and CEFC will be clearer by end 2012, when both have released details of their structure and operation.

Large-scale projects only:

- Loan guarantees are where a government guarantees that a loan will be repaid, and so reduces the risk associated with that loan and so reduces the cost of debt. For example, a reduction from 8.4% to 5.5% reduces the LCOE of a large-scale PV system by about 10%. If a loan guarantee (or portfolio of such guarantees) is managed well, it has the potential to generate a risk premium and fees for the guarantor without any outlay. The skill is in properly assessing and managing the borrower's credit risk – and all other risks involved in the transaction - to minimise the likelihood of non-payment. Given the recent publicity about failed companies with loan guarantees from the US Government, governments in Australia may be reluctant to go down that path. Nevertheless, depending on the operational guidelines under which the CEFC is to administered, loan guarantees could remain an attractive option, particularly since the Fund's money does not have to be committed up-front and can continue to be invested in other projects until such time as a default occurs.
- Concessional loans are where government provides lower interest rate loans over longer periods more in line with the project lifetime. These have similar risk management issues as loan guarantees except that the money does need to be provided up front.

[16] Other options include tax pass through, investment tax credits, production tax credits, payroll tax reduction and accelerated depreciation, but these are only appropriate at the Federal level.

- Subordinated loans are where the government would be the last lender to recoup it's money in the case of default, which should decrease the risk and interest associated with any other loans used to finance that project. Again this has similar risk management issues as loan guarantees, however they are higher risk for government.
- Public-private partnership is where the government takes out a position in the project, becoming a joint developer. It thus takes on some of the risk but also shares some of the reward. This is much more complex than the types of loans discussed above, simply because the government would become an active partner in the project.

Large and medium-scale projects:

- Contracts for Difference (CfD) are where the government provides the difference between the system's LCOE and the market rate for electricity. They are essentially a type of FiT where the amount paid by government reduces as the market rate increases, and vice versa. The CfD rate can be arrived at through a reverse auction, as has occurred in the ACT. This process received 49 proposals, 22 of which (148MW) were considered suitable for further assessment. At this stage the levels of the CfDs are not publicly available.
- Put options on LGCs can be used to guarantee the price of LGCs either during the term of a PPA and/or after the PPA has expired. They would reduce the risk associated with a project and so make it easier to obtain a PPA, and may possibly reduce the cost of finance. There are at least two distinct ways LGC put options could be used. They could be used to guarantee the price of LGCs either (i) during a PPA, but only for say, years 11 to 15, or (ii) only after the PPA has finished. For (i), given that whoever is providing the PPA (eg. PWC) would receive the LGCs, this measure would presumably make it easier to get a longer/higher PPA. For (ii), guaranteeing the price of LGCs after the PPA has finished would benefit the system owner, and may or may not make it easier to obtain a new PPA.
- Direct capital subsidies, as has occurred through Solar Flagships, simply reduce the upfront cost of a project, and hence the level and cost of finance required. However, it seems unlikely in the current political climate that a direct subsidy would be introduced across the board and, if it were, the level of support made available may be low. From an operational point of view, administering direct subsidies requires significant institutional capacity and careful structure, whether across the board, as was done for the Solar Homes & Communities Plan, or for one-off projects, such as the Solar Flagships. Nevertheless, direct subsidies are often politically attractive, since they can be controlled via budget processes and selection criteria. Hence, such support may well be offered, especially for targeted sub-sectors or high profile projects.

Commercial-scale and residential-scale projects:

Some projects that are used to offset the purchase of electricity, and so earn the available retail tariffs, are likely to be commercially viable at present. While such systems can be bought upfront, an increasingly popular business model is the use of 'solar leasing' where the installer owns the PV system and sells the electricity to the owner of the building, be it commercial or residential.

However, increased penetration of distributed PV will reduce revenue for PWC. In the eastern Australian states, utilities are threatening to, or are already, offering much lower per kWh tariffs but higher daily connection charges or demand-based charges (eg. based on monthly peaks) in response to high PV uptake. This of course makes distributed PV much less viable for the end-use customer. An alternative is to increase the per kWh charges, however this will simply reduce usage further. Significantly higher levels of energy efficiency and demand management will be required to achieve high levels of solar penetration, which will also reduce PWC's sales. It is likely that the only option that allows high penetration of DG is the development of a Distributed Energy market.

Distributed Energy markets are where customers, the electricity sector and businesses can buy and sell electricity, heat, coolth, storage, efficiency, demand and ancillary services such as frequency and voltage control. Such a market will require the development of appropriate regulatory arrangements as well as consideration of a range of other issues including:

- Rights and technical standards for connection of DE technologies to the grid
- Formalisation of the portability of DE services
- Trading rules and requirements
- Ancillary service requirements and rewards
- Appropriate network charges
- The role and regulation of new energy service providers
- Pass through of energy and network cost reductions due to DE to the owners or customers generally.

4 The Central Australian region in 2012 – the baseline

4.1 Alice Springs Energy supply

Alice Springs is a town of 28,000 people with approximately 8,000 households, this report has assumed a stagnant population growth rate through to 2015, then population growth of 1% thereafter. Of the 8,000 domestic residences in Alice Springs there are around 2,500 Rental Properties or Public Housing.

Alice Springs has a gas connection to Darwin and an electricity network operated by PWC that is one of the NTs "regulated systems". This regulated network services a small extended region around the town, a copy of the network map is included in Appendix 2. The network is made up of a mix of 11kV, 22kV and 66kV lines.

Load growth has flattened over the last couple of years – partly as a result of the Alice Solar City program (including PV installations and SHW installations) and partly due to constrained population growth. Table 9 lists key load statistics. Total generation capacity exceeds the estimated requirements through to 2020.

Table 9: Alice Springs Electricity Load Summary

Maximum Load	55 MW
Minimum Load	15 MW
Average Load	26 MW
Annual Load	230 GWh
Central Generation Capacity	100 MW

Electricity on the network comes from four sources:

- The Ron Goodin power station, located close to Alice Springs centre and operated by PWC
- The Brewer power station, located on the Brewer estate 25 km south of Alice Springs and privately operated for peaking and system support under contract to PWC
- The new Owen Springs power station, also on the Brewer estate south of the city
- Grid-connected PV systems, both large iconic and small private systems as discussed further below, including:
  - 1MWp tracking flat plat PV system at Uterne Solar farm
  - 305kWp fixed flat plate PV system at Crowne Plaza Hotel
  - 235kWp tracking Solfocus CPV system at Alice Springs Airport
  - 190kWp combined test /demonstration systems at the Desert Knowledge centre

The key systems are shown on the map in Figure 2.

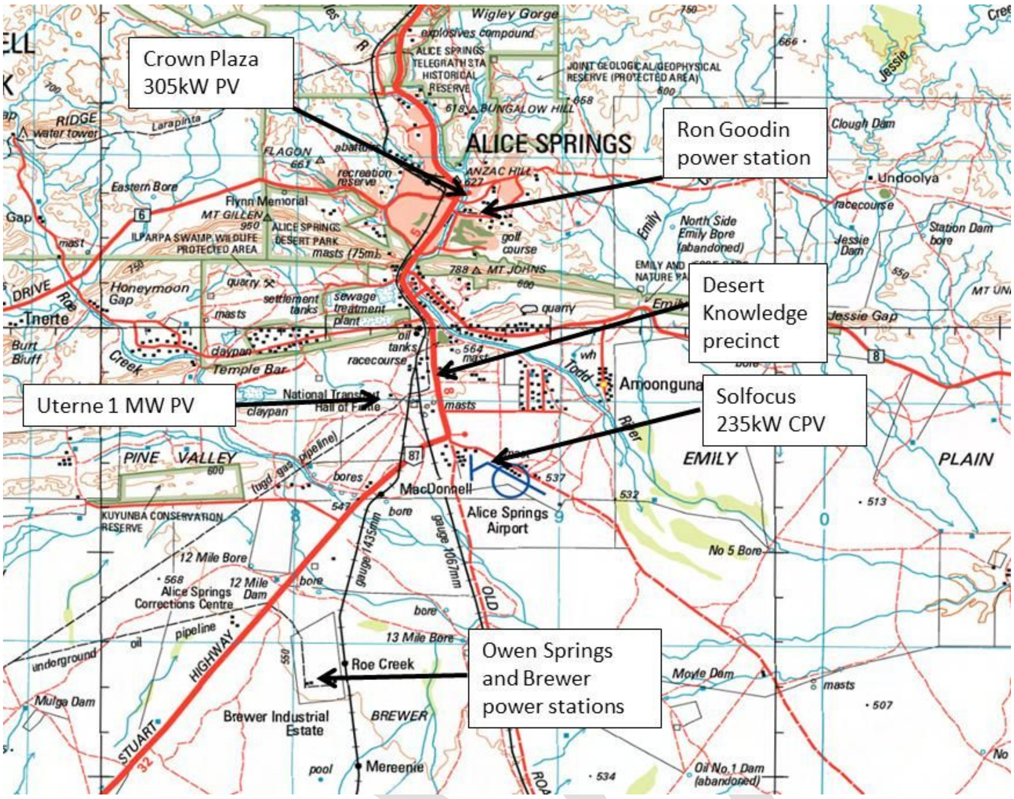

Figure 2: Alice Springs and nearby region, showing the location of the major generating assets on the regulated network.

The gas pipeline joining Alice Springs to Darwin brings gas to the town and other towns along the route. The gas comes from the 'Black Tip' field which is currently dedicated to providing NT domestic needs and is separate from the other major gas initiatives destined for LNG export operations. According to the Green Energy Taskforce report:

> *"There is a small reticulated natural gas network in Alice Springs, supplying 983 residential customers and 97 industrial and commercial customers. Envestra's gas distribution network in Alice Springs comprises 37.56 km of gas main."*

Of the three fossil fuel-fired power stations, the newest is Owen Springs. This system is still being progressively established, but is intended to be the main location for generation on the network moving into the future. It is connected to the town via a new substation with 30MW of capacity on a 66kV line.

According to PWC[17]

> *"Owen Springs Power Station … has the capacity to meet the town's power needs for the next 50 years. …." "The new power station will allow the gradual retirement of units from Ron Goodin Power Station, in Alice Springs, over the next 10 years."* and is *"…providing an additional 33MW of power at a cost of $150 million."*

The first generation unit was a 4MW Taurus gas turbine that was relocated from the Ron Goodin power station in 2009. Three MAN 12V51/60DF 10.9MW gas-fired reciprocating engines have been installed and are in the final stages of commissioning. These units were shipped into Darwin and transported 1,500km by road to Alice Springs.

[17] http://www.powerwater.com.au/about_us/major_projects/owen_springs_power_station

The Ron Goodin power station is located within just a few hundred metres of homes in Alice Springs and is being gradually retired due to issues around noise etc. Some of the machines are close to the end of there useful life. It consists of a number of reciprocating engine systems, some of which were diesel sets converted to run on gas, with a total combined capacity of 58.7MW.

The Brewer power station consists of four 2.2MW units which are currently operated at high capacity factor by a private operator under a Power Purchase Agreement with PWC.

Whilst the PWC website suggests that the new power station has the capacity to meet the town's needs for the next 50 years, this is clearly a reference to the capacity of the site rather than the current installed capacity of 35MW, given that the peak load of the town is already close to 50MW. Rather, a continual process of expansion at Owen Springs is understood to be planned and an expansion / duplication of the substation would also be needed. Clearly such plans can be varied in accordance with progress in moving Alice Springs to a greater level of solar contribution.

Existing energy prices for residential are currently subsidised as part of the Northern Territory's 'Community Service Obligation' (CSO) and are:$217.7/MWh or $317/MWh peak and $184.8/MWh off peak. Commercial Tariffs – non contestable, $250.9/MWh or $317/MWh peak and $184.8/MWh off peak

The actual costs of generation and the commercial tariffs that are the subject of individual negotiation (ie. contestable) are commercial-in-confidence information held by PWC. However the Green Energy Report(GTF 2011) notes that:

> *"…estimates of the current tariffs can be made by adding the value of the CSO subsidy and the uniform tariff. This suggests that commercial tariffs are in the range of $201 -$230 for DKIS users and $210 - $240 for users in Alice Springs."*

Current estimates are approximately $340-$380/MWh peak, and $230-$280/MWh.

Key statistics for the various power stations as they were in 2010 (ie prior to the installation of the 3 new systems at Owen Springs) are given in Table 10. The capacity factors based on quoted annual generation are noted. Both Ron Goodin and Owen Springs, with low capacity factors just over 30%, are indicative of the extent that there is considerable excess capacity in the system. The results for Brewer indicate that it is operates at full capacity most of the time. The average capacity factor for the solar assets, at 26%, however is high by world standards and reflects the excellent solar resource levels in Alice Springs, combined with the fact that two of the major iconic systems are tracking and so collect more energy per installed kW than fixed systems.

Table 10: Key generation assets in the Alice Springs regulated system as they were in 2010.

Alice Springs Regulated Network stations	Owner	Type	Capacity (MW)	Annual generation in 2010 (GWh)	Capacity factor
Ron Goodin	PWC	Natural gas	58.7	172.5	33.5%
Brewer [3]	Central Energy Power	Natural gas/Diesel	8.5	70	94%
Owen Springs	PWC	Natural gas	4.0	11.1	31.7%
Grid Connect Solar PV	Private	Solar PV	1.3	3.0	26.3%
TOTAL			**72.5**	**256.6**	**40.4%**

4.2 Alice Solar City

The Alice Springs Solar City[18] has been very successful in raising community awareness of solar options, and of increasing solar uptake rates. At the time of the mid-term review of the Australian Solar Cities program[19]:

- Around half of Alice Springs households had solar hot water systems installed
- There were approximately 1.5MWe of large iconic PV systems
- More than 300 homes and business have roof top PV
- It has the largest concentration of solar energy of all the solar cities
- It initially operated its own solar buy back tariff program, but new customers now have access to an NT wide tariff, with details shown in Table 11.

Table 11: The Northern Territory Solar Buy-back Tariff program

TABLE 4: NT SOLAR BUYBACK PROGRAM	
Status	**In operation**
Tariff model	Gross
Rate	from 1 July 2011
Residential	19.77c/kWh
Residential elevated buyback trial	52.08c/kWh
Commercial	23.00c/kWh
Commercial time-of-use	
Peak	29.43c/kWh
Off-peak	16.57c/kWh
Cap	$5 per day

Progress reported by Alice Springs Solar City since its launch in March 2008 through to May 2012 is summarised on their website as:

- 2672 Households registered
- 2493 Home energy surveys have been carried out
- 194 Businesses registered
- $6.64M Worth of incentive vouchers issued
- $5.67M Worth of funding provided for residential solar and energy efficiency measures
- 314 PV systems installed on homes and businesses (funded directly by Alice Solar City).
- 100 Estimated additional PV systems installed in homes and businesses.
- 730 Solar hot water systems installed
- 608 Smart meters installed on homes

The mid term review by Wyld group offers some valuable observations on the Alice Solar City:[20]

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[18] http://www.alicesolarcity.com.au

[19] http://www.climatechange.gov.au/government/initiatives/solar-cities/publications-resources/~/media/publications/solar-cities/mid-term-review-solar-cities-pdf.pdf

[20] http://www.climatechange.gov.au/government/initiatives/solar-cities/publications-resources/~/media/publications/solar-cities/mid-term-review-solar-cities-pdf.pdf

- It suggests that Alice has suffered from a shortage of suitably qualified tradesmen for PV and SWH installs, partly as a consequence of the mining boom driving demand for such people. It is suggested that the consequence is a lack of completion, with high prices and poor service.
- It suggests that PWC as a vertically integrated utility with a remit to “keep the lights on”, has a possible tendency “to work against introduction of more innovative solutions to supply / demand challenges”, this however is not a view supported by PWC, who can rightly claim a track record of commitment to innovation and renewable energy use.
- It suggests that the Solar City initiatives will have no effect on deferral of network and generation augmentation since PWC has recently relocated and upgraded the power station. Presumably PWC now has excess capacity (note this is in contrast to the Townsville experience which has shown a clearly demonstrated avoidance of an extra connection to Magnetic Island).
- It suggests that with 1.2MW of PV on the Alice grid, Alice is already a high penetration PV case study and that PWC is starting to experience network management issues around frequency and voltage with sudden demand increases experienced by the power station. This has been analysed and reported by the APVA[21].
- It is suggested that the federal Green Loans program could have complemented the Alice SC program, but did not. This could offer some important lessons in designing innovative financing models going forward.

4.3 Existing solar installations in Alice Springs

The current installed capacity, location, size and contribution of PV in Alice Springs is shown in the Tables and Figures below.[21] An estimated 50% of households also have solar water heaters.

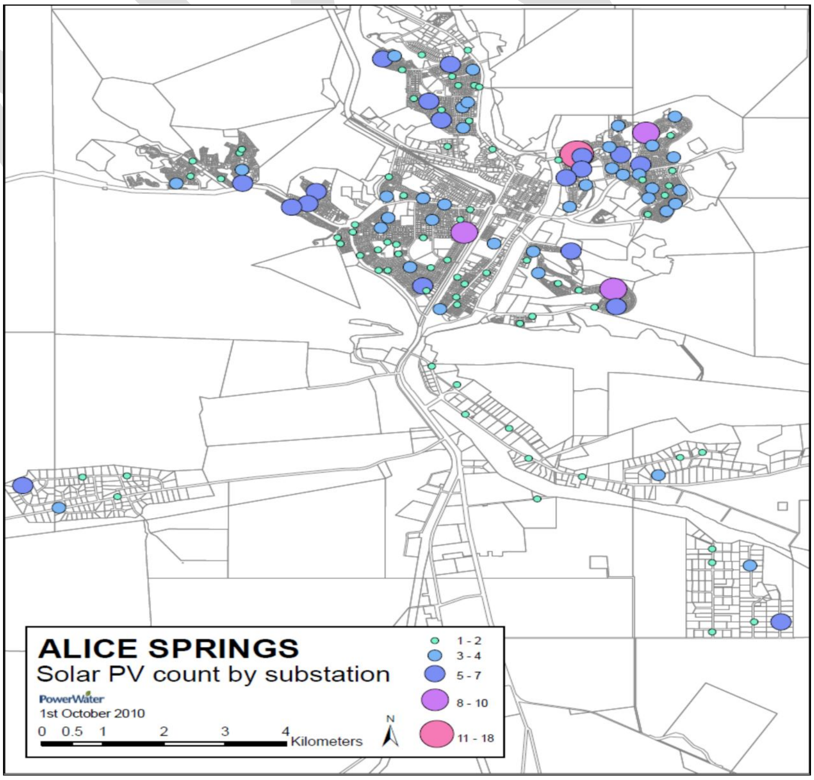

Figure 3: Location and size of PV systems in Alice Springs 2011-12

[21] APVA, 2011, Alice Springs: A Case Study of Increasing Levels of PV Penetration in an Electricity Supply System.

Table 12: PV installations in Alice Springs in 2011-12

Category	#	Capacity (kWp)	% Inst. Cap	Comments
Residential Systems				
Installed under ASC program	277	530	17%	Mostly 2kW (some 1 & 1.5kW)
Installed outside ASC program	183	464	15%	1.5kW to 5kW systems
Total Residential	**460**	**994**	**32%**	
Commercial Systems				3kW to 40kW systems
Installed under ASC program	35	367	12%	
Installed outside ASC program	4	14	0%	
Total Commercial	**39**	**381**	**12%**	
Iconic/Showcase Systems				
Desert Knowledge Solar Centre	27	220	7%	Showcase (2008)
Crowne Plaza Hotel	1	305	10%	ASC Iconic (early 2009)
Alice Springs Airport	1	235	8%	ASC Iconic (Nov 2010)
Uterne Solar System	1	969	31%	ASC Iconic (July 2011)
Total Installed Iconic/Showcase	**30**	**1,729**	**56%**	
CURRENTLY INSTALLED PV SYSTEMS	**529**	**3,104**	**100%**	

Table 13: PV capacity and penetration levels – Alice Springs 2011-12

PV Penetration Measure	PV Measure	Value	System Measure	Value	% PV Pen.
PV Capacity Penetration	Installed Nominal PV Capacity	3.1 MW	Peak Load	55 MW	5.6%
PV Peak Power Penetration - Summer	Est. Summer Midday PV Peak Power	2.6 MW	Ave. Summer Midday Load Demand	40 MW	6.5%
PV Peak Power Penetration - Winter	Est. Winter Midday PV Peak Power	2.2 MW	Ave. Winter Midday Load Demand	26 MW	8.3%
PV Annual Energy Penetration	Est. Annual PV Energy Generated	5.7 GWh	Annual Gross System Load	230 GWh	2.5%

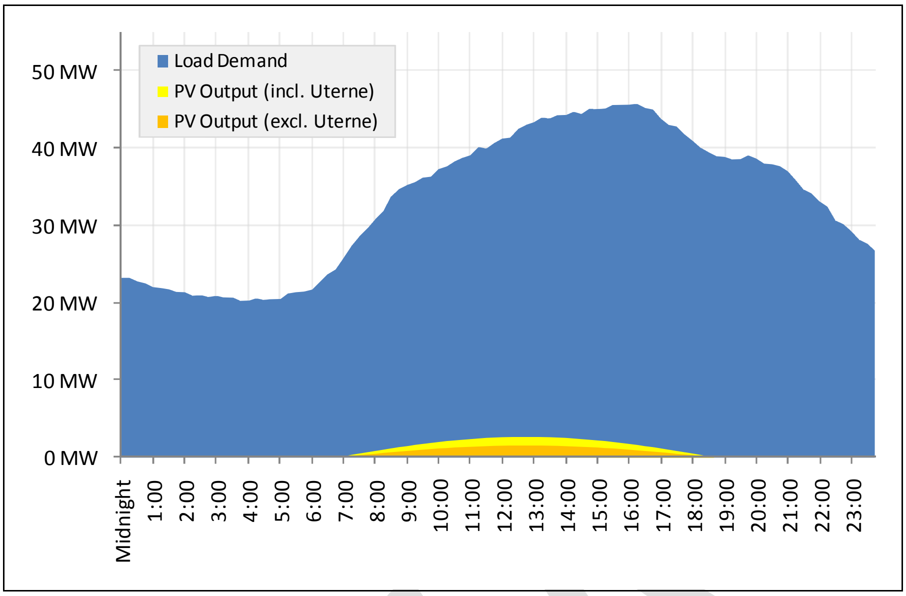

Figure 4: PV output in Alice Springs as a proportion of load in Summer.

