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Analysis of the Period of Greatest Network Utilisation by Loads and Exports – Final Report

Prepared for Power and Water Corporation

9 December 2022

ENERGEIA

Executive Summary

Power and Water Corporation (PWC) is the electricity distribution and transmission network service provider for the Northern Territory. PWC operates under the National Electricity Rules as in force in the Northern Territory (NT NER), which set out the rules and requirements, which PWC operate under, including the Pricing Principles[1]. The Pricing Principles require that network tariffs be based on the Long-Run-Marginal-Cost (LRMC) of providing the service at the times of greatest utilisation[2].

PWC faces challenges to setting tariffs which are unique amongst distribution network service providers (DNSPs):

- PWC operates three standalone grids; Darwin-Katherine Interconnected System (DKIS), Tennant Creek, and Alice Springs
- PWC's networks are geographically diverse, resulting in significant variation in climate between northern and southern networks
- The Northern Territory has a small population, resulting in PWC's networks servicing a relatively low number of customers over a large area
- Electricity pricing is additionally regulated under the Electricity Pricing Order[3] set by the Northern Territory Government, which prevents network pricing signals being passed through to customers using < 750 MWh per annum, which is most of them.

The above challenges all need to be considered when making recommendations for the upcoming regulatory period.

The Australian Energy Market Commission's (AEMC) Export Tariff Rule Change[4] requires DNSPs to additionally develop an Export Tariff Transition Strategy and allows for the assignment of customers to an Export Tariff from 1 July 2025. PWC plans to trial an export tariff within the upcoming 2024-29 regulatory period, before assigning customers to an Export Tariff from the consecutive 2029-34 regulatory period. Such an Export Tariff will need to comply with the Pricing Principles, including being based on the LRMC of providing the service at the time of greatest utilisation.

The timing of the greatest utilisation of PWC's distribution network has historically aligned relatively closely between the networks, which equates seasonally to the:

- wet season in the Darwin-Katherine Interconnected System in the tropical north, and
- summer months in Tennant Creek and Alice Springs Networks in the southern networks

The peaks have historically occurred in the mid-to-late afternoon due mainly to cross over of air-conditioning and commercial load. However, increasing penetration of rooftop solar PV is reducing demand on the system during the daylight hours, pushing the period of maximum utilization outside of daylight hours. Transport electrification is not yet having an impact but could impact on timing in the future.

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[1] National Electricity Rules As in Force in the Northern Territory Version 96 Section 6.18.5

[2] National Electricity Rules As in Force in the Northern Territory Version 96 Section 6.18.5(f)

[3] Electricity Reform Act 2000 As in Force at 19 November 2021 Section 44.1

[4] National Electricity Amendment (Access, pricing and incentive arrangements for distributed energy resources) Rule 2021 No. 9

Scope and Approach

Energeia was commissioned by PWC to determine periods of maximum and minimum demand across the three regulated networks over the next regulatory period to inform the design of its Peak and Export periods, and to demonstrate their conformance with the NT NER.

Energeia worked closely with PWC to develop the following study scope and delivery approach to achieve the key study objectives and PWC requirements:

1. **Develop and Validate Methodology** – Energeia developed a robust methodology for identifying optimal peak and export periods and benchmarked it against PWC's peer DNSPs.
2. **Gather Inputs** – Energeia developed and managed a formal Request-for-Information (RFI) register and reviewed the inputs from PWC to ensure they were fit-for-purpose.
3. **Determine Optimal Peak and Export[6] Periods** – Energeia modelled the forecast minimum and maximum demand periods across PWC's three networks, and then developed a unified recommendation for peak and export period across the three networks.
4. **Validation and Documentation of Results** – Energeia validated its key findings with PWC subject matter experts prior to finalising the modelling and drafting this report.

Each of the above steps is described in further detail in the following sections.

[6] Peak refers to the load peak, and Export refers to the export peak.

Definition the Peak and Export Period

Energeia reviewed other Australian DNSPs to inform the development of a robust and best practice framework for peak and export period setting. The resulting period definition methodology can be seen in Table E1 below.

Table E1 – Peak and Export Period Definition Methodology

	Peak Period		**Export Period**	
Period of Maximum Utilisation	System Coincident Max Demand	Non-Coincident Zone Substation (ZS) Max Demand	System Coincident Min Demand	Non-Coincident Zone Substation Min Demand
Years of History Considered	5	4	5	
Customer Classes Considered	N/A	N/A	N/A	
Peak Period Definition	> 90% of Coincident Maximum Demand	> 50% of ZS > 90% Maximum Demand	< 10% of Coincident Max Demand	
Shoulder Period Definition	N/A	N/A	N/A	N/A
Resolution	1 hr.	1 hr.	1 hr.	
Weather Normalisation (P10, P90)[8]	✓	✓	✓	
Forecast Demand	✓	✓	✓	

Source: Energeia

Key aspects of our recommended methodology include defining the peak period as when more than 50% of assets are peaking, including normalising for weather. This approach provides a more informed and accurate representation of maximum and minimum utilisation on the networks.

Energeia's modelling methodology is detailed in Section 3.

Findings and Recommendation

Energeia's recommended PWC peak period is shown Figure E1 alongside the current peak period definition, and the hours where > 50% of zone substations are >90% of their forecast annual peak demand assuming 1 in 10 (P10) year hottest temperature.