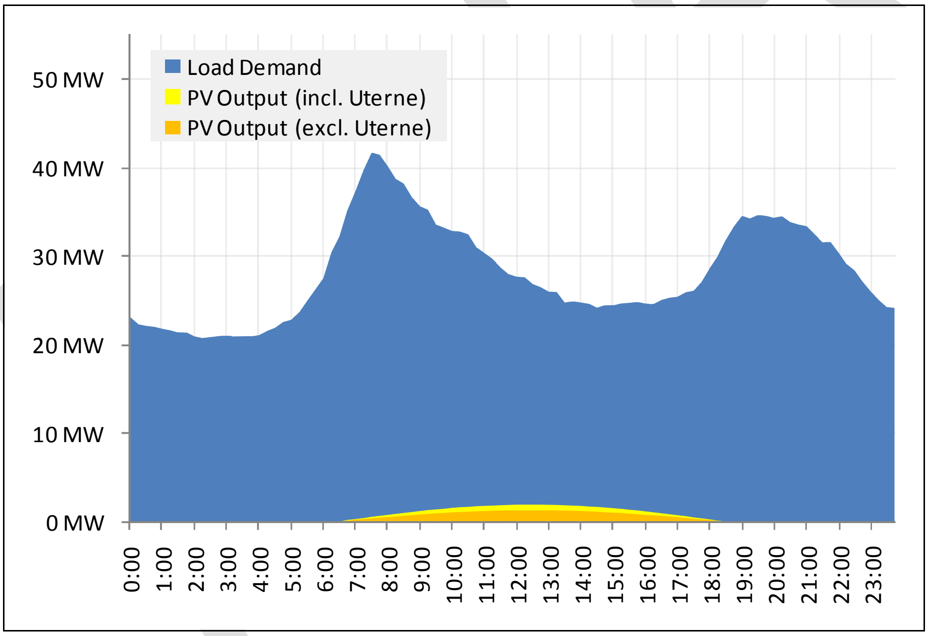

Figure 5: PV output in Alice Springs as a proportion of load in Winter.

4.4 Off Grid

The Northern Territory's electricity network is not linked to that of any other State, nor is there a Territory-wide network. Instead, the NT electricity market consists of three separate networks, namely the Darwin-Katherine grid, the Alice Springs network, and Tennant Creek grid. IES purchases electricity from the PWC power grids for 12 communities.

The majority of remote communities are supplied by isolated diesel power stations. IES operates 53 diesel power stations at communities not connected to the regulated grids. The total installed generation capacity at the Growth Towns is approximately 46MW, and 25MW at other IES communities. IES also purchases electricity from the Rio Tinto Alcan operated power station on the Nhulunbuy power grid for two communities and from the GEMCO power grid on Groote Eylandt for one community.

There are over six hundred small-scale renewable energy systems deployed throughout the Northern Territory, with many of these servicing outstations. There is also approximately 1MW of photovoltaic system capacity deployed across Yuendumu, Hermannsburg, Lajamanu, Kings Canyon, Bulman and Jilkminggan.

Within the Central Australian off-grid arena, there is general data that can be used to categorize the market as shown in Table 14.

Table 14: Approximate numbers of Off-Grid Sites

Aboriginal Communities	20
Homelands or Outstations	75
Active off-grid mine sites	1
Pastoral Stations	45
Offgrid gazetted townships Off grid ranger stations	4 5

The numbers noted above may be disputed, as the definitions that are applied are critical to determining the final numbers. For example, the specific delineation of Central Australia is influenced by the inclusion, or otherwise, of areas to the north that include the Barkly region, or by assessing aboriginal homelands based on their levels of permanent occupancy.

For example, the four wards of the Central Desert Shire cover regions that include significant areas to north-west of Alice Springs while not including areas such as Tennant Creek. Notwithstanding which communities and locations are formally part of “Central Australia”, the underlying conclusions and recommendations noted below are not significantly altered.

The primary issue facing the off-grid market is one of cost, as the majority of off-grid energy generation comes from diesel generators, which is, in turn, driven by the gate price charged for diesel at the primary import hub in Darwin.

Figure 6 below shows the terminal gate price for diesel over the last eight years:

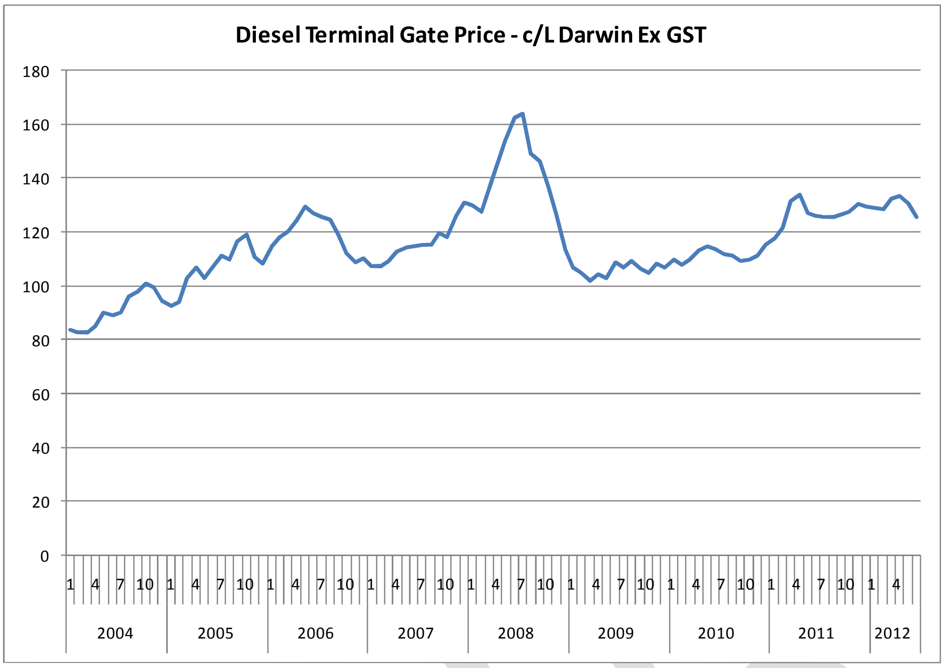

Figure 6: Diesel prices in Darwin over the past 8 years.

As can be seen, fuel prices have been consistently higher than $1/litre for the last seven years and general market opinion suggests that these prices are likely to be sustained, or indeed increase, over the coming years.

Although all diesel gensets operate with different underlying efficiency curves, the graph below provides an example of a typical efficiency curve for smaller (<1MW) generators that are often used within Central Australia:

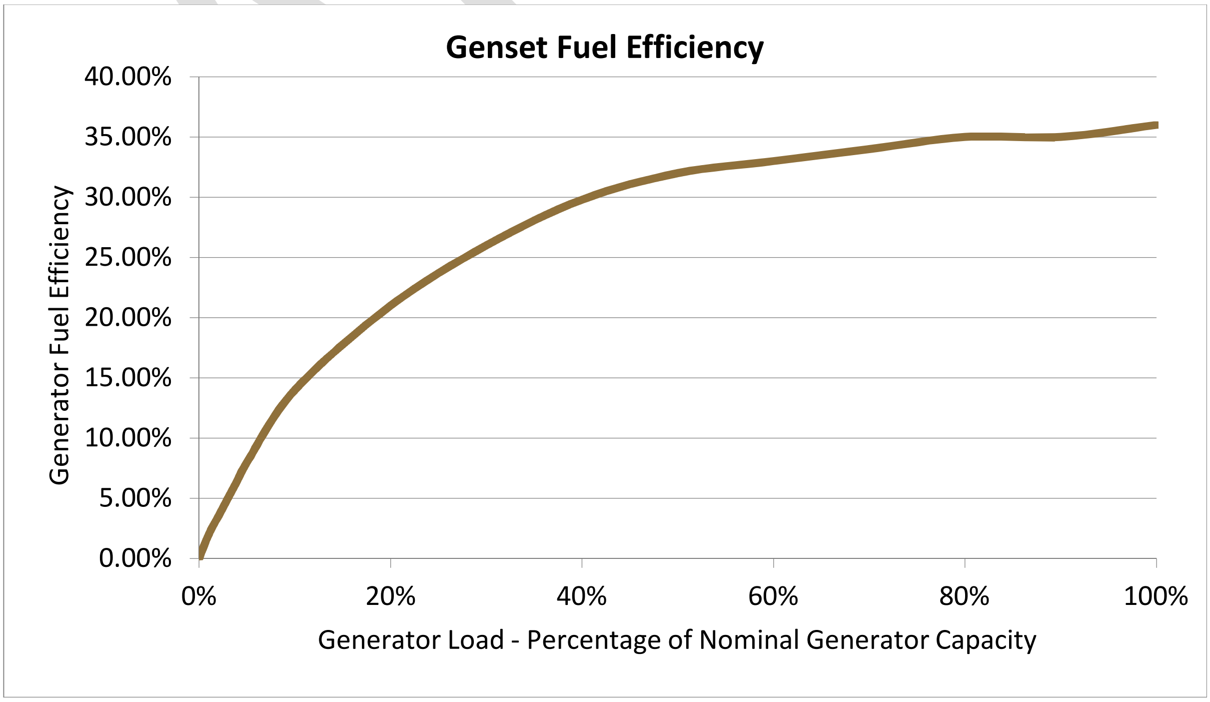

Figure 7: Diesel use efficiency in typical small gensets.

The generator efficiency curves translate to average kWh/L rates of between 3-4kWh/l, implying a marginal cost of generation for most off grid sites of between $280/MWh and $350/MW/MWh. This price is higher for more remote sites, and anecdotal data suggests that some locations may have marginal costs of generation exceeding $450/MWh.

5 Technology Options

5.1 Photovoltaics

With appropriate incentives, the number of buildings with rooftop PV can be increased over time, with more commercial and light industrial systems adding to the largely residential market at present. More centralised 'utility-scale' farms like the Uterne 1 MW system can also be contemplated. The level of penetration of intermittent PV that can be reasonably managed in a mini grid is limited by the type and number of existing generators, the load pattern, the solar resource and the regulations under which the power station operates, including redundancy levels. A recent study by CSIRO[22], suggests penetration could be increased to as much as 40% if comprehensive efforts are made to introduce demand management and generation forecasting strategies.

Over the period to 2020, costs for PV systems are expected to continue to decline. Estimated capital costs and life cycle electricity costs for PV systems in Alice Springs modelled by the APVA are shown in Figure 8 and Figure 9. Note that these costs include the value of Small-scale Technology Certificates (STCs) or Large-scale Generation Certificates (LGCs).[23] This is so the life cycle cost of the residential and commercial-scale systems can be compared directly to the retail tariffs. The large-scale life cycle cost should be compared to the LRMC of gas-fired generation which we estimated in Section 4.1 to be in the range \$150 - \$170/MWh.

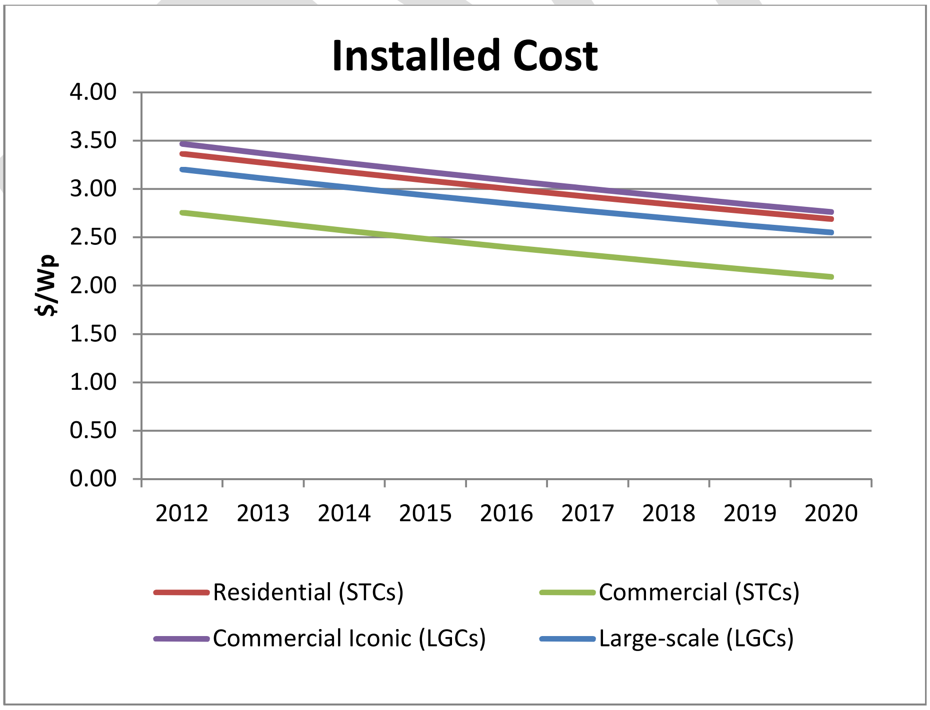

Figure 8: Projected Capital Costs for PV systems in NT
(includes estimated value of STCs or LGCs)

[22] CSIRO, 2012, Solar Intermittency – Australia's Clean Energy Challenge, June 2012.

[23] Thus, the life cycle costs are not strictly LCOEs because the latter do not include the impact of external factors.

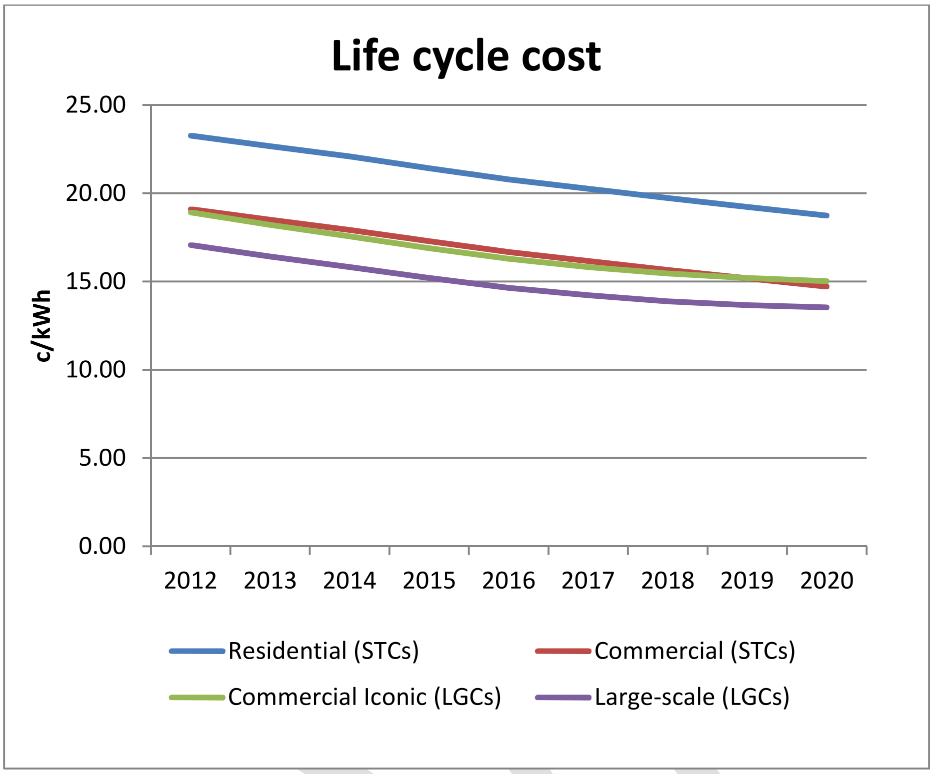

Figure 9: Projected Life cycle electricity costs for PV systems
(includes estimated value of STCs or LGCs)

The figures noted above have been based on fixed PV systems operating at an optimal tilt angle (presumed to be 20-25degrees facing true North; however many larger PV systems, including thoses at the DKASC, Uterne and the Airport utilise tracking systems to increase the overall energy yield of the PV system.

Tracking systems allow the PV panel to follow the sun across the sky, thus allowing the panel to operate at higher output levels for more hours each day. Trackers can operate on a single axis, following the sun from east to west, or on two axes, thus allowing for seasonal variation in the sun's position as well.

Tracking systems add a mechanical component and extra installation costs to a technology which otherwise relies on no moving parts. Certain PV technologies, particularly high efficiency panels, benefit significantly from tracking systems, while concentrating PV systems are unable to operate without trackers. Additional land area is also required, compared to static arrays, to prevent shading of adjacent panels while careful consideration of wind loading and additional maintenance expenditure are also necessary when determining the appropriateness, or otherwise, of a tracking installation versus a fixed array.

Nevertheless, output can be increased by as much as 20-30% for single axis trackers and 25-40% for dual axis tracking systems, and the squarer output profiles can better match summer load profiles so that trackers can be justified in high sun locations and where energy costs are high, particularly in later parts of the day.

Greater levels of penetration can also be facilitated by adding electrical energy storage / battery systems. For the remote communities and pastoral systems, PV plus battery systems are likely to become the norm.

5.2 Advanced batteries

There are a range of electricity storage / battery systems that are at various stages of commercial development, although all are relatively costly at present. Lead acid batteries are the current commercial standard and likely to remain the technology of choice for supporting small, off-grid systems for some time. For the Alice Springs town area, the moderate and stretch solar centre targets could provide a strong motivation for acting as a test bed for innovative large battery systems, the Vanadium Redox or Zinc Bromine flow batteries would be obvious candidates.

Electrical energy storage options have recently been reviewed in an Australian context for both domestic and utility scale applications by Gawler et al 2011. Pumped hydro and compressed air storage are covered in detail however do not have any realistic role in Alice Springs. Whilst a range of battery options exist across the spectrum from R&D to comercial application, lead acid batteries are found to be the most cost effective realistic solution. (reproduce Table 6.1 from page 44). Table xxx show their estimated capital costs for a range of medium / large scale systems. In interpreting such numbers it is important to note that battery life is very dependent on depth of discharge and typically might be 7 years if discharge is limited to 50%. Round trip efficiency through storage is around 70% so the lost energy needs to be considered in overall economic analysis.

Table 15: Lead acid battery costs from SKM MMA (Gawler et al 2011)

Energy (MWh)	Power (MW)	Storage hours	600 V DC ($/kWh)	1000 V DC ($/kWh)
1	2.286	0.438	$839	$630
1	1.143	0.875	$927	$572
1	0.571	1.750	$927	$541
5	11.429	0.438	$716	$558
5	5.714	0.875	$702	$429
5	2.857	1.750	$702	$386
10	22.857	0.438	$419	$432
10	11.429	0.875	$464	$293
10	5.714	1.750	$464	$293

5.3 Smart Meters

A major facilitating technology for greater uptake of Solar technologies are smart meters. These are an established technology and have already been trialled in most of the Australian Solar Cities initiatives, including Alice Springs. Key features can include the ability to monitor continuously varying time of day related energy tariffs and to interface to various loads and possible generation sources on the customer side of the meter. To take full advantage of the capability requires a tariff structure which can vary in price in response to the overall supply and demand on the network. On the customer side, non-essential loads can be curtailed and / or rescheduled at times of high price (high demand relative to generation). It is suggested that these should become the mandatory approach for the commercial / industrial / government sectors in the moderate scenario and for all consumers in the stretch scenario.

Additionally, there exists potential for the integration of other “Smart” technologies into the broader grid, including substation monitoring. Establishment of these monitoring and control mechanisms within the grid would both increase the efficiency of the overall grid as well as providing the opportunity for utilising some of the advanced functionality that exists in many PV inverters, such as active VAR Compensation at a street level and voltage support

5.4 Solar Water Heating

Alice Springs already has a 50% penetration of Solar Water Heating (SWH). SWH represents one of the most cost effective technologies for increasing the solar contribution to end-use energy. It should be increased to as close to 100% as practically possible over a relatively short period. Where a lack of suitable solar access precludes the use of direct SWH systems, heat pump based units should be employed in preference to resistive heated units.