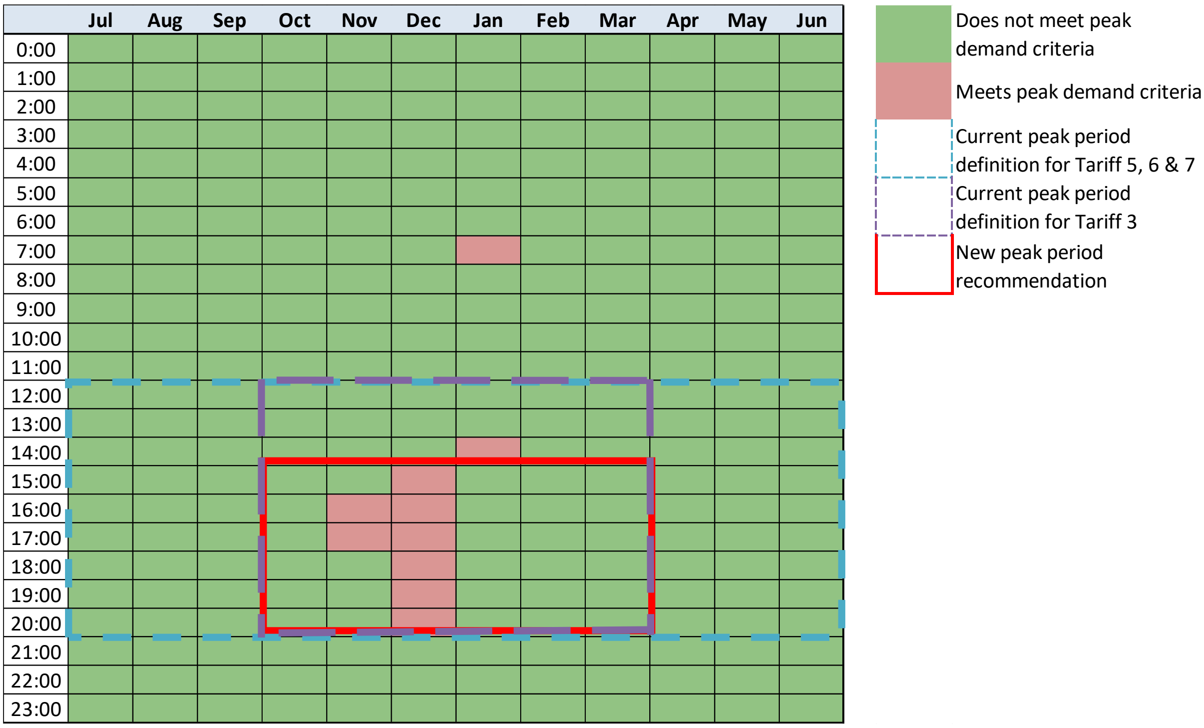
The recommended peak period was defined as 3 pm – 9 pm from October to March. Energeia notes that, historically, peak demand has occurred outside the proposed peak period. However, after further investigation, these were found to be anomalies which did not require expanding the peak window. The recommended peak period also includes months which do not meet the non-coincident peak demand definition, e.g. October and January through March, as a stepping-stone to the future peak period when solar PV generation is expected to bring these into the export period.

[8] P10 refers to a 1 in 10 probability of exceedance. P90 refers to a 9 in 10 probability of exceedance.

Energeia’s recommended peak period was narrower than PWC’s current definition, which consists of a longer period, starting at 12 pm, and occurring year-round for the majority of customers consuming above 750 MWh pa (Tariffs 5 – 7), and seasonally for the remaining small customers on a demand tariff (Tariff 3).

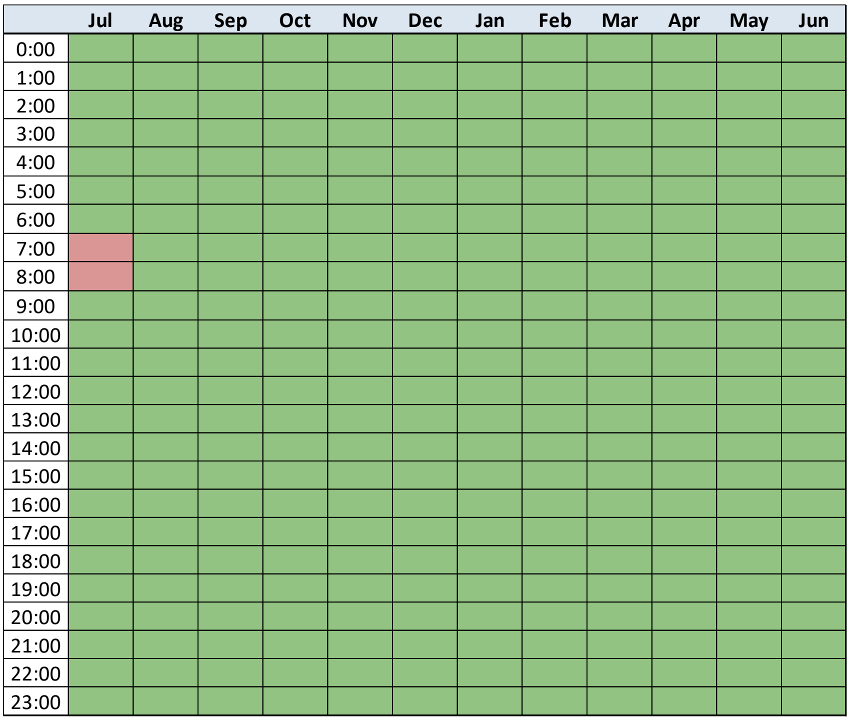
While different periods for different customer classes makes sense for customers located on different grids, it is challenging and costly to manage operationally and in billing and other systems, especially given PWC’s small customer base. Rooftop solar PV is making each network’s respective peak periods more homogenous over time, which is another reason to keep them unified.

Figure E1 – Peak Period Definition Weekday



Source: Energeia Modelling

Figure E2 – Peak Period Definition Weekend



Source: Energeia Modelling

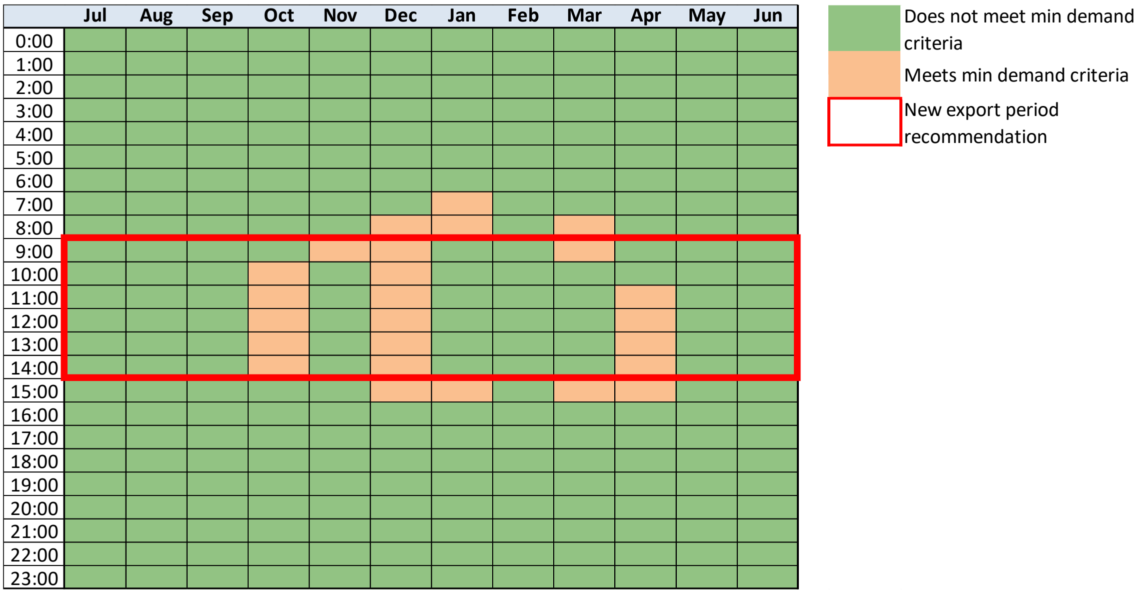
An export period sends a price signal to increase grid imports and/or to reduce solar PV exports during the period to reduce the risk of triggering costs due to voltage excursions, protection maloperations and/or thermal limits. This, like other network price signal, is seen by retailers, and only passed onto consumers at the retailer's discretion where allowed by the Pricing Order.

Energeia's recommended PWC export period is shown Figure E2 alongside the hours where > 50% of zone substations are < 10% of their forecast annual peak demand assuming 1 in 10 (P90) coldest weather. The recommended export period is 9am – 3pm for all months of the year. This excludes time periods that overlap with the peak period, as defined above. This export period thereby captures the majority of at-risk minimum demand periods identified.

Again, as is the case for the recommended peak demand period, the recommended export period does not solely reflect the timing of forecast peak utilisation of the export service. This is because such a definition would lead to a significantly increased unit price due to it being a smaller time window, which would significantly increase risks for customers. It would also be more difficult for consumers to understand[9].

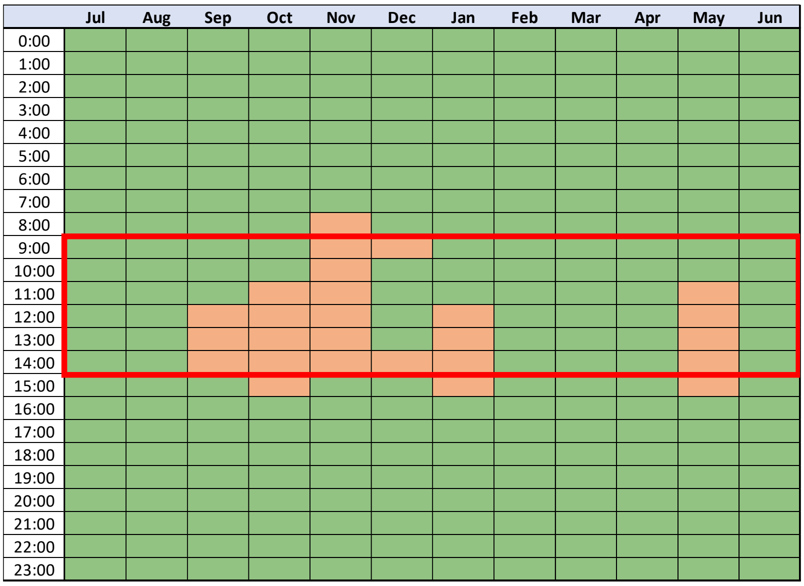
[9] Energeia recommends revisiting this strategy in the future when customer responses to price signals are more automated.