SWH should also be adopted as the standard approach for remote communities, for commercial applications and in government buildings.

5.5 Solar Cooling

Various solar cooling systems are in the early stages of commercial application. One established approach involves combining solar thermal collectors with absorption based chiller units. The solar thermal collectors could be evacuated tube based systems, or small scale roof mounted linear concentrators. Concentrators produce higher temperatures and so allow absorption chillers to operate with a higher coefficient of performance. Against that is the added complexity and O&M requirements of tracking systems. Evacuated tube systems are mass produced globally (particularly in China) for SWH applications and so are the more commercially mature approach.

However, with continued cost reduction for PV systems, the option of simply running conventional electric driven vapour compression systems, in parallel with PV generation, is also available. A desirable system optimisation would be the addition of low temperature (coolth) thermal stores that facilitate the direct management of cooling electrical loads to match the availability of PV generation. This could have the effect of facilitating higher overall levels of PV penetration more cost effectively than electrical storage systems.

Coolth storage would also be an important addition to solar thermal drive solar cooling systems.

5.6 Concentrating Solar Thermal Power technologies

Mirror based concentrator systems configured as Trough, Linear Fresnel, Tower / heliostat and Dish systems are well established and at various levels of commercial maturity. Any of these could be applied in Alice Springs in a range of possible configurations. Trough systems using steam turbine based power generation are the most mature approach and account for 95% of all CSP commercial systems in operation. Tower / heliostat systems are the next most mature approach. Overall global installed capacity is only approximately 2GWe compared to around 70GWe for PV. Nonetheless, the industry is growing strongly. Because PV is already a well-established technology in Alice Springs, whilst little is known about CSP, this report provides a more detailed examination of CSP technologies, performance and costs.

The configuration of a focus mounted Stirling engine on a dish concentrator has been offered by a couple of commercial players, however this approach offers essentially the same service as a PV system and is struggling to compete in the market place.

The steam turbine based approaches could only be applied for the Alice Springs Town and the size of the load is such that only one or two systems could be accommodated. For stand-alone CSP systems, the use of two tank molten salt energy storage has become the standard approach with most new CSP systems globally incorporating it. The strongest appeal of applying CSP in Alice Springs would be the possibility of high solar contributions and dispatchability that thermal energy storage would provide.

Unlike PV systems, CSP systems are typically large utility sized systems. The industry and technology is well established globally although it is still at a much earlier stage than PV. The potential for CSP systems in Australia has recently been reviewed in detail, and the impact of system size on energy cost examined as part of that[24].

In contemplating the possibility of a major CSP power plant connected to the Alice Springs network, one possible logical location would be immediately adjacent to the Owen Springs power station. A satellite view of the site as shown in Figure 10, indicates that, subject to the land being available, there is clearly area available to do this.

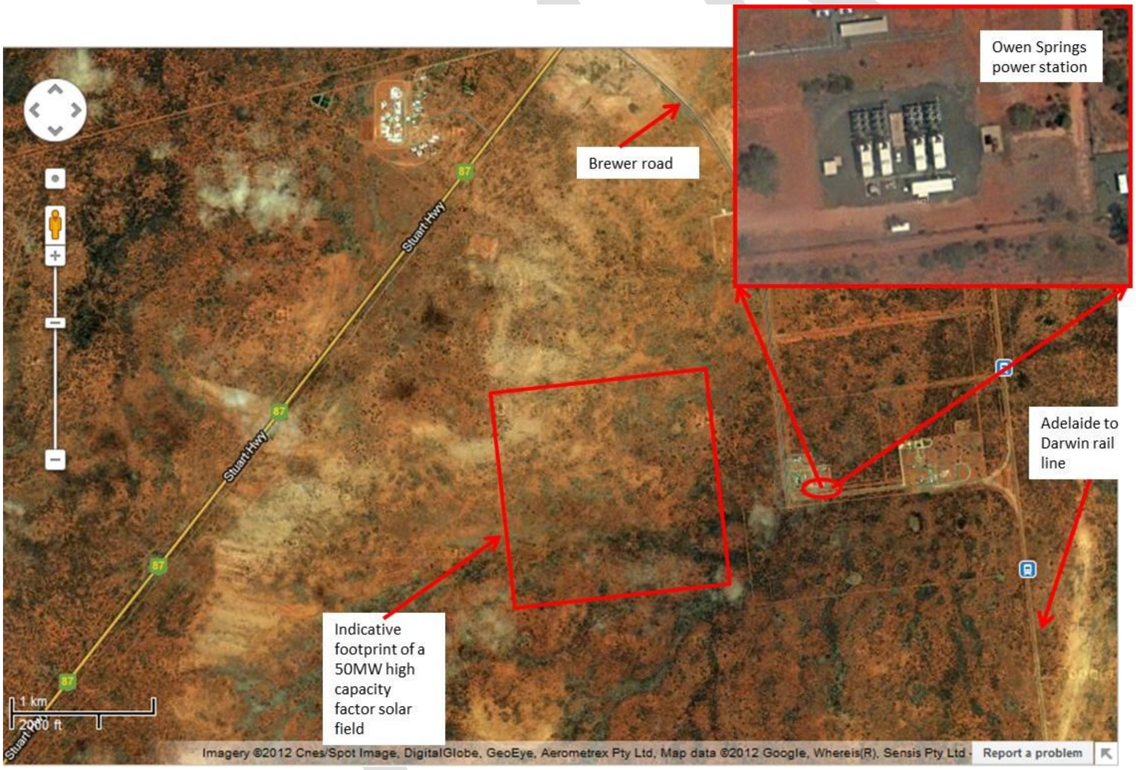

Figure 10: Site map of Owen Springs power station

Costing of CSP options is much more complex than it is for PV options for a number of reasons. The industry is much less mature and not established at all in Australia, so and cost information is hard to obtain. Costing is also very dependent on the choice of plant configuration, particularly the level of storage. Costs are also very dependent on system size, particularly for sizes below 50MW.

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[24] Realising the potential of concentrating power in Australia. Report by ITPower for the Australian Solar Institute. http://www.australiansolarinstitute.com.au/SiteFiles/australiansolarinstitutecomau/RPSCPA_Report_180512_Web.pdf and the summary at: http://www.australiansolarinstitute.com.au/SiteFiles/australiansolarinstitutecomau/CSP_AUST_Final_May2012.pdf

Appendix 5 assembles cost information that can be deduced for CSP systems in Alice Springs. In general terms, in 2012, LCOE's are between 30 – 50% higher than utility scale PV systems, however 2 or3 hours of thermal storage can be incorporated for no increase in LCOE so they do offer a more cost effective option that utility scale PV plus battery configurations.

5.7 Integrated Solar Combined Cycle

A proven approach to hybridisation of conventional fossil fuel technology with CSP is the Integrated Solar Combined Cycle (ISCC) system. A conventional Combined Cycle plant is configured with a gas turbine where the exhaust gases are used in a Heat Recovery Steam Generator (HRSG) to produce steam that is then used to operate a steam turbine in parallel. The combination of the two converts the fossil energy to electricity at efficiencies of around 50%.

For an ISCC operation, solar steam is also fed to the steam turbine in a combined cycle plant. Unless the solar steam contribution is very small, the whole system needs to be designed in an integrated manner for optimal operation. Typically the steam turbine is oversized relative to the gas turbine such that it can accommodate both solar steam and HRSG steam. At times of no solar input, the steam turbine runs at part load.

Combined cycles can also be contemplated with reciprocating engines as the primary cycle. With current generation at Alice provided by relatively new gas engines, the option of retrofitting these for combined cycle operation with the addition of solar input could be considered.

5.8 Solar Gas

The CSIRO National Solar Energy Centre in Newcastle has been working for a number of years on the development of a system they refer to as SolarGas™ . This uses high temperature solar heat to drive a chemical reaction process that is adapted from conventional steam reforming of natural gas. The product gas is a mixture of hydrogen and carbon monoxide (syngas) and has an energy content that is increased by about 25% over the original by the addition of the solar energy.

The syngas can be used in a number of ways. One of the easiest would be to replace the natural gas in a combustion gas turbine or engine (ideally combined cycle), so providing 25% solar generation with unchanged gas turbine dispatchability characteristics. Unless gas accumulators were provided, the solar gas would only be available during sun hours, and such a system would revert to natural gas at other times. However if a solar gas system were installed upstream of the town (maybe at Tenant Creek for example), then the gas pipeline itself would provide an ongoing storage mechanism.

Another target application of solar gas is as the reactant feed to a Fischer Tropsch synthesis plant. Such plants produce a range of liquid hydrocarbons that can be further processed to petrol and diesel substitutes. They are the basis of well-established gas to liquids technology.

The CSIRO work has progressed to the point that a major pilot / demonstration project is contemplated and Alice Springs could be an ideal location for such an initiative.

5.9 Solar system output

Appendix 3 discusses the prediction of annual generation and the profile through the year of various solar power generation options. Key metrics are summarised in Table 16.

Table 16: Key metrics for different Solar options at Alice Springs

Technology	Flat plate PV, no tracking[25]	Trough no storage	Tower with 6 hours storage	Tower with 40 hours storage
Annual generation (kWh/kW)	2074	1983	3773	6526
Average daily generation (kWh/kW)	5.68	5.4	10.34	17.88
Average Capacity factor	24%	23%	43%	74%
Land requirement (ha/MW)	2.56	2.18	5.20	10.39

For the stretch scenario, it becomes important to consider the challenges of meeting supply and demand at all times. This is explored in detail in Appendix 4.

[25] Metrics for the PV option are expressed per high voltage AC kW rather than per nominal DC capacity.

6 Possible Future Scenarios

6.1 Scenario Descriptions

For this report, three scenarios are defined: 'Business as Usual' (BAU), 'Moderate' and 'Stretch', to analyse possible solar futures. These scenarios are simply examples of the development that may occur from across the full spectrum of possibilities. The current situation has been defined previously.

- The "BAU" scenario builds on the current situation with a projection out to 2020.
- The "Moderate" scenario limits solar energy use to that which is predicted to be compatible with the economic and social constraints expected for the region in the short term.
- The "Stretch" scenario is defined as the highest level of solar energy use that is predicted to be technically possible using commercially available technology out to 2020.

Electricity demand for all scenarios is assumed to have been 186.7GWh in 2010 and projected to be 230GWh for 2020, a growth rate of about a 2.1% per annum.

Within each scenario, the levels of solar penetration will differ for each of the two different markets. The markets have been broadly categorised as:

- Alice Springs
- Off-grid – Central Australia

The off-grid market has then been broken down to a number of smaller levels, based on the unique characteristics of mine sites, pastoral stations and remote communities, including outstations, homelands and gazetted communities.

Each of these markets currently has very different levels of solar penetration, and importantly, very different characteristics (barriers, issues and opportunities) and so will require different approaches to achieve the scenario targets.

In addition to being based on the percentage of energy provided by solar sources ('levels of deployment'), the scenarios are defined according to the activities identified previously as being required for Alice Springs to be regarded as a "Solar Centre":

- Test & demonstration facilities
- Community and stakeholder engagement
- Education and training
- Financial and market mechanisms.

6.2 Alice Springs

6.2.1 BAU

For the business as usual scenario it is assumed the existing level of community engagement and institutional support is at least passively maintained within a broader financial environment that supports continued development without being subject to major external shocks, such as the global financial crisis. Whilst the BAU scenario is anticipated to result in some significant levels of solar deployment based on present trends, it would not be world leading.

Levels of deployment

It has been assumed that the BAU scenario involves around 9MWp of PV and no CSP. **Error! Reference source not found.** shows the assumed level of PV deployment within the Business As Usual scenario.

The following sections describe the underlying assumptions leading to the proposed deployment rates.

Residential

Within the BAU Model it is assumed that:

- Public housing will not see any notable uptake of PV
- 20% of houses are unsuitable for the installation of PV
- 20% of the balance (that don't already have PV installed) is viable without incentive beyond existing price signals.
- As a result, about 16% of houses are assumed to have PV by 2020.

Commercial Rooftop

Around 200-300 larger commercial roof tops (warehouses, Work sheds etc) averaging around 10kW per system – many of the shed structures use purlin based shed design, limiting total load and panel spacing.

Given constraints on business investment, even with higher energy prices, the uptake will be somewhat constrained and a total market penetration of around 15-16% by 2020 is probably feasible. Take up is assumed to reduce in 2012 – 2014 then increase through 2017, before dropping off due to natural market limits.

Large Commercial Roof top

Around 10 opportunities for large 100kW+ size roof installations exist (excluding schools etc which already generally have PV installed). It is assumed that under current economic conditions, and the slow transition through contestable pricing increases, that the uptake of large PV on rooftops will stall through to 2014, with a couple of large installs following increase in business confidence, then tailing off in later years due to smaller number of rooves available.

Government buildings and schools have generally been excluded from much growth in the Business as Usual Scenario, as existing barriers to uptake are unlikely to be resolved in the medium term political cycle – ie. the incentive for schools to do more than already implemented through the National Solar Schools Program (NSSP) is constrained as any energy savings are not returned to their own budget, and public schools are generally operating with lower bulk negotiated tariffs.

Similarly for Government buildings, barring specific political decisions to invest capital into building upgrades, existing bulk purchasing of energy from PWC essentially creates a second CSO for government agencies.

Commercial Ground Mount

There is some potential for commercial ground mount, although it is likely to only be viable through a large (1MW) size install through a PPA with PWC. PWC have shown a willingness to explore this option, but even given the lower PV prices, the underlying marginal cost of generation, coupled with the depressed LGC market, make it unlikely that this will occur before 2016, and then maybe through one more expansion in 2020.

Table 17: PV Deployment in Alice Springs under a BAU Scenario

				2012		2013		2014		2015		2016		2017		2018		2019		2020		Total	
	GWh/A	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW
Installed under ASC program	1.70	283	566		0		0		0		0		0		0		0		0		0	283	566
Installed outside ASC program	1.65	177	428	50	100	50	100	75	150	75	150	100	200	100	200	100	200	100	200	200	400	1027	2,128
Total Residential		**460**	**994**	**50**	**100**	**50**	**100**	**75**	**150**	**75**	**150**	**100**	**200**	**100**	**200**	**100**	**200**	**100**	**200**	**200**	**400**	**1310**	**2,694**
Commercial Systems																							
Installed under ASC program	1.75	35	367		0		0		0		0		0		0		0		0		0	35	367
Installed outside ASC program	1.7	4	14	3	30	3	30	5	50	7	70	10	100	7	70	5	50	3	30	3	30	50	474
Total Commercial		**39**	**381**	**3**	**30**	**3**	**30**	**5**	**50**	**7**	**70**	**10**	**100**	**7**	**70**	**5**	**50**	**3**	**30**	**3**	**30**	**85**	**841**
Iconic/Showcase Systems																							0
Desert Knowledge Solar Centre	1.77	27	220		30																		250
Crowne Plaza Hotel	1.75	1	305																				305
Alice Springs Airport	2.2	1	235				250		250														735
Uterne	2.2		969																				969
Araluen	1.75				165																		165
Large (>100kW) Com Roof Top	1.7								200		150		150		100		100		100		100		900
Large (>100kW) Com Ground	1.75												1,000								1,000		2000
																							0
Total Iconic Showcase			**1,729**		**195**		**250**		**450**		**150**		**1,150**		**100**		**100**		**100**		**1,100**		**5,324**
TOTAL		**499**	**3,104**		**325**		**380**		**650**		**370**		**1,450**		**370**		**350**		**330**		**1,530**		**8,859**

Large Iconic Installations

Beyond the immediate developments planned, there appears to be little appetite to explore any further large PV iconic projects other than a potential expansion of the Airport PV system which is being explored over the coming years.

CSP

BAU includes no uptake of CSP because the minimum practical system size is large and capital intensive. They would also only be approaching economic viability under a realistic PPA in 2020 or later in the absence of a major grant or other financial support mechanism.

BAU Percentage Contribution from PV

The Business as Usual scenario would result in about 20% peak solar contribution in summer and as high as 35% during lower demand months, with a total generation contribution of 14.2GWh out of an overall 230GWh annual load (7% total energy).

Test & demonstration facilities

The BAU scenario presumes that the existing DKASC facilities would be maintained and some organic growth would occur, but no further development of the facilities would occur. Data-mining activities and research projects using data from the DKASC, ie. ASI research projects, may continue but would not likely extend beyond 2016.

Community and stakeholder engagement

The BAU scenario relies on an existing high level of engagement from members of the community and businesses as well as from organisations such as the Arid Lands Environment Centre (ALEC). Within the BAU model it is assumed that Alice Solar City receives a small amount of ongoing funding to maintain its activities, but has no capacity to grow the program.

This has a necessary flattening effect on the overall takeup because, with the high level of population turnover, it is highly likely that many residents living in Alice Springs in 2020 will never have heard of, or engaged with, the Alice Solar City or the broader activities of the constituent members of Alice Solar City. Instead the growth will rely on peer influence and the prevalence of existing housing stock with solar PV or solar water heaters.

Education and training

Centralised solar systems are likely to be installed and operated by PWC or private industry with a PPA. Education and training would be limited to up-skilling PWC staff and perhaps specific operational and maintenance training for a few local people, undertaken by the system installer.

Financial and market mechanisms

Within the BAU model, it is assumed that underlying pricing is sufficient to support the deployment of renewables without specific financial incentives.

6.2.2 The Moderate Scenario

In the context of the national Renewable Energy Target of a nominal 20% renewable electricity by 2020, achieving an overall 20% renewable electricity contribution for the Alice Springs 'solar centre' could be seen as a reasonable outcome that could be consistent with a conservative but significant move. The Moderate Scenario can be interpreted as the minimum level of achievement needed to be consistent with a world leading position. Given that it would need to be solar specifically, it would likely put Alice Springs at a level well above the average for solar penetration for regional centres in

Australia and many parts of the world at that time. In order to achieve these levels of solar contribution in a sustainable manner, this scenario also requires:

- All stakeholders agreeing and willing to proactively participate
- A gradual transition e.g. using a solar option whenever an asset is replaced, and advancing the associated technical, informational, institutional and educational arrangements necessary on an ongoing basis
- A stable investment environment, with certainty that the aims will not be changed in the next budget cycle or after the next election
- Potentially a pre-arranged set of transitions, by date, capacity, cost or other measure, so that there is minimal disruption
- A timetable to develop skills bases
- An ongoing program of community engagement and information update
- Flexibility to adjust to new technologies as they emerge, always with a view to maximising local benefit via lowest cost energy services, local jobs and environmental gains
- A mix of mandated and market-based support mechanisms, where the former are used if they are easier to implement and provide the best outcomes.

Levels of deployment

We have assumed the Moderate scenario is achieved using around 13MWp of PV, a CSP demonstration centre, together with the existing 35MW of gas-fired generation systems at Owen Springs and the retirement of other units as possible.

Table 18 shows the assumed level of PV deployment within the Moderate scenario. The following then describes the assumptions required to support the Moderate scenario.

Residential

Within the Moderate Scenario it is assumed that:

- Public housing will have some uptake of PV
- 20% of houses are unsuitable for the installation of PV
- 35% of the balance (that don't already have PV installed) is viable without incentive beyond existing price signals.
- As a result, about 23% of houses are assumed to have PV by 2020.

Thus, the overall uptake of household PV is assumed to be about 8% higher than for the BAU assumption.

Commercial Rooftop

Within the Moderate Scenario, 40% of all the smaller business premises, sheds, warehouses etc have PV systems installed with an average size of 10kW.

Large Commercial Rooftops

Similarly to the BAU scenario, government buildings and schools have generally been excluded from much growth in the moderate scenario, with the primary growth occurring on the larger buildings, such as hotels and resorts.

Table 18: Levels of PV deployment under the Moderate Scenario

				2012		2013		2014		2015		2016		2017		2018		2019		2020		Total	
	GWh/A	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW
Installed under ASC program	1.7	283	566		0		0		0		0		0		0		0		0		0	283	566
Installed outside ASC program	1.65	177	428	50	100	75	150	100	200	150	300	150	300	200	400	200	400	300	600	300	600	1702	3,478
Total Residential		**460**	**994**	**50**	**100**	**75**	**150**	**100**	**200**	**150**	**300**	**150**	**300**	**200**	**400**	**200**	**400**	**300**	**600**	**300**	**600**	**1985**	**4,044**
Commercial Systems																							
Installed under ASC program	1.75	35	367		0		0		0		0		0		0		0		0		0	35	367
Installed outside ASC program	1.7	4	14	3	30	3	30	5	50	7	70	10	100	10	100	10	100	10	100	7	70	69	664
Total Commercial		**39**	**381**	**3**	**30**	**3**	**30**	**5**	**50**	**7**	**70**	**10**	**100**	**10**	**100**	**10**	**100**	**10**	**100**	**7**	**70**	**104**	**1,031**
Iconic/Showcase Systems																							0
Desert Knowledge Solar Centre	1.77	27	220		30																		250
Crowne Plaza Hotel	1.75	1	305																				305
Alice Springs Airport	2.2	1	235				250		250														735
Uterne	2.2		969																				969
Araluen	1.75				165																		165
Large (>100kW) Com Roof Top	1.7								200		150		150		100		300		200		150		1,250
Large (>100kW) Com Ground	1.75												500		1,500		500		500		1,000		4000
																							0
Total Iconic Showcase			**1,729**		**195**		**250**		**450**		**150**		**650**		**1,600**		**800**		**700**		**1,150**		**7,674**
TOTAL		**499**	**3,104**		**325**		**430**		**700**		**520**		**1,050**		**2,100**		**1,300**		**1,400**		**1,820**		**12,749**

Commercial Ground Mount

The moderate scenario assumes the installation of a number of larger, but generally <1MW installations installed “behind the meter” at locations such as the prison, the cement works and at the airport.

CSP

The moderate model assumes that a reasonable sized investment would be made in the development of a Solar Thermal demonstration centre building on DKASC that would allow for the installation of around four different solar thermal technologies. Siting could be adjacent to the DKASC, or near the Owen Springs power station, for example. The demonstration CSP plants would operate at a lower capacity factor than would commercial plants, depending on the level of R&D activity involved, A total effective level of installation from this might be around 5MW.and have been assumed to generate 3.5kWh/kW.

Solar Contribution

The various measures assumed within the moderate scenario would provide for around 22% of the forecast energy demand by 2020 from a combination of PV and CSP, with peak penetration of PV reaching 50% of the midday peak in winter.

Test & demonstration facilities

Any central generation plant would need to be monitored in detail, and where feasible also made available for trials of different operating strategies, storage options or other tests. A world-leading demonstration facility would need to allow access to local and international researchers for these trials and also to cater for visitors from other jurisdictions, including other utilities, politicians, solar industry, financiers and the public, wishing to inspect the site and gain detailed information.

This would require specific engagement by the NT Government to support new research activities that build on and develop the profile of the DKASC and the broader activities in Alice Springs. Additionally it would, as noted above, require the development, with support from ARENA, of a specific Solar Thermal testing and demonstration facility. There is a strong case for such an expanded centre in Australia and Alice Springs can make a strong case for hosting such a centre. Appendix 6 discusses the issues in detail.

With about 16% of residential houses assumed to have PV systems, in particular locations of higher than average penetration, there may be noticeable impacts on the grid in terms of voltage rise, reverse power flow and power quality impacts. A number of approaches can be taken to minimise these impacts as well as take advantage of the ability of grid-interactive inverters to improve power quality. This would provide a very useful opportunity to test and demonstrate the different possible approaches, especially those that required DSM and end-user participation.

Community and stakeholder engagement

The moderate scenario relies on an active level of engagement with a variety of agencies and bodies including PWC and departments of the NT. It is likely that some uptake of PV at the residential and commercial-scale will occur in line with increases in cost effectiveness and where there is end-user interest in installation and so little community and stakeholder engagement would be required.

Education and training

In order to achieve the moderate scenario, active engagement by PWC for staff training would be required, both for system operation and public and other stakeholder information. Additionally, a broader group of suppliers and installers would need to be developed to ensure that the long term needs of the market can be sustained.

This may require higher levels of engagement by the educational sector to ensure that the training needs of the nascent industry can be supported. It is noted that PWC are now supporting a Chair for Sustainable Engineering at CDU and thus have already committed to the development of the future skills base.

Financial and market mechanisms

Depending on the level and structure of retail electricity tariffs, 'moderate' levels of uptake in the distributed generation market may occur in the absence of external funding. However, this will require PWC to maintain the relative cost structures of usage (per kWh) and standing connection charges, and assumes a steady increase in tariffs and decrease in PV prices. In addition, storage and/or enhanced control systems may be needed to increase penetration levels and, in this case, consideration should be given to applications for funding from ARENA or the CEFC to assist with establishing the necessary BOS infrastructure. It is assumed that the level of penetration in the moderate scenario does not negatively affect PWC's ability to either pay off existing infrastructure or manage existing gas contracts.

Depending on the PWC generation costs, some level of external funding support would likely be necessary for central power stations, particularly if storage or enhanced control systems are needed to increase penetration levels. Any of the three loan types discussed above could be considered (loan guarantees, concessional loans, subordinated loans) and may be available from the CEFC, as may CfDs and put options on LGCs. Direct capital subsidies may be available through ARENA.

6.2.3 The Stretch Scenario

It was initially suggested in the terms of reference that a stretch target could involve 100% renewable energy for Alice Springs and the region. In a world in which non renewable energy sources still exist, for grids the size of Alice Springs, numbers like 100% are often impractical in the short term because the cost / benefit relationship is highly non-linear, meaning that the last 10-20% may require measures that are substantially more complex or expensive than those required to achieve the first 80%. Instead, the philosophy of the stretch target is taken to be; the maximum that is practically technically possible with the technology mix that is likely to be available at any particular time.

Appendix 4 has explored the practical limits of meeting supply and demand with currently available solar technology options. It is concluded that a total of 70% electricity contribution from Solar sources by 2020 represents a reasonable stretch scenario.

Achieving the stretch target is likely to require the same additional measures and outcomes listed above for the moderate scenario, with the modification such that a gradual transition is now an accelerated transition, introducing new solar options on a progressive basis to meet the 2020 target, with early retirement of existing assets as required.

Levels of deployment

Following on the analysis in Appendix 4, we have assumed the Stretch scenario is achieved using around 22MWp of PV, a 20MW high capacity factor CSP plant with 40 hours of molten salt storage, together with the existing 35MW of gas-fired generation systems at Owen Springs and the retirement of all units in the Ron Goodin Power station.

Figure 11 and Figure 12 illustrate how such a configuration would work in meeting typical summer and winter sunny day load curves.

In this case study, it is suggested that a 20MW CSP system with 40hours of storage could run essentially as baseload for all days of good sun in Summer. On such days, a further 20MWp of PV (either centralised or distributed) could be added to come close to meeting midday peak demand from the combined solar options. Gas engines to a combined capacity of around 20MW would still be required for filling in, and these would need to be used at a low capacity factor. On days of no sun in Summer, peak load presumably also drops, if a function of air-conditioning. The CSP system could be managed to carry over stored energy to continue generation at a lower level and the gas systems would need to carry the bulk of the load.

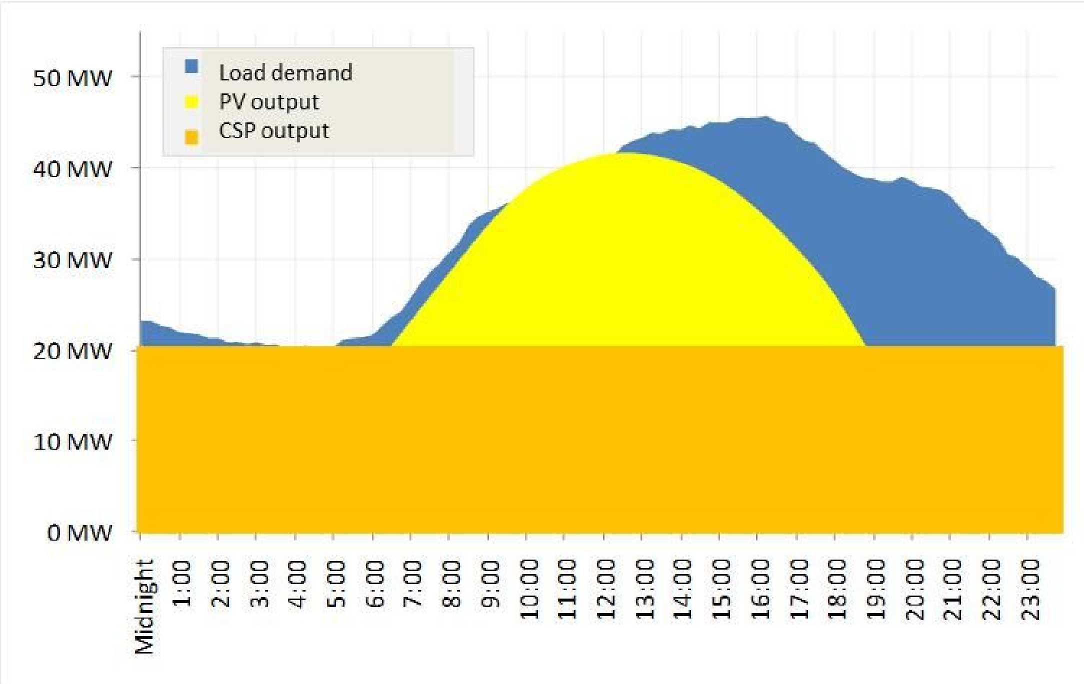

Figure 11: Sunny day summer load, PV and CSP profiles possible under a "Stretch" scenario

In Winter, the average output of the CSP plant would be about 30% less than in Summer. For the sake of this simplistic analysis, it could be considered to operate at a reduced level for most hours, but shut down at periods when the PV output was a maximum. The gas engines would again need to contribute at up to 20MW to meet demand. On non-solar days in Winter, CSP energy could be managed such that operation for at least some hours in the morning and evening peak was achieved. In this way the peak capacity needed from the gas engines could be kept to a level below 30 MW.

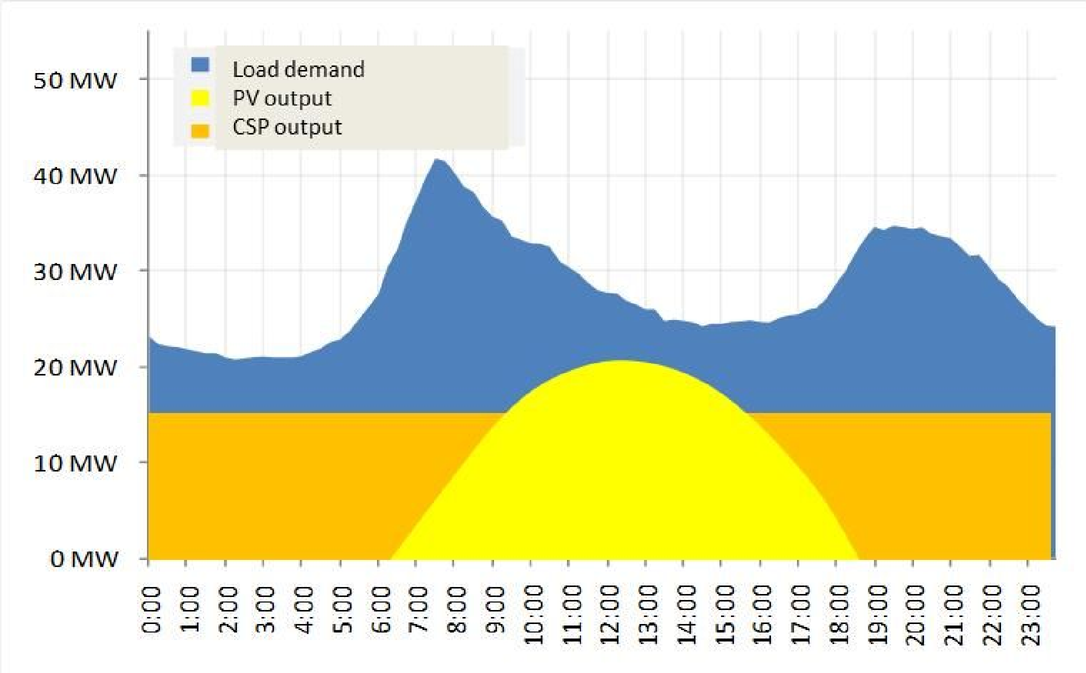

Figure 12: Sunny day winter load, PV and CSP profiles possible under a "Stretch" scenario.

Table 19 shows the assumed level of PV deployment within the Stretch scenario. The following then describes the assumptions required to support the Stretch scenario.

Residential

The primary assumption for the Stretch Scenario is that PV is installed in 60% of privately owned residences (around 3,600 houses) and 25% of rentals (around 600) by 2020, with the primary driver of rental properties with PV being previous owner occupied residences becoming rental. Average house turnover in Alice Springs is 5 years.

Commercial Rooftop

There are approximately 200-300 larger commercial roof top systems (warehouses, Work sheds etc) which have the potential space to install systems averaging around 10kW. Note that many of the shed structures use purlin based shed design, limiting total load and panel spacing.

The Stretch Scenario assumes a total penetration of the smaller commercial roof top market of around 50% (117 properties) with higher growth in the years 2018 and 2019 due to better economic conditions and settling of Carbon Pricing.

Large Commercial Roof top

Around 10 opportunities for large 100kW+ size roof installations exist (excluding schools etc which already generally have PV installed). The stretch model assumes that 80% of large commercial roof tops have PV installed, with an accelerating deployment from 2017 due to upgrades of existing buildings and other associated infrastructure.

Critically, this stretch objective assumes high levels of PV deployment on government-owned assets, including schools and community buildings.

Table 19: PV Deployment under the Stretch Scenario

				2012		2013		2014		2015		2016		2017		2018		2019		2020		Total	
	GWh/A	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW	#	kW
Installed under ASC program	1.7	283	566		0		0		0		0		0		0		0		0		0	283	566
Installed outside ASC program	1.65	177	428	50	100	##	200	##	300	##	300	200	400	200	400	200	400	300	600	300	600	1827	3,728
Total Residential		**460**	**994**	**50**	**100**	**##**	**200**	**##**	**300**	**##**	**300**	**200**	**400**	**200**	**400**	**200**	**400**	**300**	**600**	**300**	**600**	**2110**	**4,294**
Commercial Systems																							
Installed under ASC program	1.75	35	367		0		0		0		0		0		0		0		0		0	35	367
Installed outside ASC program	1.7	4	14	3	30	3	30	5	50	7	70	10	100	10	100	15	150	15	150	10	100	82	794
Total Commercial		**39**	**381**	**3**	**30**	**3**	**30**	**5**	**50**	**7**	**70**	**10**	**100**	**10**	**100**	**15**	**150**	**15**	**150**	**10**	**100**	**117**	**1,161**
Iconic/Showcase Systems																							0
Desert Knowledge Solar Centre	1.77	27	220		30																		250
Crowne Plaza Hotel	1.75	1	305																				305
Alice Springs Airport	2.2	1	235				250		250														735
Uterne	2.2		969																				969
Araluen	1.75				165																		165
Large (>100kW) Com Roof Top	1.7								200		150		150		100		300		300		500		1,700
Large (>100kW) Com Ground	1.75												1,000		1,500		2,500		2,500		5,000		12500
																							0
Total Iconic Showcase			**1,729**		**195**		**250**		**450**		**150**		**1,150**		**1,600**		**2,800**		**2,800**		**5,500**		**16,624**
TOTAL		**499**	**3,104**		**325**		**480**		**800**		**520**		**1,650**		**2,100**		**3,350**		**3,550**		**6,200**		**22,079**

Commercial Ground Mount

The commercial ground mount stretch objective is predicated on 7 significant sites being developed around the Alice Springs Grid with the respective developments targeted to relieve grid congestion. Total large ground mount deployment is assumed to reach 12.5MW. Notional locations for these deployments, based on existing grid capacity and availability of land are:

- An additional 2 MW at Uterne in two 1MW tranches
- 1 MW in or around the Kilgariff subdivision/AZRI/Airport area
- 1.5 MW in the land immediately adjacent to Lasseter's casino behind the existing golf course
- 1 MW proximate to the existing road house on North Stuart Highway
- 2 MW proximate to the primary water pumping stations to the North of the Prison
- 2 MW within the Illparpa Sewage treatment plant
- 1 MW on Ross Highway adjacent to the community of Areyonga.

These are notional developments only, and are based solely on the availability of vacant land without specific assessment of extant title.

Large Iconic Installations

Within the context of the stretch objective, the larger installations become iconic in their own right. To that end, no further installations have been classified as iconic for the purpose of this report.

PV Summary

The stretch objective results in a total PV peak contribution of approximately 90% of peak midday winter demand and around 20% of total annual consumption.

Higher level integration of PV beyond this point is not considered as necessarily desirable or viable without the integration of localised storage. Existing technology and pricing trends suggest that local, decentralised storage may be available to serve the market within Alice Springs by 2020. However, given the lack of reliable data to support such projections, it has not been incorporated into the model.

CSP

The primary driver of the stretch objective is a single high capacity factor (>6kWh/kWp) 20MW solar thermal power plant to be developed, most likely adjacent to the existing power station at Owen Springs. At 20MW, this represents a smaller than average CSP plant size by world standards, however the high level of energy storage, and correspondingly larger relative solar field size, mean that overall it is closer to a typical commercial project size. Given these constraints, there is not the same opportunity to consider a progressive deployment profile over time, as contemplated for PV. It would however be possible to build the system in two or three stages if desired, possibly beginning with a full sized power block but half the field and storage capacity to begin with. The major planning decision would be in which year prior to 2020 to consider construction. As outlined in Appendix 5, waiting to close to 2020 would be expected to result in major cost savings. On the other hand, moving immediately would represent a major leadership initiative. This would be contingent on funding from ARENA or other sources, analogous to a modified version of the solar flagships program.

Locating the CSP plant adjacent to the reciprocating gas engines at Owen Springs allows for more optimal power system control and management. As illustrated in Figure 10, there is un-developed land adjacent to the site that could possibly be used for this. Co –location allows use of common infrastructure such as maintenance workshops etc. It also allows easy connection to gas supplies for back up salt heaters. There are also further possible synergies that could be contemplated, such as capturing heat from exhaust from the gas engines for extra input to the salt / steam system of the CSP plant.

Wider issues

A rather perverse outcome of increasing the solar contribution to Alice Springs is that according to the RET Rules, if installed capacity rises above 100MW in a particular grid,[26] all purchases of electricity from that grid become liable under the renewable energy target. Alice Springs is close to that limit and so adding low capacity factor solar systems could increase the likelihood of passing it, depending on the ownership structures used. This would result in an extra financial burden for the NT. This is most likely to occur for this Stretch scenario and highlights the importance of energy efficiency and peak load management measures that would allow fossil fuel-based generators to be permanently retired. Assuming that annual demand is constrained at around 2010 levels, only about 75MW of generation capacity would be required.[27]

It is also understood that the fuel cost contribution to the cost of generation is in the range of $140 - $150/MWh. If the Levelised cost of investment were also included, the LRMC would be in the range of $150 - $170/MWh. It could thus be argued that a large-scale solar system that was able to offset the addition of a further gas-fired generator should in principle be producing value equal to this plus the LGCs produced (Say $35/MWh), ie $185 - $205/MWh. Offsetting a new generating unit with solar would require addressing needs related to backup and spinning reserve etc and would most likely require a system with energy storage.

However there are other complicating issues. It is understood that PWC has a "take or pay" contract for gas out to 2030, that includes an increased volume for each year between now and 2030. Thus installing solar may not necessarily realise the apparent fuel saving. On the other hand, it is possible that PWC could find a use or customer for that gas anywhere along the pipeline between Darwin and Alice. The situation around the gas contract is complex and evolving. Alice Springs consumption represents only slightly more than 10% of the contracted gas volume. It is understood that PWC has gas in reserve due to prior lower consumption levels than the contract specifies and so is already actively looking for other customers. It is quite possible demand will grow and switch to a point of demand exceeding supply. A facility for export of LNG from Darwin is due to come on line soon. With international demand and prices strong, this could also provide an opportunity for PWC to sell on its obligation, possibly at a profit. However whilst a small interconnection exists between the Black Tip and the export systems as emergency backup, there is not at present any agreement for free two way trading. If demand drives prices up overall, then installing solar systems may actually bring a hedging value against higher gas prices post 2020.

Test & demonstration facilities

At least one of each type of system installed would need to monitored in detail and made available for testing and demonstration purposes, as in the moderate scenario. More systems would be expected, with examples of a range of technologies suitable for use in regions with similar climates and power systems. These would need to be kept up-to date with the latest technology.

In this scenario about a quarter of houses are assumed to have PV systems, and so, as for the Moderate scenario, grid impacts would be expected. Thus, again, this would provide a very useful opportunity to test and demonstrate the different possible approaches to both minimising potential negative impacts as well as harnessing potential positive impacts.

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[26] Note that this is excluding standby or emergency plants and privately owned grid connected domestic generators. Thus the wording of the rules may still allow for high levels of solar, but careful consideration of the definitions will be needed

[27] Note that STCs and LGC's can be created regardless of whether that grid has a RET obligation.

The idea of expanding to CSP test and demonstration, as described for the moderate scenario, would also be incorporated in the stretch scenario. In this case it would probably make sense to co-locate with the main commercial CSP system at Owen Springs. It may well be possible to facilitate small test systems by accepting steam into the main power block.

Community and stakeholder engagement

Within the stretch objectives, the high level of takeup of both PV and CSP would require significant levels of community and stakeholder engagement. This would necessarily be achieved through the continued active support of Alice Solar City. Specifically, this would require the Northern Territory Government to provide ongoing funding of Alice Solar City to stimulate and maintain the level of community engagement and knowledge sharing required to achieve the targeted level of PV penetration. Alice Solar City will need to play a critical role in stakeholder management with PWC, advocating on behalf of residents and businesses with PWC for connections, as well as working with suppliers and installers to develop cost effective solutions for Alice Springs, ie bulk procurement contracts.