Figure E3 – Export Period Definition Weekday



Source: Energeia Modelling

Figure E4 – Export Period Definition Weekend



Source: Energeia Modelling

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Disclaimer

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1. Background

PWC is required under the Rules (NT NER) to include a Tariff Structure Statement (TSS) as part of its Initial Regulatory Proposal (IRP). Tariffs in the TSS, including Export tariffs, must comply with the Pricing Principles, which require that they be based on Long-Run-Marginal-Cost (LRMC) during the period of highest utilisation. PWC faces challenges to setting tariffs which are unique amongst distribution network service providers:

- PWC operates three standalone grids; Darwin-Katherine Interconnected System (DKIS), Tennant Creek, and Alice Springs
- PWC's networks are geographically diverse, resulting in significant variation in climate between northern and southern networks
- The Northern Territory has a small population, resulting in PWC's networks servicing low customer numbers over a large area
- Electricity pricing is additionally regulated under the Electricity Pricing Order[10] set by the Northern Territory Government, which prevents network pricing signals being passed through to customers using < 750 MWh per annum, which is most of them.

The above challenges all need to be considered when making recommendations for the upcoming regulatory period.

PWC's period of highest utilisation is changing due to increasing penetration of rooftop solar PV capacity and electrification, as is the influence of weather on maximum demand across all three regulated electricity networks

1.1. Regulatory Requirements

The National Electricity Rules as in force in the Northern Territory (NT NER) provide the regulatory framework governing electricity distribution network tariffs. The Pricing Principles require that network tariffs be based on the LRMC of providing the service at the times of greatest utilisation[11]. For providing network services, greatest utilisation typically refers the period of peak demand.

The Australian Energy Market Commission's (AEMC) Export Tariff Rule Change[12] requires DNSPs to develop an Export Tariff Transition Strategy and allows for the assignment of customers to an Export Tariff from 1 July 2025. PWC plans to trial an export tariff within the upcoming 2024-29 regulatory period, before assigning customers to an Export Tariff from the consecutive 2029-34 regulatory period. Such an Export Tariff will need to comply with the Pricing Principles, including being based on the LRMC of providing the service at the time of greatest utilisation.

In the case of exports, the time of greatest utilisation of export capacity is expected to be the period of minimum net demand, i.e. the net of load and generation.

1.2. Drivers of Change

The timing of the greatest utilisation of PWC's distribution network has historically aligned relatively closely between the networks, which equates seasonally to the:

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[10] Electricity Reform Act 2000 As in Force at 19 November 2021 Section 44.1

[11] National Electricity Rules As in Force in the Northern Territory Version 96 Section 6.18.5(f)

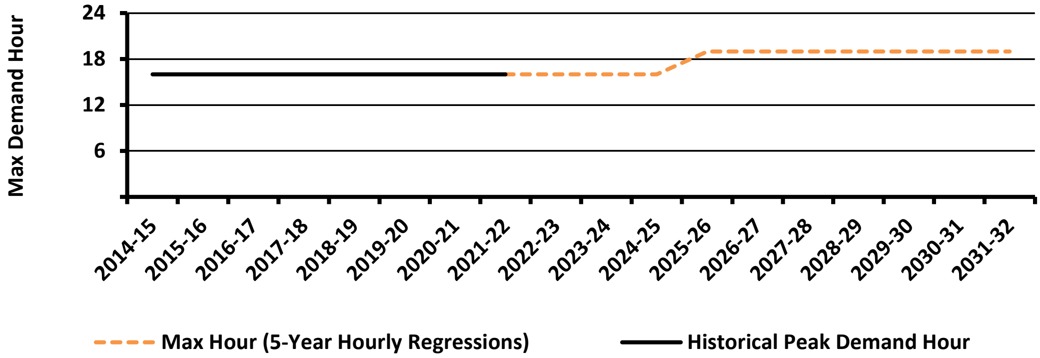
[12] National Electricity Amendment (Access, pricing and incentive arrangements for distributed energy resources) Rule 2021 No. 9

- wet season in the Darwin-Katherine Interconnected System (DKIS) in the tropical north, and
- summer months in Tennant Creek and Alice Springs Networks in the southern networks

The peak period timing is due mainly to cross over of air-conditioning and commercial load. However, increasing penetration of rooftop solar PV is reducing demand on the system during the daylight hours, pushing the period of maximum utilization outside of daylight hours. Transport electrification is not yet having an impact but could impact on timing in the future.

Figure 1 below shows the timing of PWC's peak demand in its largest system, DKIS, changing over time as a result of the rising penetration of behind-the-meter (BTM) rooftop solar PV. This trend is expected to continue, potentially impacted by rising adoption of BTM storage and other distributed energy resources (DER) including Plug-in Electric Vehicles (PEVs).

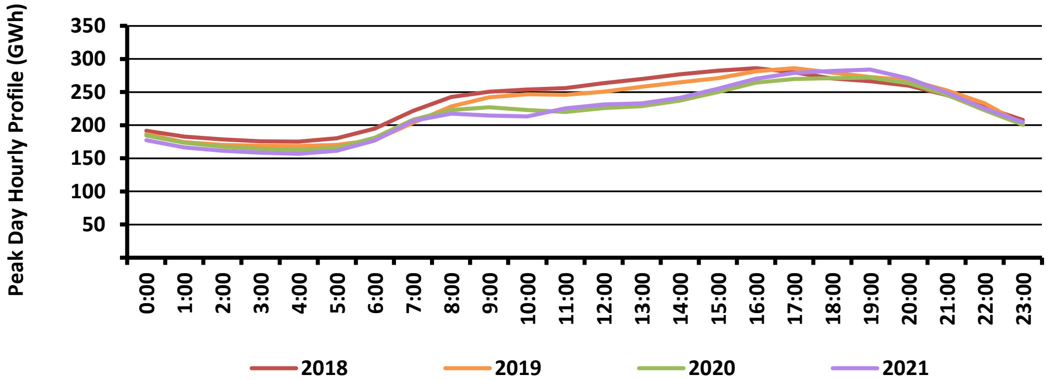
Figure 1 – Timing of DKIS Peak Demand Over Time



Source: Energeia, PWC

Figure 2 below shows the change in the shape of the peak day profile in the DKIS system over the past 10 years. The impact of solar PV reducing daytime loads is evident, with the resulting net load peak moving later in the day, when solar PV generation falls. BTM batteries are expected to accentuate the effect, as they start discharging once solar PV generation declines.