Additionally, the requirement for the continued support of Alice Solar City and the deployment of larger centralised PV and CSP plants would require a high level of engagement with a large number of stakeholders to ensure that many of the following range of issues are effectively dealt with:

- Access to land
- Environmental impacts
- Land use
- Water for CSP (if not air cooled) or PV cleaning
- Transparency in the PPA process
- Subsidy requirements
- Cross subsidies for end users
- New subsidies for solar technologies if costs are higher than current generation
- Grid integration of large power plants and implications for
- Control strategies and equipment
- Solar forecasting
- Storage requirements
- Demand side management opportunities
- Operational integration with possibly large amounts of DG in the Alice Springs area that might occur under either the moderate or stretch targets.
- Planning lead times
- New transmission lines to large solar power stations
- Trained personnel, especially for on-going O&M
- Support services for spare parts
- Large capital requirements.

Education and training

It will not be feasible to aim for a stretch target without significant commitment to the development and maintenance of a pool of locally based, trained technical support personnel. If a long-term target is set, there will be time to establish relevant programs from school through to TAFE and tertiary education, which will provide jobs for locals, and attract new residents to the area, including experienced trainers. As previously mentioned, if the target is to be met in a short time, it is more likely that people from other regions will be brought in for a short time and little local capacity will be established. It can take a decade or more to establish a successful university research centre, and continued resourcing will be necessary in order to attract top academics and research students. Nevertheless, an active solar centre with resources to facilitate trade and professional training in solar energy and related technology would provide a compelling case for establishing courses through CDU for local and international students. The existing model of online delivery already adopted by CDU, combined with the campus facilities and accommodation available in Alice Springs would make short courses and professional development an achievable option even in the short term. Full degree courses will take longer to establish.

Additionally, the level of technical integration by PWC with the various power supplies may exceed their ability to recruit and retain the necessary skill base to support the integration. Active consideration may then need to be given to different mechanisms that could be used to build local capacity, including employment sponsorships, small business grants etc. Nevertheless, it is understood that PWC is already supporting a Chair in Sustainable Energy at CDU, so that they are already anticipating the educational needs of future engineers and employees.

Financial and market mechanisms

The existing and forecast pricing of PV systems both at the residential level and the medium and large commercial level is such that it is not anticipated that direct financial subsidies would be required to stimulate this higher level of PV uptake. Indeed, if financial incentives were required to support the broader deployment of PV, then removing existing subsidies from the energy market would provide an equivalent level of financial incentive to deploy PV at a residential and commercial level. However, new energy market arrangements will be needed if optimum solutions are to be found. This could include facilitation of new energy service providers, including, for instance, those wishing to sell longer term solar electricity supply packages to customers, rather than the systems themselves.

The deployment of large-scale PV participating in the wholesale market is assumed to be financed through long term PPA's with PWC, but would need additional financial assistance. Large-scale PV is not envisaged to be deployed until 2016, by which time the installed costs of PV would have declined and, if gas costs have increased, the wholesale electricity price could well have increased. Thus, either a low interest loan from the CEFC or a subsidy (of around 25%) from ARENA could be sufficient to make large-scale PV financially viable.

To date, it appears that PWC has shown a willingness to undertake renewable energy projects, within the framework of a power purchase agreement (PPA), when a fair and competitive price is offered. A general barrier to determining a fair and competitive price by renewable energy technology proponents and developers is the limited understanding of the real marginal costs of generation within the NT energy markets.

In the stretch scenario, the possibility of a single large 20MW CSP system configured for baseload operation is analysed. Such a system could in principle be installed at any time between now and 2020. As shown in Appendix 5, cost reductions could be substantial over that time frame. If action was delayed until 2018, it is possible that a PPA that reflected costs of new gas driven generation at that time, plus attractive debt finance, would allow such a plant to be built. However there is merit in attempting to act sooner. With the CSP project in round 1 of Solar Flagships in doubt and round 2 now rolled into ARENA, a good case could be made for making Alice Springs the site for an alternative flagship project. A 30% capital grant, together with favourable finance through the CEFC and with a PPA from PWC that recognised the full avoided costs of new gas generation and the value of LGC's, should come close to making such a project viable.

In order to achieve the stretch objective, two critical financial market interventions would be required:

Government Building Energy Use – The existing policy framework that results in flat rate energy tariffs for government buildings, coupled with energy savings being achieved by individual government business units, departments and schools being absorbed back into consolidated revenue would need to be changed. As energy savings are absorbed back into consolidated revenue, there is little to no incentive for individual building managers or government tenants to engage in energy saving activities or to invest in assets such as PV, as the capital costs are borne from their local budget, but the savings are yielded back to the parent department or agency.

Bulk Gas Procurement – the existing bulk gas contracts have created a short to medium term dis-incentive to drive the uptake of higher level penetrations of renewables. This may well be resolved through the broader development of liquefied natural gas processing through the IMPEX development, thus creating a greater demand for the unused gas allocations from the existing gas contract. If however, this does not proceed, finance may need to be provided to allow for the absorption of costs associated with acquitting the contractual obligations of the "take or pay" gas contract.

6.3 Electricity supply in Remote communities

Figure 13 shows all the power stations currently serviced by IES Pty Ltd and their respective energy sources.

Figure 14 shows the indigenous communities currently not serviced by PWC or IES Pty Ltd.

More specifically, Figure 15 shows the existing outstations that are served by Bushlight, with either a Bushlight system (red dot) or which have Bushlight providing maintenace and operation services as well as general training and capacity building (Blue diamond).

As many of the pastoral stations, remote communities and mines draw on the same pool of technical suppliers and contractors, for all the criteria other than "Level of deployment" the end-use categories have been combined for discussion.

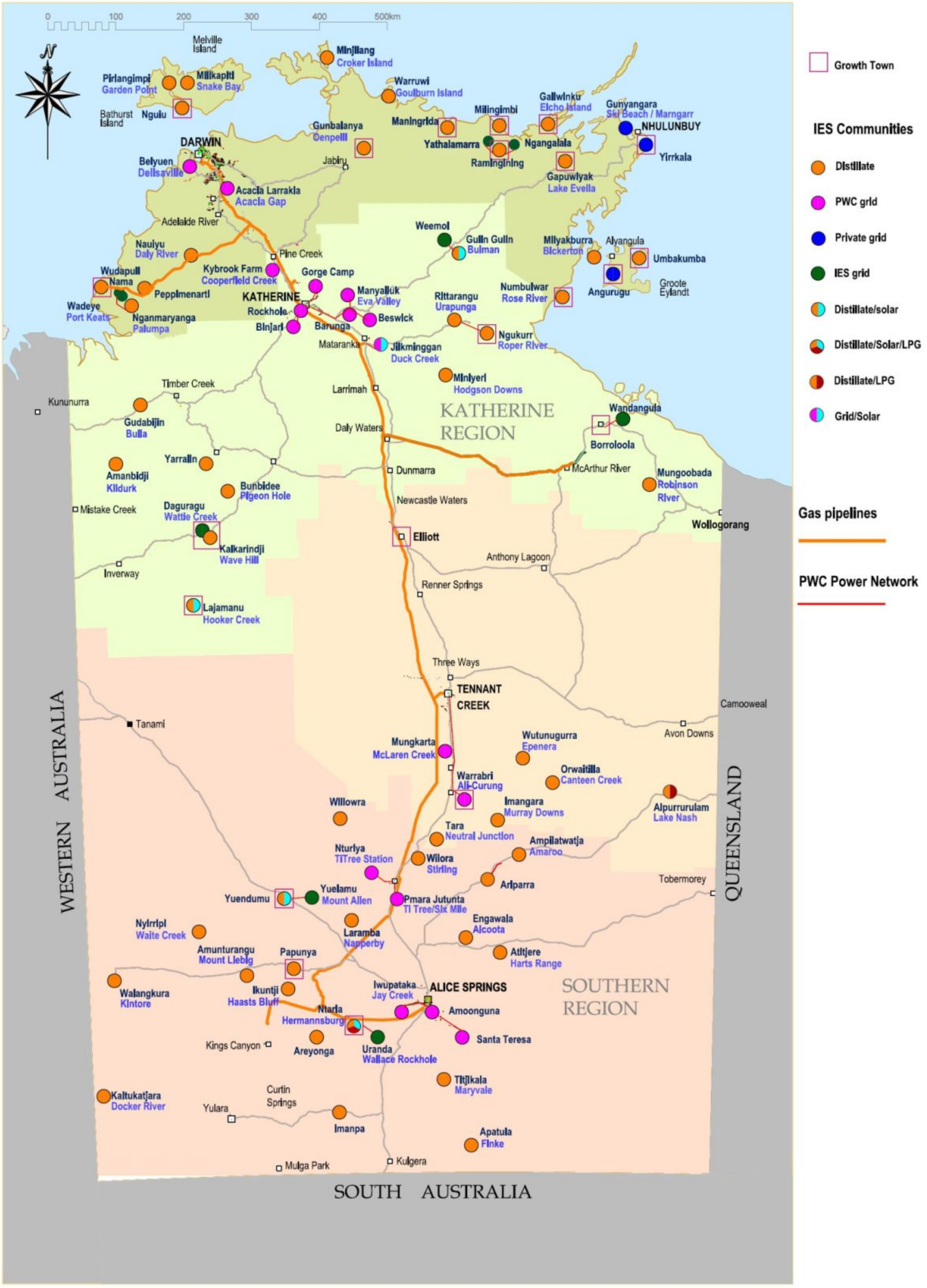

Figure 13: Energy sources used by IES Pty Ltd to provide essential services to Indigenous communities in the NT

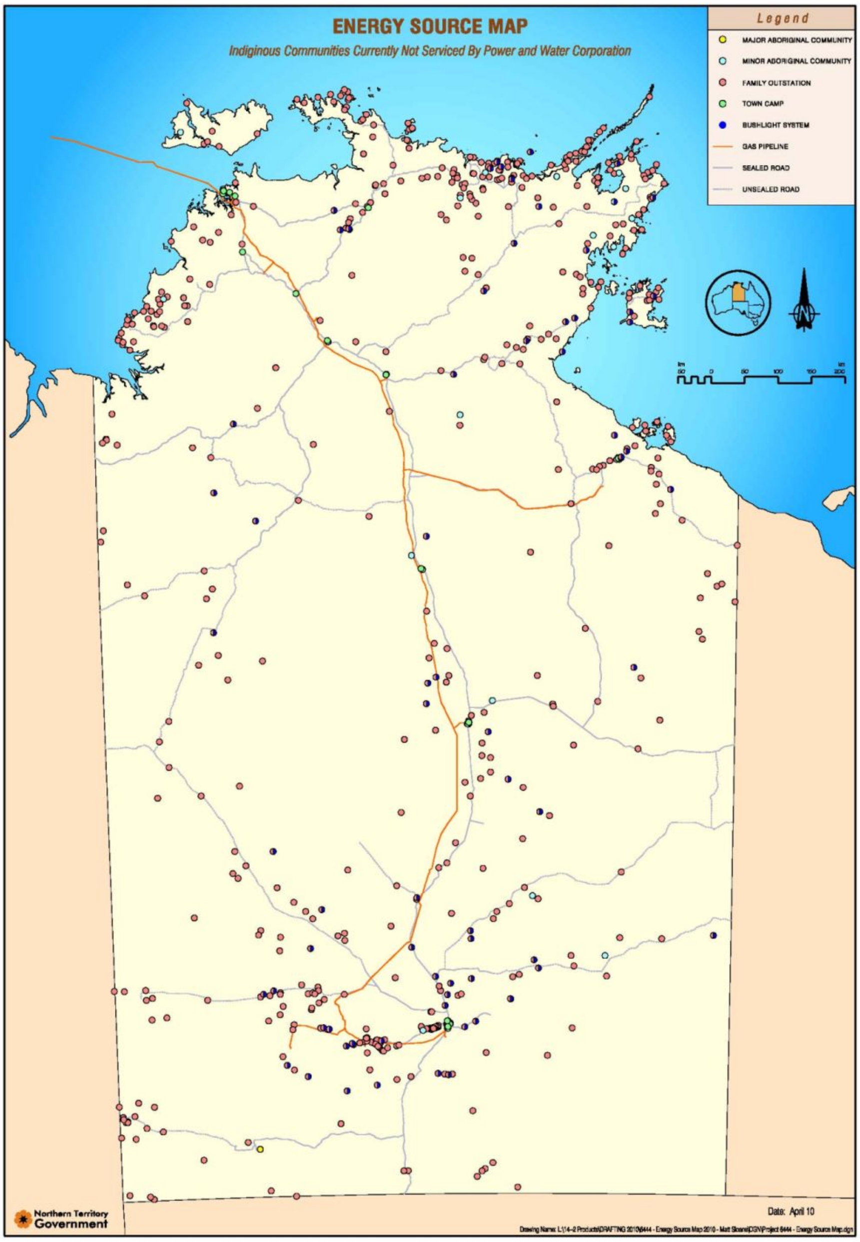

Figure 14: Indigenous communities not serviced by PWC or IES

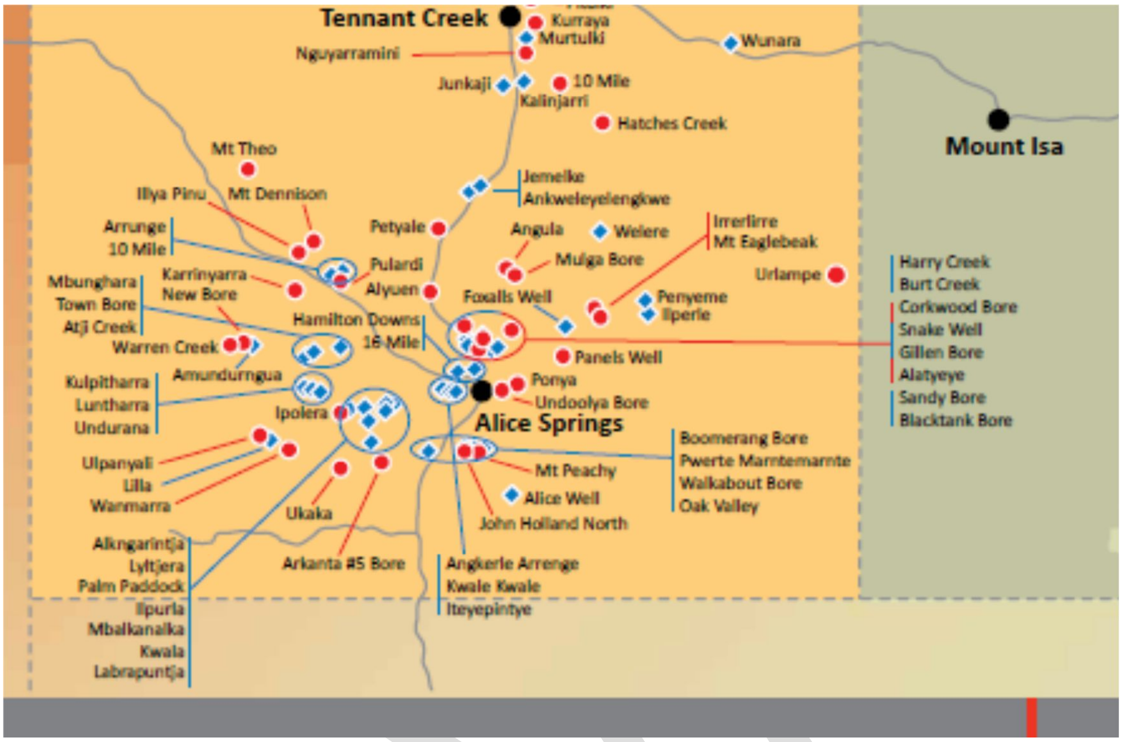

Figure 15: Remote communities in Central Australia, showing renewable energy systems installed (red dot) and managed (blue square) by Bushlight.

6.3.1 Business as usual

Levels of deployment

Outstations

As noted previously, the majority of Aboriginal Outstations in central Australia either have a Bushlight system, or have a hybrid system that is managed by Bushlight – the opportunity to upgrade to higher levels of PV is constrained within BAU.

IES Communities

Four IES communities currently have a combined total of 1MW of PV, with existing plans to increase this by a further 2MW as part of the BAU plans between 2012 and 2020. The BAU strategy for PWC/IES is based on low penetration PV (20-30% peak demand contribution) with zero storage.

The communities shown in Table 20 are likely to have some level of low penetration PV by 2020 in the BAU scenario

Pastoral Stations

The majority of pastoral stations within Central Australia have some degree of PV deployed within hybrid diesel power plants, with a similarly high level of usage of PV for remote bore pumping. The hybrid power stations generally operate with around 50% solar penetration, with gensets operating for approximately 6 hours per day on average.

Within BAU it is assumed that this market does not further evolve.

Table 20: Remote communities with potential for PV uptake

	Installed Generation Capacity(kW)	Current Energy Source
Ampilatwatja (Aherrenge)	635	Diesel
Areyonga	690	Diesel
Atitjere (Hart Range)	740	Diesel
Canteen Creek (Owaitilla)	435	Diesel
Engawala	250	Diesel
Finke (Apatula)	590	Diesel
Haasts Bluff (Ikuntji)	430	Diesel
Imanpa	475	Diesel
Kaltukatjara (Docker River)	665	Diesel
Kintore	920	Diesel
Laramba	700	Diesel
Mt Liebig	515	Diesel
Nyirripi	480	Diesel
Palumpa	960	Diesel
Papunya	1,070	Diesel
Titjikala	720	Diesel
Willowra	680	Diesel
Wilora	210	Diesel

Ranger stations

NRETA has a current project for the deployment of solar PV hybrid power systems in all its remote ranger stations, with penetration levels resulting in diesel reductions of 80% on average. This program is presumed to continue under Business as Usual.

Mine sites

There is currently only one operational mine within central Australia (the Tanami Mine) which does not have any PV within the BAU model.

Test and demonstration facilities

There are currently no formal test or demonstration facilities in remote communities, although many systems, such as those installed by Bushlight, are monitored. This situation is likely to remain under a BAU scenario.

Community and stakeholder engagement

Under a business as usual scenario, the existing programs for engaging with local communities would be maintained and, other than through Bushlight, there would be no specific community engagement activities targeted at energy management or reduction.

Education and training

The business as usual model would require the ongoing support of the local education supply base. Trade training in system operation and maintenance, as well as initial installation would provide new jobs and opportunities in remote area. Such training would also be of interest to the wider Australian and Asia-Pacific communities.

Financial and market mechanisms

The BAU scenario assumes that the existing marginal costs of generation in most areas are sufficient to support the broad-scale deployment of low penetration renewables.

6.3.2 The Moderate Scenario

Levels of Deployment

The moderate scenario would involve a more rapid uptake of PV within the IES communities, resulting in a total of approximately 5MW installed through to 2020, and no additional uptake in remote outstations or pastoral stations.

The moderate scenario includes a 1MW PV power plant for the Tanami mine.

Test and demonstration facilities

Under this scenario, test and demonstration would most likely be limited to expansion of the approach taken through existing facilities; specifically this would include the development of a stand-alone hybrid power station facility at the DKASC where different control strategies and optimisation techniques could be deployed.

Community and stakeholder engagement

A moderate scenario would require the deployment of reasonably proactive community engagement strategies to work with residents within remote Aboriginal communities to understand energy consumption patterns and the degree to which various incentives may drive behaviour changes that would support the broader uptake of high penetration renewables.

Additionally, a detailed strategy for the replacement of existing prepayment metering systems would need to be developed and may include the opportunity for in-house metering and active demand management to be trialed.

Education and training

Programs like Bushlight have developed valuable processes and experience in delivery of sustainable energy systems to remote communities, but this approach has required significant external funding. Maintaining this level of support will almost certainly be necessary if high levels of solar uptake are to be achieved. Training of local maintenance staff will certainly be required, as will supply channels for spare parts. Both of these will likely have different requirements from those established for Alice Springs. Education and training initiatives would be explored to the maximum practical extent under a moderate scenario.

Financial and market mechanisms

The moderate scenario does not require any additional direct financial support for system installation, but would require funding for expansion of the necessary test and demonstration facilities, community and stakeholder engagement and education and training.

However, removal of existing cross-subsidies, such as those provided by the Department of Housing and Local Government to other NT Government agencies consuming electricity in remote communities, would be required in order to provide greater and more transparent arguments for generating cost reductions. The cross-subsidies are well known by those providing them. This in turn would provide IES Pty Ltd with the institutional support required to adopt more aggressive implementations of solar technologies.

6.3.3 The Stretch Scenario

Levels of Deployment

A stretch scenario for the off-grid market would see 20% of the IES communities with high penetration PV, with battery storage operating as full hybrid systems, resulting in deployment of a combined 8MW of PV.

No additional uptake in outstations or pastoral stations is assumed, nor is there an increase in the penetration of renewables in the ranger stations.

The primary opportunities that exist for a significant CSP project are at either the Tanami Mine or at the Yulara resort adjacent to Uluru.

Test and demonstration facilities

Under this scenario, test and demonstration would be highly desirable and could be expanded to not only technical monitoring but also the social aspects of such high penetration in remote communities.

This would include the development of a storage technology test and evaluation centre that would be used to test both battery/other storage durability and battery/inverter interactions and topologies.

It is likely however that the most effective location for much of this test and demonstration role would be at the Alice Springs located sites. For example off-grid demonstration systems, either PV or CSP, configured for pastoral, community and mining applications, could be installed in Alice Springs to provide accessible demonstration to support commercial deployment around the whole country, not just southern NT.

Community and stakeholder engagement

For the stretch objective, extremely active, targeted community engagement would need to be undertaken to work with remote communities, to challenge existing patterns of energy consumption and presumptions regarding equality of service expectations within remote communities versus that available in regulated markets.

This may include changes to the structures of existing CSO support processes that are “invisible” to the consumer. For example, in lieu of subsidising energy costs directly to IES Pty Ltd, the NT Government may consider a proposal to provide direct support payments to households for EE and DSM, equivalent to the level of subsidy currently provided, but then allow IES to charge a full cost recovery tariff, thus providing a higher level of household incentive for energy savings. This would need to be accompanied by proactive access to energy efficiency and demand management options, as well as suitable renewable energy and storage technologies. An alternative would be to use the funds for targeted programs that undertake EE and install PV directly.

Education and training

Under a stretch scenario, the same level of activity in education and training as the moderate scenario would be expected. However, the interest generated by having a world-leading solar centre would provide added opportunities to target education and training in off-grid solar applications to the wider Australian and international communities. The online course delivery already established in CDU provides an excellent base on which to develop this education market.

Financial and market mechanisms

As noted previously, the existing pricing of diesel is sufficient to support much of the proposed stretch activities in all markets other than mining. Again, additional funding would be required for expansion of the necessary test and demonstration facilities, community and stakeholder engagement and education and training.

An important issue for the mining sector is the typical financial planning need for an asset life that is equal to, or less than, their advertised mine life. As for the primary Alice Springs market, any of the three loan types discussed above could be considered (loan guarantees, concessional loans, subordinated loans), as could CfDs and put options on LGCs. Direct capital subsidies may be available through the CEFC or ARENA.

Proactive intervention from the NT government may be needed regarding the treatment of diesel fuel subsidies, the depreciation period for solar equipment, tax pass-through arrangements and other such support mechanisms in order to accelerate solar uptake in this sector.

7 Discussion and Recommendations

The NT has high energy generation costs and a substantial Community Service Obligation (CSO) budget commitment[28], thus providing significant incentive to reduce energy consumption and deploy alternative generation sources. Nevertheless, there are many consequences of increased uptake of solar[29]. The most significant will be the impact on the existing electricity generation and transmission/distribution assets, and how those assets are paid for. Uncontrolled expansion of solar without storage can reduce power quality, and can increase the cycling rate and spinning reserve requirements of conventional generators as well as the strain placed on the network due to, for example, reverse power flow and power fluctuations. Significant reductions in the amount of electricity bought from the network because of DG can also negatively affect the financial viability of generators and network operators, depending on their regulatory environment. The need to pay for stranded assets may be passed onto end users, and if this occurs through higher electricity usage prices, it will act as a driver for increased uptake of DG, further exacerbating the problem.

Conversely, through appropriately configured grid-interactive inverters, solar PV can improve power quality, and concentrating solar thermal with storage, as well as distributed storage options, can provide dispatchable power. Integrating these various generation options with demand side management and energy efficiency can improve the operation of the entire energy network – although such approaches result in higher complexity and associated management requirements. How well these various issues are managed will in turn have a significant impact on the final level of uptake.

Whilst the terms of reference for this study suggested that a stretch scenario of 100% solar energy by 2020 could be investigated, this level of penetration would be extremely impractical. Thus, the stretch scenario has been defined as 70% of annual energy demand being met using proven and available technologies. For example, this could be achieved using 20MWp of PV, a 20MW high capacity factor CSP plant with 40 hours of molten salt storage, together with the existing 35MW of gas fired generation systems at Owen Springs and the retirement of all units in the Ron Goodin Power station.

The higher levels of solar penetration discussed in this report provide an enhanced opportunity for the Desert Knowledge Australia (DKA) Solar Centre to extend its current role to monitor and analyse grid impacts, and to undertake underlying solar research which will consolidate its status as a world leading solar research centre. The lessons learned from implementing a range of solar strategies in the Central Australian Solar Centre will be internationally valuable. Having such a facility in Central Australia will encourage local and international researchers to undertake further research in Alice Springs and the surrounding areas, with implications for educational and tourist potential.

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[28] The Northern Territory Government currently spends over $60 million per year on Community Service Obligation power supply cross-subsidies and estimates $100 million per year will be needed by 2014 (NT Government Budget Papers, Community Service Obligations, Budget Paper 3: (http://www.budget.nt.gov.au/papers/bp3/community_service_obligations.pdf).

[29] According to the Green Energy Taskforce, in 2011, the cost of the most developed renewable technologies, relative to the marginal cost of generation within the regulated market, meant that the NT Government would have to provide a substantial subsidy, by way of capital injection or ongoing price support, to meet the objective of meeting the 20% RET obligation from NT sources by 2020 (equivalent to our 'Moderate' scenario). It was estimated that the cumulative value of this subsidy between 2013 and 2020 would be between $60M and $110M. **I would have thought we should comment on this. We are saying that PV is already cost competitive and so the only direct funding would be for CSP. There is also the funding for test and demonstration facilities, community and stakeholder engagement and education and training. Note: these figures are currently only indicative and should be confirmed or amended on the basis of additional review and modelling. Were this further review to suggest that the subsidy is more likely to be at or below the lower figure, then the Taskforce would recommend that the Government intervene to specifically subsidise solar thermal or solar PV, to address its twin objectives of meeting the RET liability from NT sources and developing the Territory's renewable energy industry

There is a strong case for a major expansion of the role played by the DKA centre to encompass larger demonstration systems and CSP activities. Alice Springs is blessed with excellent solar resources, it has good supporting infrastructure and it can be visited easily via an airport conveniently located near likely sites and serviced by regular flights from all capital cities. It is the best location for such a Centre in Australia. It could also offer a very attractive opportunity for international collaboration with researchers and companies from the Asia-Pacific region. Associated education and training opportunities would also be viewed with keen interest in the region, providing another valuable employment income and stream.

The following recommendations are therefore proposed:

- The 'moderate' scenario be adopted as the starting point for Central Australia and Alice Springs as it represents a no regrets overall least-cost approach that best capitalises on the infrastructure and capacity developed as a result of the Alice Springs Solar City, Desert Knowledge Australia Solar Centre, Bushlight and other recent programs. Without a pro-active program in place to maintain and enhance them, these established facilities, the expertise associated with them and the profile created, will be dissipated.
- Some version of the 'stretch' scenario is highly plausible and consistent with a goal of a world leading position. It should be analysed in more detail to select at least some components which can be pursued via ARENA, the CEFC, education or other budgets in the short term.
- Existing plans to extend the Owen Springs power station and retire the Ron Goodin Power station, together with forward planning around gas contracts and network augmentation, should be reviewed in detail to seek savings and least-cost solutions that could accompany a move to high solar contributions.
- The policy frameworks underlying energy supply and demand should be examined to ensure that decisions taken by government agencies are consistent with achieving the 'moderate' scenario goals. As cost gaps reduce, regulatory aspects of energy sector operation, including reliability criteria and supply side preferences, will become more significant barriers and regulations may need to be revised.
- Government-owned buildings currently benefit from a bulk purchase contract with PWC for low-cost electricity. In addition, the occupiers of these buildings don't pay for their electricity use. As such, the financial incentive for uptake of energy efficiency and solar is significantly reduced, and the low-cost electricity provides no net benefit to the NT government as a whole. Consideration should be given to providing appropriate signals and mechanisms to encourage uptake of EE and solar, with those responsible for taking action benefiting from the savings.
- Government procurement procedures should be examined so that planning is consistent with the agreed targets and so that decisions are made in light of the actual costs incurred for energy supply, not the cross-subsidised cost.
- Long-term commitments should be made to educational outcomes at all levels, since the availability of local personnel with training and expertise in solar will be an essential component of maintaining and expanding on current levels of solar use and ensuring quality installations and O&M availability. It will also facilitate the establishment of more local solar businesses as well as expanded research and development capabilities.
- The Alice Springs Solar City should continue to be supported so that it can maintain and extend its activities, especially with regard to information dissemination and advice. As penetration levels of solar extend from early adopters through to mainstream consumers, the marketing needed will increase.
- Resources should be provided to the Solar City to enable it to be pro-active in promotion of the Solar Centre for educational purposes, energy events and relevant sectors of the tourist market.

- A detailed feasibility study into establishing an expanded solar test centre should be carried out that includes preferred site selection, cost analysis and negotiation with federal government and possible international stakeholders should be considered.

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Appendices

Appendix 1: International Research and Demonstration Centres

There are a range of solar energy research and demonstration centres around the world. Centres that involve CSP technologies are typically larger and more visible to the general community. Centres range between a strong focus on pure R&D through to more commercially focussed centres for testing and demonstrating pilot scale commercial systems.

The following listing is not comprehensive, however, it covers the highest profile sites and gives examples across the spectrum.

Switzerland PSI www.sollab.eu/psi.html

The Paul Scherrer Institute in Switzerland is a major research centre that hosts a solar technology laboratory in conjunction with ETH Zurich. Facilities include:

- a 40-kW 5,000-suns solar furnace;
- a 50-kW 11,000-suns high-flux solar simulator;
- two 75-kW 5,000-suns high-flux solar simulators; and
- physical chemistry laboratories.

This is much very much a fundamental research facility.

US Sandia www.sandia.gov/Renewable_Energy/solarthermal/nsttf.html

The Sandia National Laboratories, based in Albuquerque, New Mexico, hosts the National Solar Thermal Test facility.

Figure 16: Sandia site

It includes a solar furnace and experimental solar tower facility for fundamental research. Of more relevance to the NT proposal, is its role in hosting tests and demonstrations of commercial systems.

In 2010, this included an array of dish systems being trialled by Stirling Energy Systems and an array being trialled by Infinia. A multipurpose platform also is used for performance testing of prototype commercial trough modules.

US Nation Renewable Energy Laboratory www.nrel/gov/solar/

The National Renewable Energy Laboratory Solar Thermal facility in Colorado is similar but smaller in extent to Sandia. The website states, 'NREL plays a leadership role in analyzing cost and performance of solar systems, developing parabolic trough technology for solar electricity generation, and developing advanced technologies such as concentrating photovoltaics. Researchers support the development of new designs and manufacturing processes for solar components and systems with an emphasis on improved performance, reliability and service life.'

Australia NSEC (Newcastle) www.csiro.au/places/Solar-Energy-Centre.html

The CSIRO's National Solar Energy Centre has a small solar tower facility, experimental trough systems, various supporting laboratories and is currently constructing another small tower and heliostat field. The land area is limited and its work is very much R&D rather than commercial demonstration.

Australia DKA Solar Centre (Alice Springs) www.dkasolarcentre.com.au/

The Desert Knowledge Australia Solar Centre is a relevant precedent. It showcases fully commercial technologies focussing on small-scale PV systems. It should be noted though that the size of a PV system needed for a demonstration / performance test is considerably smaller than the size needed for a CSP system.

Israel Weizman IS www.weizmann.ac.il/ESER/People/Karni/research.html

In Israel, the Weizmann Institute of Science hosts the solar research facilities unit. The website states, 'A major feature of the unit is a Solar Power Tower containing a field of 64 large, multi-faceted mirrors (heliostats), each measuring 7 x 8 meters.' Once again, the work is very much R&D focussed.

US; SolarTAC, Colorado (www.solartac.org)

Work is underway to establish the Solar Technology Acceleration Centre, (SolarTAC) in Colorado. This new centre occupies a 74 acre (30 ha) site near Denver International Airport. It is a public-private partnership that aims to be an integrated, world-class test facility where the solar industry can research, test, validate, and demonstrate solar technologies. Both CSP and PV technologies are included in its scope. Abengoa are one of the foundation partners and are planning a significantly sized test system of commercial trough units. SunEdison is also a founding partner.

According to the website, it is still in construction. It's site animation gives an excellent example of what expanding a concept like DKA in Alice Springs, to utility scale and encompassing CSP, could look like.

Spain, Plataforma Solar de Almeria (PSA) (www.psa.es/webeng/index.php)

The Plataforma Solar de Almeria (PSA) in south-east Spain is the largest existing global solar thermal test facility. The PSA site is more than 100 ha (250 acre) and is utilised for testing and optimisation of a variety of high-temperature solar technologies. PSA is owned and operated by CIEMAT. It was established through a Spanish-German collaboration and also closely collaborates with several large companies.

At present, the main test facilities available at the PSA are:

- CESA-1 and SSPS-CRS central receiver systems, 7 and 2.7 MW_{th} respectively;

- SSPS-OCS 1.2 MW_{th} parabolic -trough collector system, with associated thermal storage system and water desalination plant;
- DISS 1.8 MW_{th} test loop, an excellent experimental system for two-phase flow research and direct steam generation for electricity production;
- HTF test loop for new parabolic trough collector components;
- DISTAL dish/Stirling facility, 6 units;
- A 60 kW_{th} solar furnace for thermal materials treatments;
- DETOX Loop: A solar chemistry facility;
- Laboratory for Energy Testing of Building Components (LECE); and
- Meteorological station.'

Figure 17: Plataforma Solar de Almeria site (picture www.psa.es/webeng/index.php).

In addition to the key features listed on the website, there is an extensive administration, reception, visitors' centre complex. While much of the activity is R&D based, there are also major commercial demonstrations of technologies.

Spain, Solucar

The Spanish company Abengoa are the developers of the PS10 and PS20 tower based CSP plants demonstrated at Solucar. The towers are co-located with three Solnova 50 MW trough power plants, plus a range of private R&D facilities. This is a major overall concentration of effort across all technology types and spanning the full spectrum of RD&D activity. It is unique in the world for its major scale, combined with exclusively commercial ownership and operation.

Appendix 2: Alice Springs Network Map

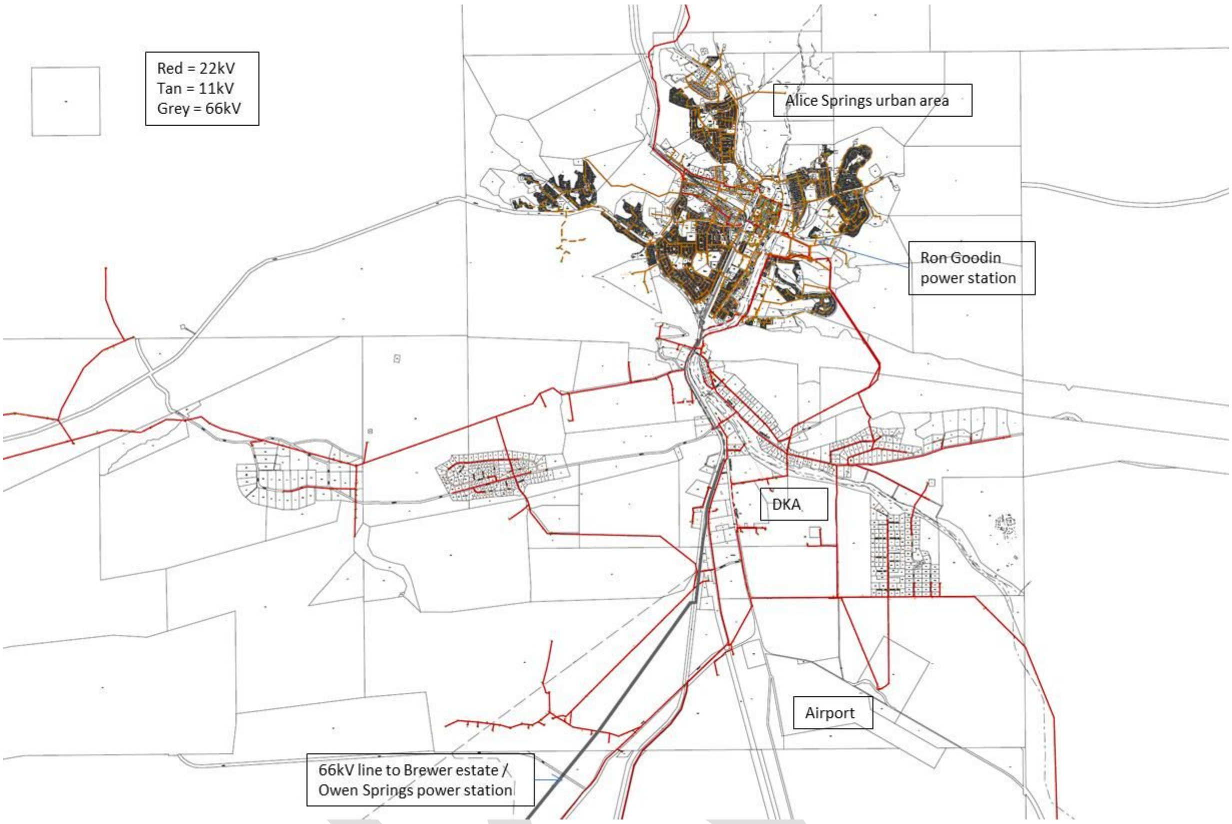

Figure 18: Map of Alice Springs showing electricity distribution layout

Appendix 3: Solar System Performance

The Moderate and Stretch Scenarios for Solar Energy deployment in the Alice Springs Solar Centre imply levels of penetration that are high enough that all possible solar electricity technology options should be considered. In particular, some level of energy storage seems essential and this opens up the consideration of CSP options as well as PV. In mid 2012, the cost of energy from CSP systems is considerably higher than that of PV systems and thus PV is the obvious choice on a cost of energy basis. However, against this, CSP systems can add several hours of energy storage with no energy cost penalty (indeed 1 - 2 hours of storage actually reduces the cost of energy by improving system performance).

To help with an initial assessment of the system requirements that may be needed for various levels of contribution to the Alice Springs load, a range of standard system configurations have been modelled using the NREL System Advisor model. Specifically, a non-tracking flat plate PV system, a Trough based CSP system with no thermal storage and a Molten salt Tower CSP system with 6 hours storage have been assessed. Whilst specific systems have been modelled, the results have been expressed per kW AC of installed capacity such that they can be used to consider the implications for a range of system sizes.

Figure 19 shows monthly output for a flat plate PV system over a year (Typical Meteorological Year used in SAM) for Alice Springs, with Tennant Creek and Darwin also modelled for comparison.

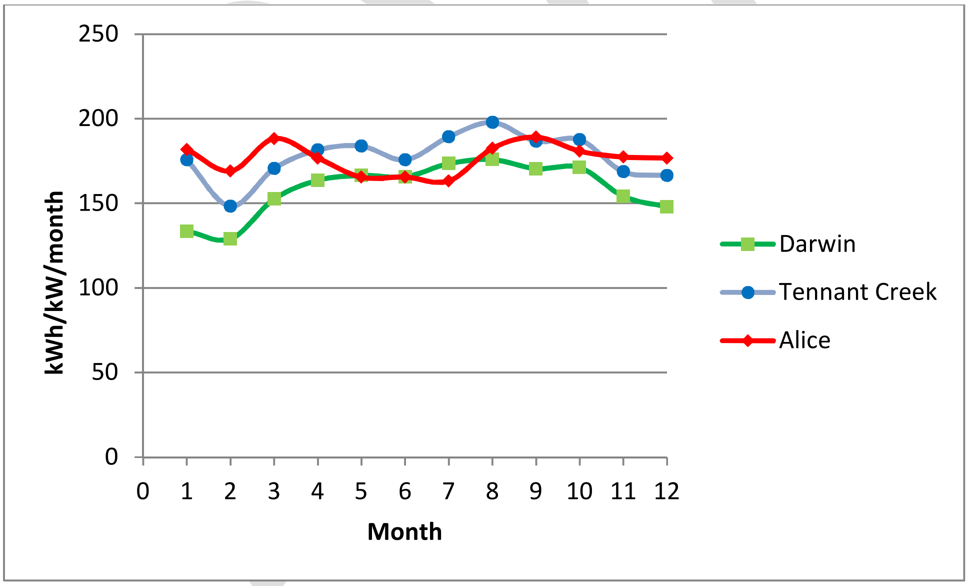

Figure 19: Typical Flat Plate PV system performance in NT centres.

It can be seen that Alice and Tennant Creek offer similar levels of generation and both exceed that of Darwin, with its higher cloud frequency associated with its tropical location. The Alice profile shows a slight dip towards the mid-winter months, although this is almost lost amongst the inter-month variability. It should be noted that the inter month variability is an artefact of the actual TMY used and does not represent a pattern to be expected in each real year, but it does indicate the level of actual variability that might be expected.

Figure 20 shows the profiles for a Trough CSP system with no energy storage. This indicates a pattern that shows an amplification of the inter–month variability of the PV system. CSP systems cannot use the diffuse component of solar radiation and so produce no output under cloud conditions and, even if clouds are intermittent, their thermal inertia can preclude effective start up. This is particularly seen in the drop in modelled output in Darwin during the wet season, relative to a PV system. Against this however, when they do operate, CSP systems can generate smoothly through transients such as the occasional cloud, in contrast to PV systems that may experience a rapid drop in generation levels.