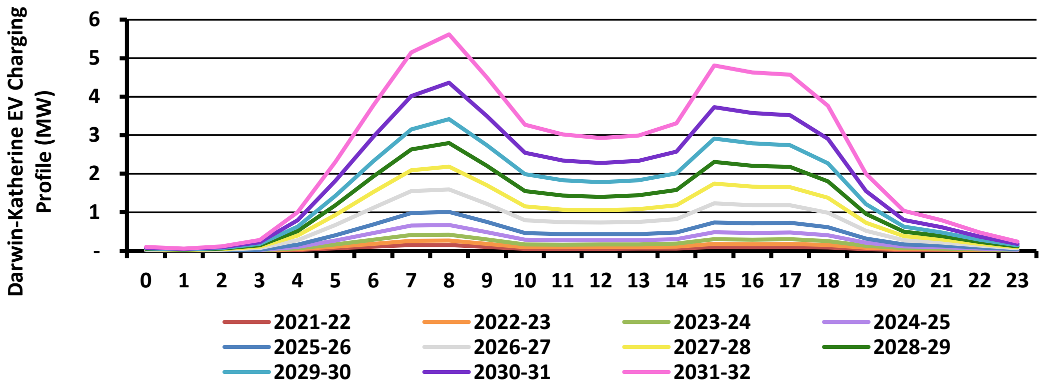
Figure 2 – Peak Day Load Over Time



Source: PWC

Although in their infancy in terms of adoption, electric vehicles are expected to become widely adopted in the longer-term to achieve zero carbon emission in the transport sector. The timing of their charging loads remains uncertain. However, data from other states and from overseas shown below in Figure 3 suggest that at-home charging will contribute additional demand to evening peak loads, at least until ToU based pricing signals and complementary load management technologies become more readily available and support moving charging to lower cost periods.

Figure 3 – Illustrative PEV Charging Load in the NT



Source: PWC

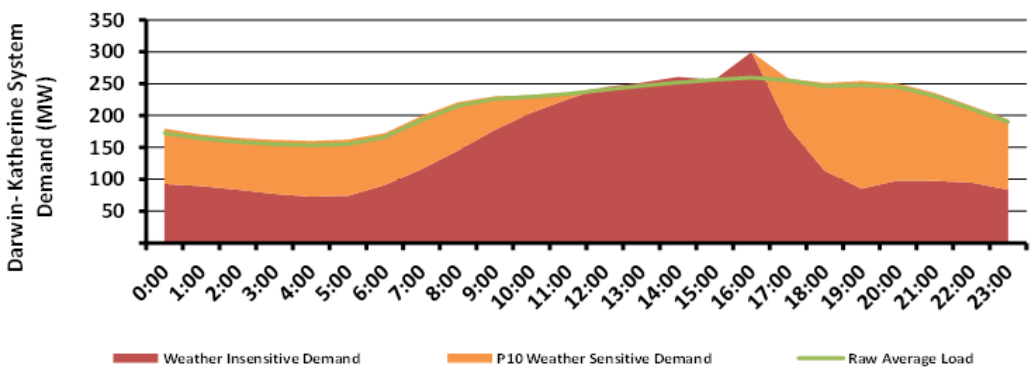
The trajectory of DER, therefore, will be a key driver of the timing of the NT's peak demand and exports over the next regulatory period.

1.3. Drivers of Uncertainty

Peak demand and peak exports are both driven by the weather, which is stochastic, or random, in nature, and whose effects must be taken into consideration when trying to accurately and precisely identify the timing of greatest utilisation. In the absence of correcting for weather variability, historical data could be biased due to reflecting relatively hot or cold weather or a relatively wet or dry year. This could in turn result in selecting the wrong peak and export periods.

Figure 4 below displays PWC's weather sensitive and insensitive load during the highest 10% of days in the year. Up to half of the load during expected future[13] peak hours is weather sensitive, and it is therefore essential that this load is correctly adjusted when determining the expected period of highest utilization, and for setting the appropriate likelihood, e.g. 1 in 10.

Figure 4 – DKIS Maximum Demand Weather Sensitivity by Hour



Source: PWC

The impact of the weather on solar PV output due mainly to cloud cover is also stochastic and requires correction to avoid biased estimates of historical minimum demand and incorrect export period definition[14].

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[13] Load is relatively insensitive during the middle of the day due to saturation of AC load when hot and humid.

[14] Data was not available at the time of writing to include weather correction for solar PV insolation

2. Scope and Approach

PWC engaged Energeia to determine the time of highest utilization across their three networks (DKIS, Alice Springs and Tennant Creek), to recommend peak and export periods for the upcoming regulatory period and to demonstrate their compliance with the NT NER. This included an analysis of the impacts of weather variation.

Energeia worked closely with PWC to develop the following study scope and delivery approach to achieve the key objectives and requirements:

1. **Develop and Validate Methodology** – Energeia developed a robust methodology for identifying optimal peak and export periods and benchmarked it against PWC's peer DNSPs.
2. **Gather Inputs** – Energeia developed and managed a formal Request-for-Information (RFI) register and reviewed the inputs from PWC to ensure they were fit-for-purpose.
3. **Determine Optimal Peak and Export[15] Periods** – Energeia modelled the forecast minimum and maximum demand periods across PWC's three networks, and then developed a unified recommendation for peak and export period across the three networks.
4. **Validation and Documentation of Results** – Energeia validated its key findings with PWC subject matter experts prior to finalising the modelling and drafting this report.

The in-depth methodology used in of each of the above steps is detailed in Section 3.

[15] Peak refers to the load peak, and Export refers to the export peak.

3. Methodology

This section describes the methodology Energeia used to develop our recommended peak and export period definitions. This method included:

- **Benchmarking** – Energeia researched and benchmarked DNSP peak period methodologies
- **Load Profile Processing** – Energeia pre-processed raw system load profile data provided to ensure the data was corrected for outages and temperature variation
- **Defining the Peak / Export Period** – Energeia calculated annual maximum and minimum demand of the processed load data and mapped it to hour by day type by network. Energeia then to developed a unified peak and export period recommendation
- **Consultation and Validation** – Energeia's peak demand and export analysis was validated by key stakeholders and subject matter experts within PWC

The following sections detail each of the key steps and their outcomes.

3.1. Industry Benchmarking

Energeia reviewed the most recent methodologies, inputs and assumption used by PWC's peer DNSPs to identify benchmarks and best practice for determining peak and export periods. Current methodologies from the most recent regulatory determinations are summarised in Table 1.

Table 1 – Peak Period Methodology

	Ausgrid	Endeavour	Essential	Energex	Ergon	EvoEnergy	AusNet	Jemena	Citipower / Powercor	United	SA Power	TasNetworks
Peak Type	CMD	CMD	CMD and NCMD	CMD and NCMD	CMD	CMD	CMD	CMD	CMD and NCMD	CMD	CMD	CMD
Years of History Considered	6	3	2	1	1	1	1	1	8	1	5	?
Customer Classes Considered	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✓	✗
Definition of the Peak Period	Top 48 Annual Peak Demand Periods Summer/ Winter	Top 10% of Daily Peak Demand	Daily Peak Demand Summer/ Winter	Res – Avg. Daily Peak Demand Non-res – Top 1% of Monthly ZS Peaks	Average Daily Peak Demand Summer/ Winter	Average Daily Peak Demand	Peak Demand timing of a Peak and Average Day	Daily Demand Peaks of 5 Highest Peak Summer Days	Daily Peak from Example ZS Summer / Winter Day	Daily Peak Demand Summer/ Winter	Daily Demand Peaks of Specific Peak Demand Events	Not Found
Definition of the Shoulder Period	N/A	Periods Within Top 10-20% of Peak	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Resolution	30min	30min	30min	30min	30min	30min	5min	30min	30min	30min	30min	30min
Weather Considered	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Forecast Demand	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

Source: Energeia Research, DNSP RIN Reporting
Notes: Coincident Maximum Demand (CMD) refers to the assessment of the demand of an aggregated network and Non-Coincident Maximum Demand (NCMD) refers to the aggregation of impacts on the zone substation level to the network.
ZS = Zone Substation

As defining export periods were not standard practice for DNSPs, data on DNSP export period methodologies was limited at the time of writing this document.

Interestingly, none of the DNSPs assessed appeared to be using weather normalisation or forecasts in their peak period definitions.

3.2. Gather and Process Inputs

Energeia processed zone substation load profiles from SCADA data to correct for network outages and to account for variation in temperature.

The key data provided by PWC for this analysis is listed in Table 2 below along with the source:

Table 2 – Data Sources

Data Type	Data Description	Start/End Date	Contact Provided
Historical Temperature	Daily Max and Min temperature, by network	July 2016 – June 2021	Senior Power Development Engineer
Historical Network Demand	Half-hourly demand trace by network	July 2016 – June 2021	Power Planning Engineer
Zone Substation Demand	Half-hourly zone demand trace by zone substation	April 2017 – March 2021	Power Planning Engineer
Outage Record	Date and time of generator and network outages	January 2015 – May 2021	Power Planning Engineer

Source: Energeia, PWC

3.2.1. Outage Correction

Energeia accounted for outages in the load profiles that occur as a result of generation, transmission, and data outages. This was important to ensure that the reliability and accuracy of minimum period forecasts were not impacted by noise in the data due to these factors.

Outage data was provided by PWC, a sample of which is reported in Table 3:

Table 3 – Sample of Outage Record

Date	Power System	Time Off (HH:MM)	Time On (HH:MM)	Incident Duration (HH:MM)	Description	Indicative Cause	Year
03/01/2016	Alice Springs	14:42	15:25	00:43	Alice Springs Power System – UFLS Stage 1A – OSPS Unit 2 Loss of Power	Generation	2016
09/01/2016	Alice Springs	17:08	18:11	01:03	Alice Springs Power System – UFLS Stage 3A – BR-SD 2 Slow Clearance Fault	Networks Transmission	2016
24/01/2016	DKIS	18:46	19:05	00:19	Darwin-Katherine Power System – 132kV PK-KA Line Tripped-UFLS Stage 2 in Katherine Island – Weather Lightning Strike	Networks Transmission	2016