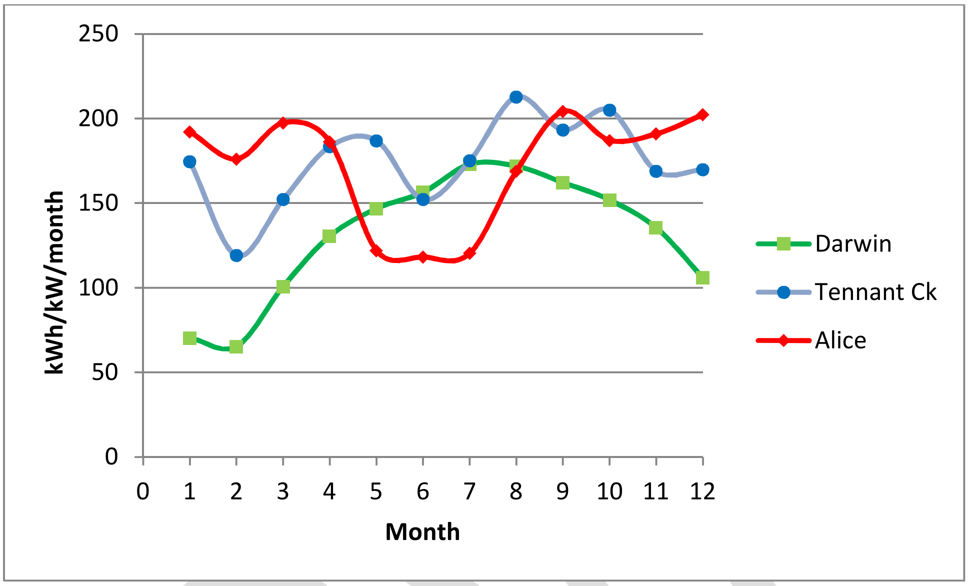

Figure 20: Typical Trough CSP without thermal storage system performance in NT centres.

It is also seen that there is a substantial mid-year drop in output at Alice Springs. This corresponds to the sun being at a lower elevation in the sky throughout the day and is a particular penalty for a trough plant that is horizontally mounted and tracks from East to West. The effective projected area of the system aperture, and hence amount of sunlight captured, is reduced by the sun not being perpendicular to the mirror on both axes.

Figure 21 shows output profiles for a Tower based system with 6 hours of molten salt energy storage.

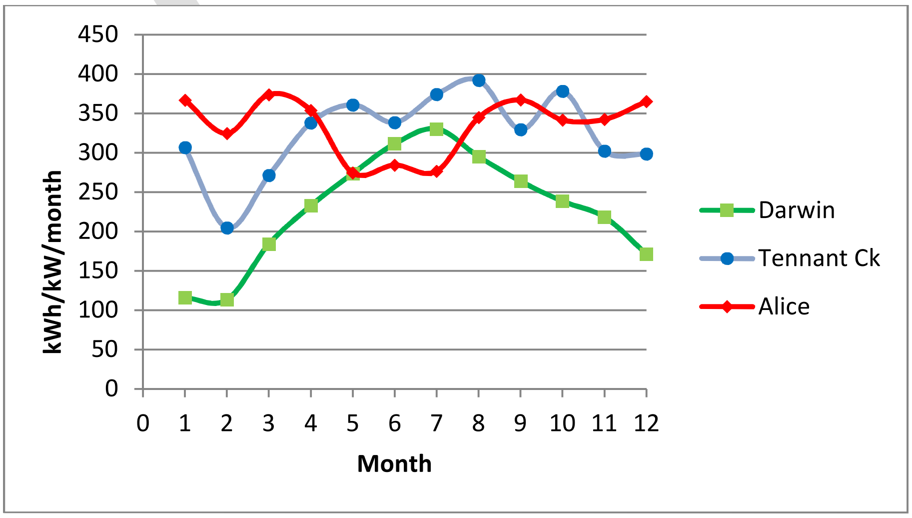

Figure 21: Typical Tower CSP with 6 hours thermal storage system performance in NT centres.

It is seen that predicted output also drops off in Darwin in the wet season. In Alice Springs, the mid year drop off is considerably reduced over that of the trough system, as a consequence of the two axis tracking characteristics of the mirrors, which work to remove the dependence on sun elevation angle. The mid year drop off that still does occur is due to the extra cloud cover expected in those months. The other key feature to note is that the level of generation per installed kW is nearly twice as high as the other two cases, as a consequence of the system configured with 6 hours of storage and an increased mirror field size relative to the power block.

Figure 22 compares the three technology options assessed for Alice Springs.

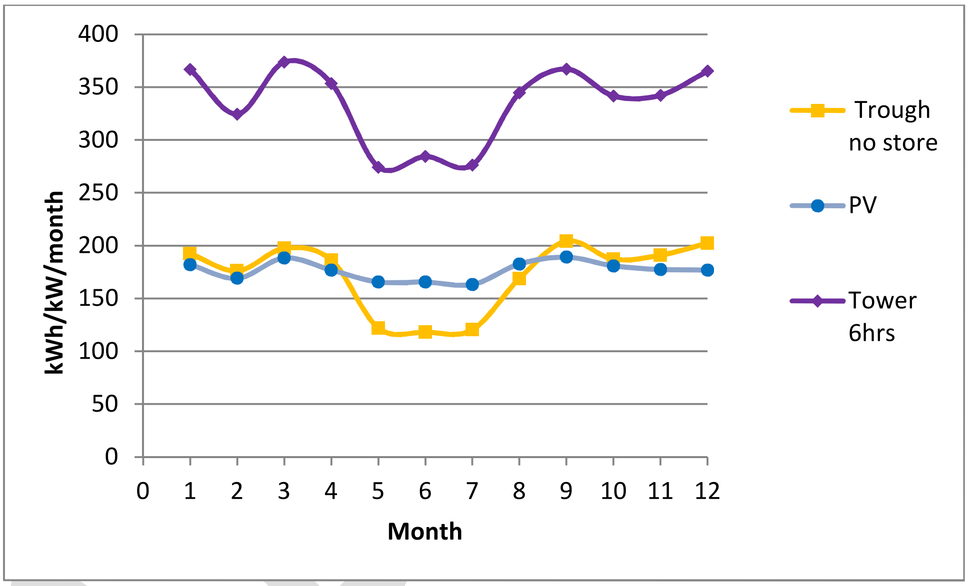

Figure 22: Comparing PV, Trough without storage and Tower with 6 hours storage at Alice Springs.

In anticipation of the need for a baseload type contribution of solar in Alice Springs, a tower system with a very large solar field and storage system (40 hours) has also been modelled. Its annual output curve has essentially the same characteristics as the tower with 6 hours storage, but with significantly higher generation per installed capacity.

Overall key metrics for these four technology examples are given in Table 21:

Table 21: Key metrics for different Solar options at Alice Springs

Technology	Flat plate PV, no tracking[30]	Trough no storage	Tower with 6 hours storage	Tower with 40 hours storage
Annual generation (kWh/kW)	2074	1983	3773	6526
Average daily generation (kWh/kW)	5.68	5.4	10.34	17.88
Average Capacity factor	24%	23%	43%	74%
Land requirement (ha/MW)	2.56	2.18	5.20	10.39

[30] Metrics for the PV option are expressed per high voltage AC kW rather than per nominal DC capacity.

Appendix 4: Matching supply and demand

Whilst it is a simple matter to specify solar systems with typical annual generation equal to annual demand, it becomes increasingly challenging to meet demand at all times throughout the year as the solar contribution is increased.

As Alice Springs moves forward with the goal of becoming a world leading solar centre, increased penetration of PV should be accompanied by appropriate use of smart demand management systems, such that maximum use can be made of the solar resource when it is available. It could also be accompanied by use of some distributed electrical energy storage.

Electrical energy storage is currently a very expensive proposition and hence would only be feasible for dealing with short-term fluctuations in solar output, e.g. due to clouds, or to cater for short periods of high demand. CSP systems with thermal energy storage are now commercially proven at a large scale and can handle longer-term storage requirements, such as overnight. Whilst CSP alone is currently nearly twice the cost of PV, the combination of CSP with storage is considerably lower cost than a combination of PV and electrical storage for long term storage. It is projected to remain so, even as all relevant technologies come down the cost curve with time.

Figure 23 shows daily average DNI and energy generation for a tower plant with 6 hours of thermal storage using the TMY data in SAM. It can be seen that, even with 6 hours storage, the electricity generated in a day is very much a function of the solar radiation available on that day. The significance of the energy storage is to simply allow the generation to be delivered at which ever hour of the day it is required.

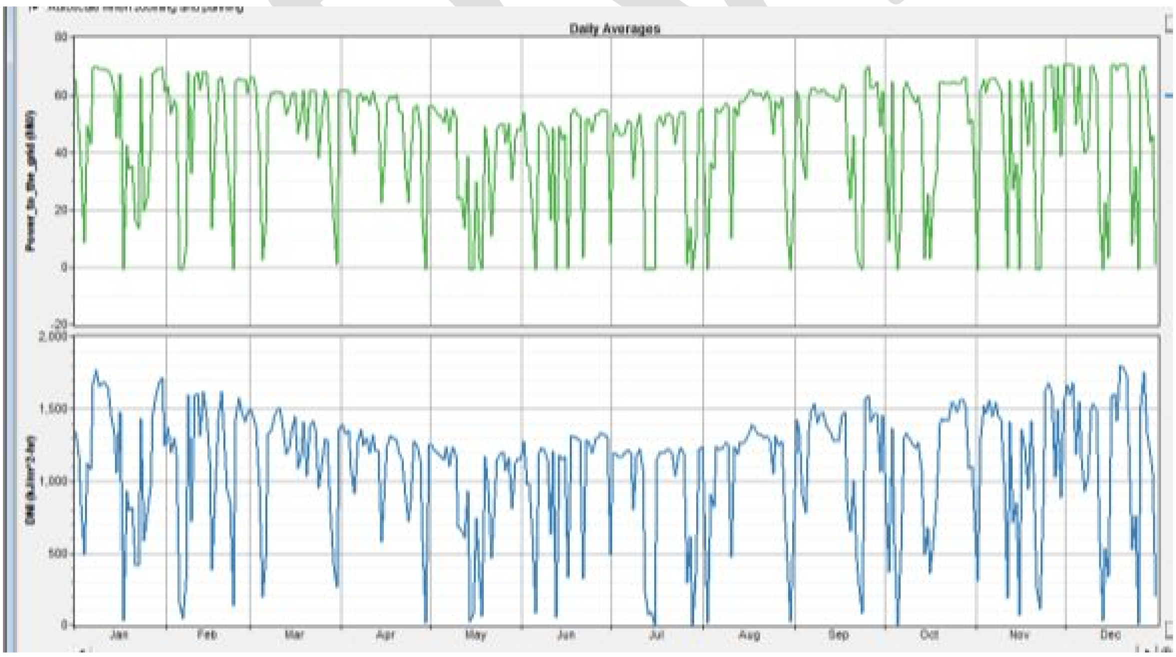

Figure 23: DNI levels (bottom) and corresponding CSP generation (top) from a plant with 6 hours of thermal storage.

Looking at the month of June in detail (see Figure 24) it can be seen that a system with 6 hours storage that simply uses that storage to continue generation into the evening, does not offer any generation on a cloudy day. Roughly speaking two or three days per month could be expected to have no generation at all in Alice Springs and this is fairly consistent across all months.

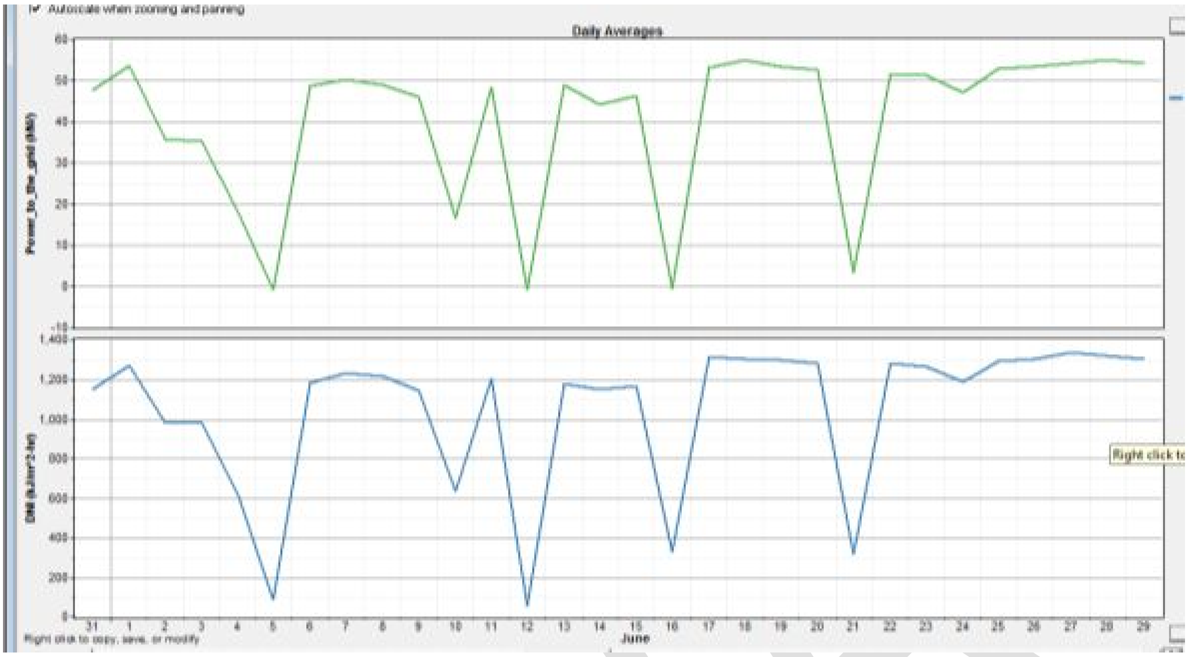

Figure 24: DNI levels and CSP generation in Alice Springs in June

To decrease the number of days for which solar does not meet any demand requires a configuration with more storage and managing that storage such that some significant fraction of stored energy is held in reserve from day to day. This is quite technically feasible, however, the investment in the storage system simply increases in proportion to its size.

Figure 25 shows the annual profile of daily generation from such a plant with 40 hours of storage, still with an immediate dispatch strategy. It is apparent that many days now show a constant maximum level of generation and the number of days of zero generation is considerably reduced. This indicates around 12 days per year of zero generation with another 10 days with generation at around 50%. In reality a system would be scheduled in a more optimal manner, with day by day forecasting of solar availability and load and optimisation of dispatch between the CSP plant and gas fired units, taking into account factors such as:

- Actual availability of various units
- Start-up time requirements of CSP turbines vs gas engines
- Relative part load efficiencies
- Provision of spinning reserve requirements.

Figure 25: DNI (bottom) and CSP generation (top) from a plant with 40 hours of thermal storage

A technically realistic stretch scenario level of solar penetration can be estimated by considering the typical sunny day summer and winter load profiles as shown in Figures 4 and 5 previously. These have been adapted in Figure 26and Figure 27Figure 27 to show a simplistic indicative overall solar stretch scenario for meeting the typical summer and winter load profile.

Rather than a single large oversized CSP system, the system has been scaled back to a high capacity factor system with around 40hours of storage and a capacity of 20MW. In Summer, it is suggested that such a unit could run essentially as baseload for all days of good sun. On such days a further 20MWp of PV (either centralised or distributed) could be added to come close to meeting midday peak demand from the combined solar options. Gas engines to a combined capacity of around 20MW would still be required for filling in and these would need to be used at a low capacity factor. On days of no sun in Summer, peak load presumably also drops, if a function of air-conditioning. The CSP system could be managed to carry over stored energy to continue generation at a lower level and the gas systems would need to carry the bulk of the load.

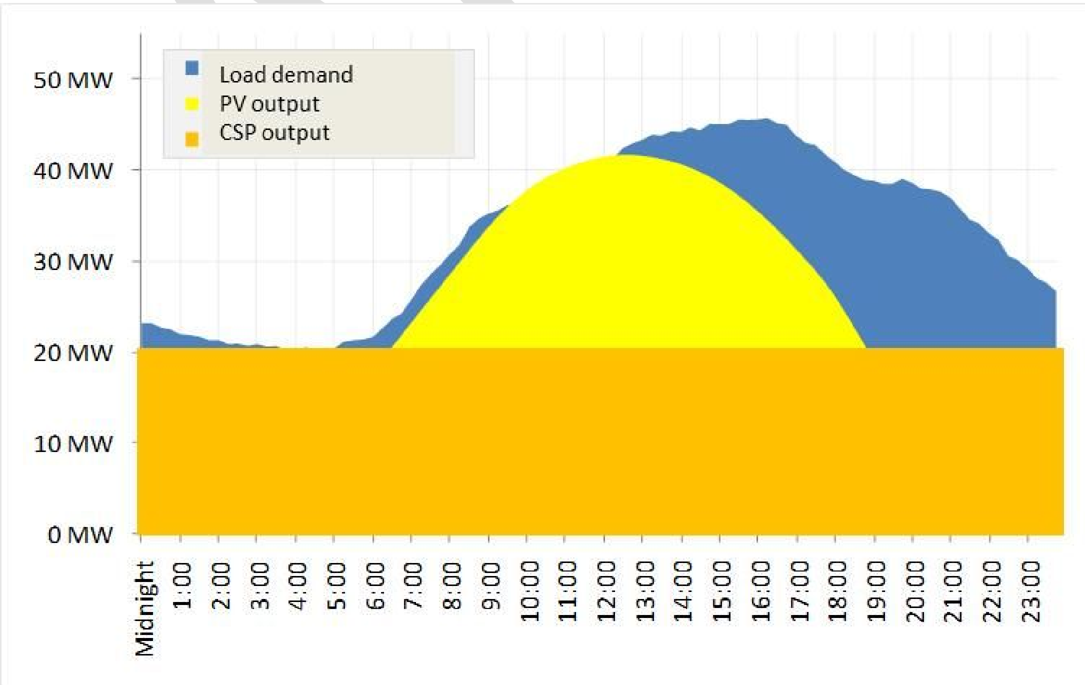

Figure 26: Sunny day summer load, PV and CSP profiles possible under a “Stretch” scenario

In Winter, the average output of the CSP plant would be about 30% less than Summer, for the sake of this simplistic analysis, it could be considered to operate at a reduced level for most hours, but shut down at periods when the PV output was a maximum. The gas engines would again need to contribute at up to 20MW to meet demand. On non-solar days in Winter, CSP energy could be managed such that operation for at least some hours in the morning and evening peak was achieved. In this way the peak capacity needed from the gas engines could be kept to a level below 30 MW.

Thus overall it can be seen that a solar contribution of approximately 70% could be achieved with available technology approaches. A detailed feasibility study could investigate system configurations that increase this to higher levels. This simplistic analysis is however sufficient to illustrate that it would be essentially impossible to meet 100% of electricity supply with solar. To do so would require a vastly oversized solar system with over 100hours of energy storage, which dumped much of the energy it collected.

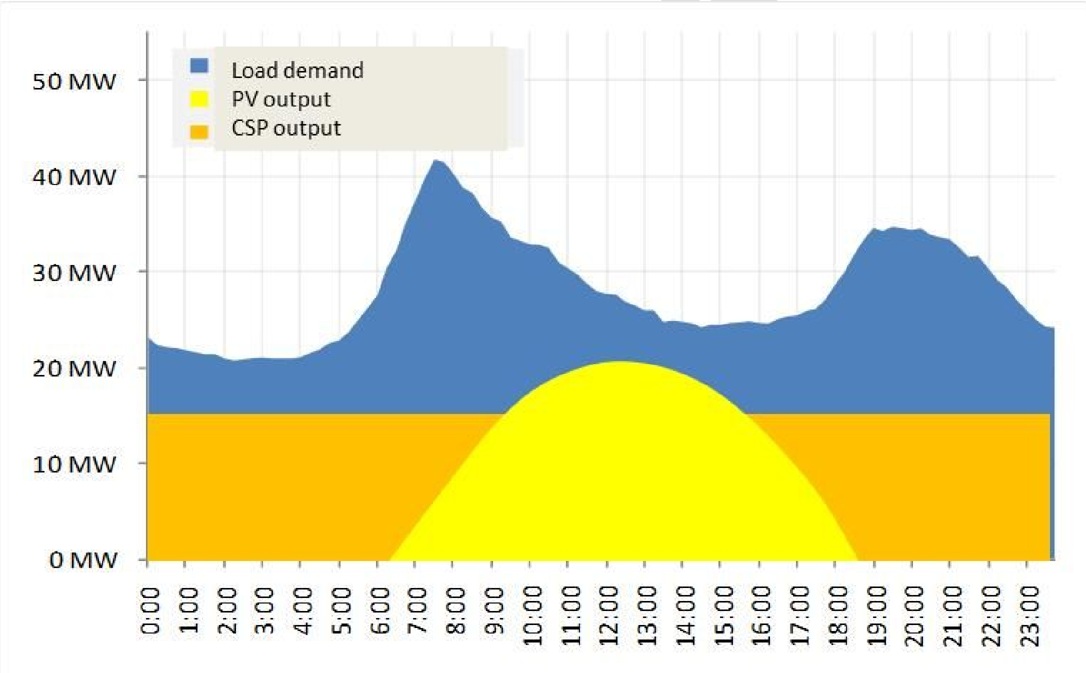

Figure 27: Sunny day winter load, PV and CSP profiles possible under a “Stretch” scenario.