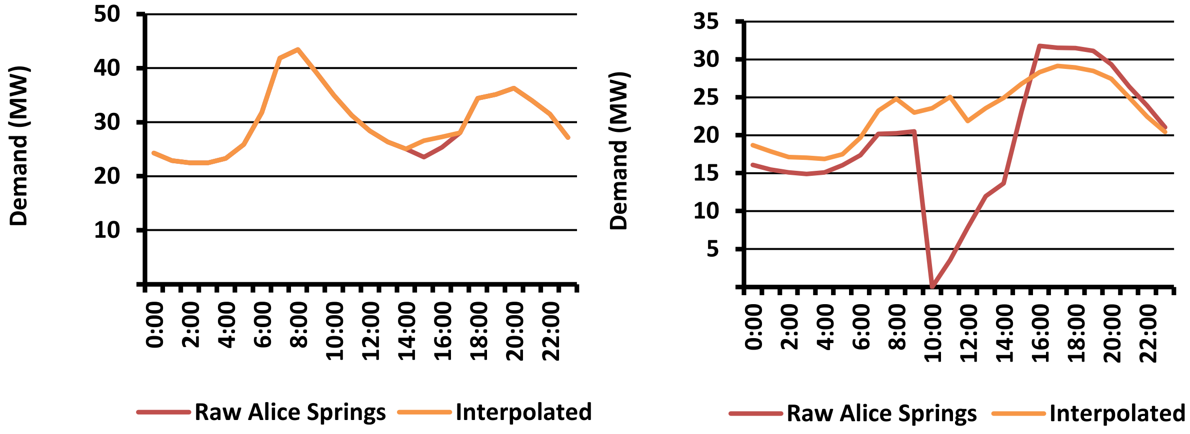
Source: PWC

Energeia corrected for generation, transmission and distribution outages using two methods:

- **Short Outages** – Outages lasting less than 2 hours were linearly interpolated
- **Long Outages** – Outages lasting longer than 2 hours were replaced with the comparable day-type 1 week before or after[17]

The impacted of outage correction can be seen in Figure 5 below.

Figure 5 – Example Short (Left) and Long (Right) Outage Corrections – Alice Springs



Source: PWC. Note: Interpolation shows Alice Springs load profiles on the days 9/11/2017 and 20/07/2015 respectively

While this method of outage correction can change the minimum and maximum demand of the corrected day, this process prioritised changing data minimally, therefore simple interpolation and a comparable day replacement approach were deemed sufficient.

3.2.2. Weather Normalisation

Peak and minimum demand events are highly correlated with temperature variation. Weather normalisation removes stochastic weather variation, enabling more accurate quantification underlying demand trends. It also ensures that weather sensitive load reflects a standard level of probability, which is typically 1 in 10 for peak and demand analysis. Considering the typical climate of the NT, minimum demand used the lowest daily temperatures and maximum demand used the highest daily temperatures.

The purpose of weather normalisation was to identify and account for variation in weather-dependent load (such as HVAC) and non-weather dependent load (such as industrial / commercial demand trends, cooking and other non-weather sensitive household appliance loads), then consider how this weather-dependent load typically behaves for a given time period. Holding temperature constant.

[17] Both weeks before and after were considered to account for periods where outages occur more than 1 week in a row.

The methodology was implemented in the following steps:

- **Determine Weather-dependent Load** – Load during the top 10% and bottom 10% of days was regressed by hour, day-type (i.e. – weekday/weekend) and month against the minimum and maximum observed daily temperature[18]. The regression coefficients, when the correct sign and with p-values < 0.05, indicated the percentage of demand which was correlated with an increase or decrease in temperature.
- **Adjust Demand for Historical and Target Weather –** Energeia first removed the actual weather sensitive load in each hour by year using the actual temperate and the hourly regression coefficient. We then added back the weather sensitive load using the same regression coefficients and the P10 temperature for peak demand, and the P90[19] temperature for the export period. Total load for the given hour, day-type, month, and year was thus the sum of the weather insensitive and the weather normalised, weather sensitive load.

The definition and calculation of P10 and P90 temperatures and their impact on each of PWC's peak day profile by network is detailed in Appendix A – Inputs and Assumptions.

3.2.3. Forecast Demand

Energeia forecasted demand in each interval over the five-year regulatory period using the weather-normalised historical trends in each hour, month and day-type combination's maximum and minimum demand. This was undertaken to ensure that a period definition is representative of customer behaviour during the period in which it will be implemented.

Energeia recommends that as PWC moves to an interval-based forecasting methodology as the smart-meter rollout progresses. This would allow the impacts of PEV and solar PV adoption to be better factored into estimates of future peak and export periods.

3.3. Period Determination

Energeia's analysis identified the times of greatest utilisation of the network for load and for exports over the forthcoming regulatory period by identifying the expected timing of maximum and minimum demand periods across PWC's zone substations assuming P10 weather.

[18] Weather normalisation could account for other measurements of weather such as humidity and solar irradiance to improve accuracy. At the time of this analysis, other weather data was not available at the required granularity.

[19] P10 refers to a 1 in 10 probability of exceedance. P90 refers to a 9 in 10 probability of exceedance.

Energeia defined PWC's peak and export periods by hour, day-type and month. The final peak and export period definition methodologies utilised in the analysis are summarised in Table 4 below.