Appendix 5: Costs for CSP options

The most widely deployed CSP configuration in 2012 is a 50MWe nameplate capacity trough system with 7.5 hours of molten salt energy storage. This configuration is largely an artefact of the size limits and rules that have applied to the relevant feed in tariff in Spain. There is a general consensus that lowest LCOE would be achieved with a plant around 200MWe. There is also increasing interest in Tower based systems over the more technically conservative trough approach. Systems smaller than 50MWe are quite possible, but for higher relative cost. Thus, in the context of a goal of reaching a high level of solar energy generation for Alice Springs, a CSP contribution to capitalise on the benefits of thermal energy storage, would most cost-effectively be achieved with a single plant.

Given that the rationale for employing CSP would be to offer high capacity factor load following and baseload operation for 24 hours a day, via thermal energy storage, the level of storage desired will be higher than for systems designed for most economic operation in a grid connected competitive energy market environment. This immediately favours use of a Tower-based system, which has the higher temperature range between hot and cold stores and provides a cost of storage capacity only one third of that for a trough plant.

A tower system capable of meeting the bulk of Alice Springs demand in 2020, with the parameters listed in Table 22 has been modelled using SAM.

Table 22: Indicative parameters for a 20 MW high capacity factor tower CSP system in Alice Springs

Nameplate capacity (MW)	20
Total heliostat mirror area (m2)	406,560
Total land area (hA)	207.8
Storage (hours)	40
Storage (MWth)	2,146
Receiver design Thermal (MWth)	101.92
Salt cold tank temp (degC)	280
Salt Hot tank temp (degC)	500
Net Annual Energy (kWh)	130,511,432
Annual generation per capacity kWh/kW)	6,526
Capacity Factor	75.10%

If the costing formula and methodology presented in the CSP in Australia study are used, with an assumed 10% penalty for higher costs of construction in Alice Springs and a 20% penalty for the reduced system size, the results are as shown in Table 23.

Table 23: Capital cost contributions for a 20MW high capacity factor tower system (based on cost coefficients from Lovegrove et al, 2012)

Subsystem		
Solar field (excluding receivers and HTF)	$54,108,659	12.29%
Receiver System (including HTF, piping, Tower as appropriate)	$33,066,403	7.51%
Thermal Storage System	$227,859,464	51.74%
Power block	$23,284,800	5.29%
BOP and Other	$13,970,880	3.17%
Subtotal	$352,290,207	80.00%
Indirect costs	$88,072,552	20.00%
TOTAL	$440,362,759	100.00%

If the same financial parameters as the CSP in Australia study are used[31], the resulting Levelised Cost of Energy (LCOE) is $347/MWh. A larger system or a system with less energy storage would have a lower LCOE. Note that unlike the lifecycle costing of PV system in Figure 9, these LCOEs do not assume income from LGCs.

If however a different sized system is installed at any given time, there will be a size related cost dependence, as illustrated Figure 28.

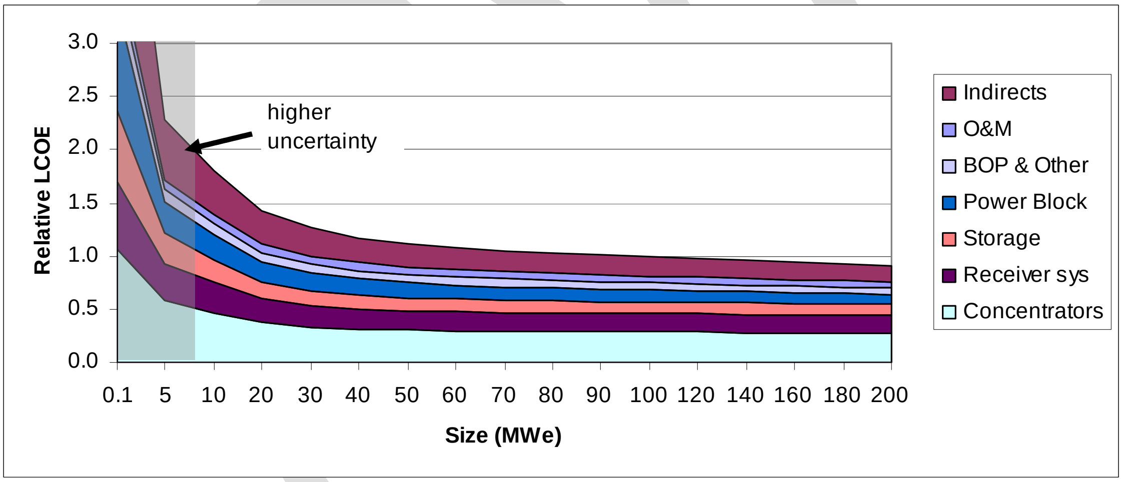

Figure 28: Life cycle electricity costs from a CSP system, depending on system size (Lovegrove et al, 2012)

Lovegrove et al (2012) analysed the likely trajectory of cost reduction for CSP given a range of possible combinations of global growth rate of deployment and progress ratios for cost, with the results shown in Figure 29. This is an analysis of capital costs that is assumed to carry over directly to cost of energy, if no changes in the cost of financing are assumed and O&M costs reduce at the same rate as capital costs.

It can be seen that, by 2020, it is predicted that costs will fall by somewhere between 20 to 50%.

[31] Loan fraction 60%, loan period 15 years, loan interest 7.78%, discount rate for equity 10.29%, depreciation period 20 years, project life 25 years, inflation 2.5%, O&M costs 1.8c / kWh, allowance for construction finance costs 6%.

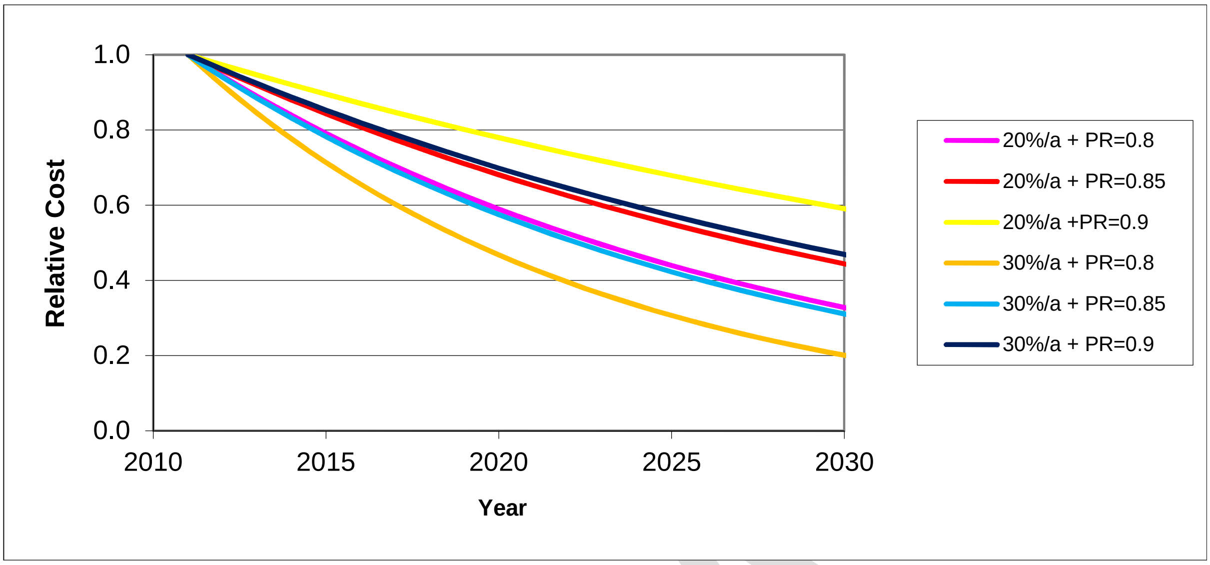

Figure 29: Capital cost projections for CSP systems (Lovegrove et al, 2012)

Applying these costs to a hypothetical 20 MWe tower system with 40 hours of storage gives the capital and LCOE results shown in Table 24.

Table 24: Projected capital and LCOE costs from a 20 MWe CSP plant

	Likely best case CSP cost reduction trajectory		Likely worst case CSP cost reduction trajectory	
Year	Capital cost $M	LCOE ($/MWh)	Capital cost $M	LCOE ($/MWh)
2012	440	347	440	347
2013	405	319	428	338
2014	372	293	417	328
2015	342	269	405	319
2016	314	248	394	311
2017	289	227	383	302
2018	265	209	373	294
2019	244	192	363	286
2020	224	177	353	278
2021	206	162	343	270

Appendix 6: A national solar test centre for Alice Springs

One of the identified measures for establishing Alice Springs as a world leading solar centre is the inclusion of some major research and demonstration facilities. The DKA system is already meeting this role for PV technologies and could be expanded further to encompass the testing and demonstration of systems with electrical energy storage at both a large and small scale.

Another major expansion could be into the area of CSP systems. CSP systems by their nature come in much larger modular sizes. The minimum realistic size for demonstrating a technology is of the order of 1 MWe. More fundamental test facilities, such as solar furnaces and multi- use experimental tower systems, can be smaller. However overall, the physical size of the infrastructure needed is larger.

The objectives for a major national solar test facility would be to provide:

1. Opportunities for Australia to advance participation in the solar industry (both PV and CSP).
2. A highly visible site to increase community understanding and support for future solar industry growth.
3. A facilitated venue for existing solar technology providers to showcase technology.
4. A performance measuring site for developers of new solar technology to demonstrate systems at a level commensurate with pre-commercial demonstration.
5. A facility for applied and experimental solar R&D activities funded from ARENA or other sources.

The PSA facility, described in Appendix 1 was for many years a joint Spanish and German initiative. It remains very much a European facility, with much EU funding. The attraction of this facility is that the Spanish site offers far superior solar availability than experimental sites in the northern countries like Germany. There are some interesting parallels that could be drawn for an Australian proposal. Both Japan and South Korea are strongly interested in solar activities, they have significant government funding and also commercial interest. They however do not have good solar resources so that their interest is really about facilitating their companies as technology providers in a global market.

Candidate Technologies

Candidate technologies that could be included can be categorised as:

- **Mature** overseas technologies seeking a first demonstration of already proven capabilities in Australia;
- **Less mature** overseas technologies seeking a first or subsequent small scale demonstration in Australia;
- **Early stage** Australian developed technologies seeking a first or subsequent small-scale demonstration.
- **Pure R&D,** ie facilities such as solar furnaces and multi-use towers

It is recommended that a high priority be given to attracting one or more partners from the first category. These players are the ones who can build an array with confidence in a reasonable timeframe and budget with the maximum chance of a high profile and reliable system. This could be facilitated simply by offering an attractive PPA on a commercial basis for a small system.

Less advanced developers are highly likely to run into unexpected difficulties, leading to time and cost overruns. This is an expected feature of the evolution of any new technology and certainly applies to CSP. It is important that the overall success of the Solar test centre and community perceptions are adversely affected by some failures, should they occur, but rather that they are seen as learning opportunities.

Selection Criteria for siting a national facility

To make the case for the choice of Alice Springs for a National facility, possible general site selection criteria can be considered. It is suggested that these might appropriately be in approximate order of priority:

a) Quality solar resource

This is clearly important from several aspects. Objectives 2,3,4 and 5 above, are best furthered by a system that has the maximum possible chance of being fully operational. Further, if the revenue from electricity generation is an important part of the financial management model, then maximising the level of revenue is important also. Unfortunately there are a number of examples around world where significant test centres have been constructed in areas of low solar resource and ended up risking a demonstration of “failure”. Alice Springs un-deniably has close to world’s best solar resources.

b) Accessibility to general infrastructure and resources required by participating organisations

This is important if systems are to be constructed and maintained cost effectively. The renewable energy industry has many examples where demonstrations have been unwisely located in remote areas where a target market exists, but the lack of supporting infrastructure leads to a failed or extremely expensive demonstration. Alice Springs is large enough and supports construction and pastoral operations to a wide regional area. It has most of the infrastructure needed for supporting fabrication, civil construction and maintenance tasks. If the international collaborative aspect is considered, Australia’s reputation as a low sovereign risk convenient destination for business is a major advantage.

c) Travel convenience from major centres

Travel convenience is extremely important for all objectives of a centre and often neglected in planning for activities around the world. Easy access is important for:

e) Out of town maintenance staff to minimise time costs
f) Ease of organised visits by investors and politicians
g) Ease and cost effectiveness of access by visiting researchers and students.

Alice Springs is extremely well positioned in this regard. It has a significant sized airport that has regular jet flights from every capital city. The airport is out of town in an uncongested area, very close to the most plausible solar test sites. For international visitors, a single international flight to a capital city of choice followed by a good connection to Alice Springs is very reasonable. If Asia-Pacific stakeholders are considered, it is a considerable advantage that Alice Springs is in a similar time zone. Alternative sites related to our major capital cities are likely to require several hours driving from CBD or airport. Other regional centres that could qualify rely on smaller airports with infrequent small aircraft flights, usually from only the nearest major centre.

d) Access to existing electricity distribution infrastructure

Electrical connection is clearly essential. As a site selection criteria, it is really the cost of this connection and what that does to the overall cost effectiveness of the site for a demonstration. This is likely to be determined by the specific location of the site in relation to substations and transmission lines.

The Alice Springs network clearly offers a number of possibilities of connection of a test site, with very little of extension of lines needed.

e) High visibility and proximity to a population centre and/or high frequency transit route

This is important in regards objective 2 above. Thought should be given to several levels of community interaction, simply being visible from a major transit route helps to raise community awareness. A drive-in elevated viewing area helps to capitalise on incidental opportunities. Going beyond this, the facility could be leveraged as a tourist attraction, providing local economic benefit whilst enhancing the community awareness even further.

In this regard, Alice Springs benefits from being a major tourist hub both for Australian and International tourists. Currently few visitors are made directly aware of the solar facilitates, so that targeted promotion will be necessary.

f) Access to low cost land

The direct issue of land cost feeds in to a cost effectiveness comparison of various sites. To a large extent, the issue around land is that there should not be pressure to limit the size of the facility or its possible subsequent growth. It is also important that it not be located in an area where future developments (such as residential) lead to future land value increases that cause a motivation for closing the facility for sale of the land. Given that any likely site in Alice Springs would be well outside the current limits of urban development, whilst still being within a 25 – 30 km radius of the city centre, Alice Springs measures favourably under this criteria. The absence of major impediments to environmental approval is clearly an essential element. Flexibility for future expansion is also important.

g) Access to water and gas

Hybridisation with gas is an important option for CSP systems. It is also a very useful tool in constructing and operating test systems. Alice Springs has good and readily accessible gas supplies. Water issues are more complex, although clearly water is available for test systems. Moving forward, a future trend with commercial CSP plants is to adopt air cooling systems over wet cooling. Reduction in water use for cleaning of both large-scale PV and CSP systems is also a future theme. A test centre in Alice Springs could adopt low water use solar technologies as a major theme.

h) Existing relevant activities in the area

Existing related activities offer the advantage of existing stakeholder understanding and support. Clearly Alice Springs with the established Solar Cities activity and the DKA site, together with the Target 13 goal that is the basis of this study, is ideally positioned in this regard.

Land Requirements

Commercial CSP power plants typically require 3-4 ha per MW_e of generating capacity. This indicates that the required area for a solar field is about 1.5 ha per MW_{th} of steam production. For the Solar Park concept consisting of several arrays producing between 1 and 5 MW_{th} of steam, each of these individual arrays will require between 1.5 to 8 ha in area. The overall site area needed is also strongly influenced by the need for each array to have its own clearance areas, access roads, assembly areas and supporting infrastructure.

Thus an indicative site area can be calculated by assuming say ten systems averaging 3 MW_{th} each requiring 5 ha each for actual field and then increasing that to 10 ha to allow for the necessary clearances and other infrastructure. This gives an overall land requirement of about 100 ha (250 acres), which is equivalent to a 1km x 1km square. This is also in line with the approximate size of the PSA system in Spain or the SolarTAC in the US.

The availability and cost of land is not expected to be a major constraint. It can be noted that the land that is likely to be used is presently either unused or used for grazing. Nevertheless ownership and zoning issues will need to be addressed. The development could be staged so that, if a larger area is put aside, a smaller portion could be fenced to the necessary security level in the first instance and the rest continue to be leased for grazing until needed.

Such areas of undeveloped land are available in many places around Alice Springs. Actual expansion of the DKA site may also be possible. There is extensive undeveloped land near the Owen Springs power station and as discussed elsewhere, it is the most likely location for a large commercial CSP plant, but could also or alternatively house a precinct for demonstration systems. Actual site selection is most likely to be determined by ownership, zoning, connection to the electrical network and other infrastructure issues, which will be less onerous than that required for a full commercial plant.

Scope and cost

The possible size and scope of a test centre can fall across a broad range and should be the subject of a detailed feasibility study. As a starting point, the numbers in Table 25 serve as a benchmark / reality check for an indicative breakdown of the expected costs of head works only for setting up a 1km x 1km Solar Park site. Site related costs, including levelling and clearing, basic roads and administration buildings, are scalable to the size of the site. Electricity and gas connections to the site will include one fixed cost for on-site infrastructure and per km costs for power and gas lines to the site. The allowance for electricity grid connection infrastructure includes the installation of a 5 to 20 MW_e power station at the site.

Regarding operating budgets, at one extreme of possibilities for an extremely research-intensive operation, the Spanish PSA centre budget in 2008 reached 8.1 million Euros (not including R&D personnel) and in 2009 it was 8.5 million Euros. On the other hand, limiting operation to basic admin and site security tasks for a site housing independent commercially operated test systems, could be as low as $200k - $300k per year.

Table 25: Estimated costs for head works only for a 100 hectare Solar Park /test centre

Item	$ Cost/unit	unit	No. Units	total
Land	$4,000	acre	250	$1,000,000
Site clearing	$0.70	m2	500,000	$350,000
Levelling	$20	m3	100,000	$2,000,000
Fencing	$90	m	4,000	$360,000
Road - cement treated crushed rock	$8.30	m2	40,000	$332,000
Electricity grid connection	$3,000,000		1	$3,000,000
Power lines to site	$100,000	km	10	$1,000,000
Gas connection				$3,000,000
Water connection				$500,000
Water reticulation	$92	m	2,000	$184,000
Basic admin buildings	$650	m2	1,200	$780,000
Solar radiation & weather data system	$10,000		1	$10,000
Pyrheliometer and tracking system	$15,000		1	$15,000
		TOTAL		**$12.5m**

Appendix 7: Stakeholder consultation

Stakeholder consultation was conducted formally and informally with a range of parties with existing and/or emerging interests in Alice Solar City, the Desert Knowledge Australia Solar Centre and the various iconic PV projects around Alice Springs.

The three primary areas of discussion conducted with each stakeholder were:

- What do you think is needed in order for Alice Springs to be a Centre of Excellence for Solar Energy by 2020?
- To what extent do you think you, or your organization would be part of that vision;
- To what extent do you think the NTG should be involved in facilitating Alice Springs becoming a Centre of Excellence for Solar Energy?

Although the questions as noted above are quite specific, the actual discussions undertaken with each stakeholder were more general in nature, with a view to allowing the stakeholders to articulate their vision for the future of Alice Springs and the projects that have already developed.

Despite the varied levels of responsibility and engagement that each stakeholder has with Alice Springs, three key issues emerged as repeated themes:

1. To be a centre of excellence implies a level of knowledge development and capacity building – this needs to be fostered and maintained;
2. Absolute numbers are less important in defining Alice Springs' status than the degree of innovation and problem solving that is being undertaken to resolve integration issues;
3. Recognition the NT Government of what has been achieved by all parties and agencies, including PWC, and championing that around Australia and Internationally must be more than a token acknowledgement – there has to be a proactive engagement by the NT Government to foster further development;

The stakeholders consulted for this report included:

Name	Position	Company
Sam Latz	General Manager	Alice Solar City
Trevor Horman	Manager – Renewables	Power Water Corporation
Russell Harris	Commercial Development Manager	SunPower Corporation
Wilf Johnston	Manager Commercial Projects	SunPower Corporation
Chris Fell	Research Group Leader, PV	CSIRO
John Huigen	CEO	Desert Knowledge Australia
Nina Brown	Acting Group Manager	Bushlight
Jimmy Cocking	Co-ordinator	Arid Lands Environment Centre
Garry Marsh	Asset Manager	BGIH (Crowne Plaza Alice Springs)
Katie Cooper	General Manager	Alice Springs Airport
Rede Ogden	Managing Director	Ogden Power
Andrew Campbell	Director,	Centre for Renewable Energy and Low Emissions Technologies Charles Darwin University

Additional, more general, conversations were undertaken with:

- Environment Centre NT
- NT Chamber of Commerce and Industry
- NT Department of Constructions and Industry
- NT Convention Bureau