Table 4 – Peak and Export Period Definition Methodology

Peak Period			Export Period	
Period of Maximum Utilisation	System Coincident Max Demand	Non-Coincident Zone Sub Max Demand	System Coincident Min Demand	Non-Coincident Zone Sub Min Demand
Years of History Considered	5	4	5	
Customer Classes Considered	N/A	N/A	N/A	
Peak Period Definition	> 90% of Coincident Maximum Demand	> 50% of ZS > 90% Maximum Demand	< 10% of Coincident Max Demand	
Shoulder Period Definition	N/A	N/A	N/A	N/A
Resolution	1 hr.	1 hr.	1 hr.	
Weather Normalisation (P10, P90) [21]	✓	✓	✓	
Forecast Demand	✓	✓	✓	

Source: Energeia

Energeia's justification for its methodology is summarised below:

- **Definition of the Annual Maximum / Minimum** – The annual minimum and maximum event is defined as the intervals that are within 10% of the global maximum and minimum demand for that system within the last five years. 10% was chosen as a balance between ensuring accuracy and efficiency. A larger window captures a greater number of peak demand intervals but lowers strength of the pricing signal.
- **Use of Non-Coincident Demand** – Substations must be built to meet maximum forecast demand, which typically occurs at different times of the year. As the peak window is increased to cover additional substation peaks, it will also include more times when substations are not peaking. The correct approach is therefore to set the peak period when more than half of substations are peaking. This is defined as realising demand that is some percentage[22] of the annual peak[23].
- **Treatment of Multiple Systems** – The approach to determining a single peak and export period across PWC's three systems was developed in consultation with PWC. The final methodology considers the DKIS and Alice Springs combined (i.e. non-coincident) peak and export periods only. Tennant Creek is not included due to the relative magnitude of the network, which is significantly smaller.

[21] P10 refers to a 1 in 10 probability of exceedance. P90 refers to a 9 in 10 probability of exceedance.

[22] This allows for modelling error and stochastic variability.

[23] Outage data was not available at the substation level, so network coincident demand was used for the export period.

Energeia's recommended peak and export periods were informed by the above methodology. However, the NT NER also require that tariffs be reasonably able to be understood by customers[25], and mitigate the risk of significant[26] bill shocks. Energeia therefore proposed a transitional pathway that made the period definitions easier to understand and mitigated the risk of significant bill impacts over the next regulatory period.

As behind the meter technology is increasingly able to automatically manage customer load and exports in response to tariff prices, Energeia recommends PWC consider evolving its peak period definitions and pricing structures towards more complex designs, potentially at an individual network or more spatially granular level.

3.4. Validation of Results

Energeia's peak and export period development methodology and results were validated with stakeholders and subject matter experts from PWC, including:

- **Data Processing** – PWC assisted in refining the quality of inputs, including identifying the removal of sub transmission load profiles from non-coincident demand analysis prior to finalisation of the analysis; and
- **Period Definitions** – PWC SMEs reviewed the proposed period definitions due to their understanding of asset loading and trends, and their understanding of trends in customer responses to weather extremes over the year.

4. Results

The following sections report on the results of Energeia's analysis of the projected timing of weather adjusted Non-Coincident Maximum Demand (NCMD) and coincident minimum demand on each of PWC's systems. We have also reported the results of a projection of weather normalised Coincident Maximum Demand (CMD) as a cross-check on the results of the non-coincident demand analysis.

4.1. Maximum Demand

The results for the peak period analysis are summarised in the section below by network.

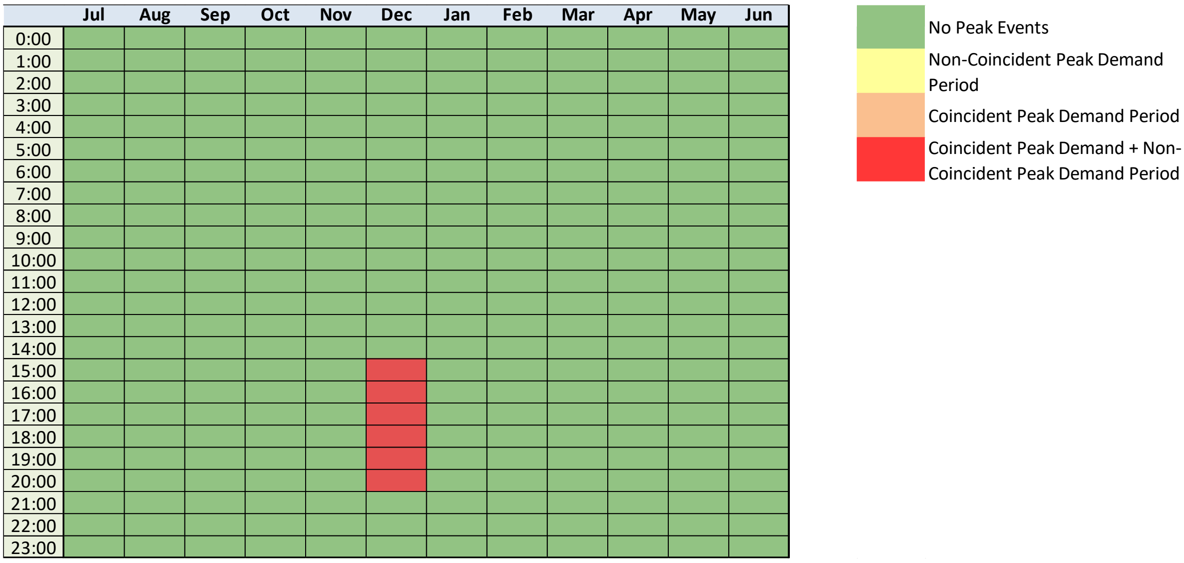
4.1.1. Darwin-Katherine Interconnected System

The projected, weather normalised peak period for DKIS is strongly aligned between the CMD and NCMD analysis. The results indicated a peak period during December from 3 pm – 9 pm on weekdays for the DKIS network, as indicated in Figure 6.

[25] National Electricity Rules as in Force in the Northern Territory Version 96 Section 6.18.5(i)

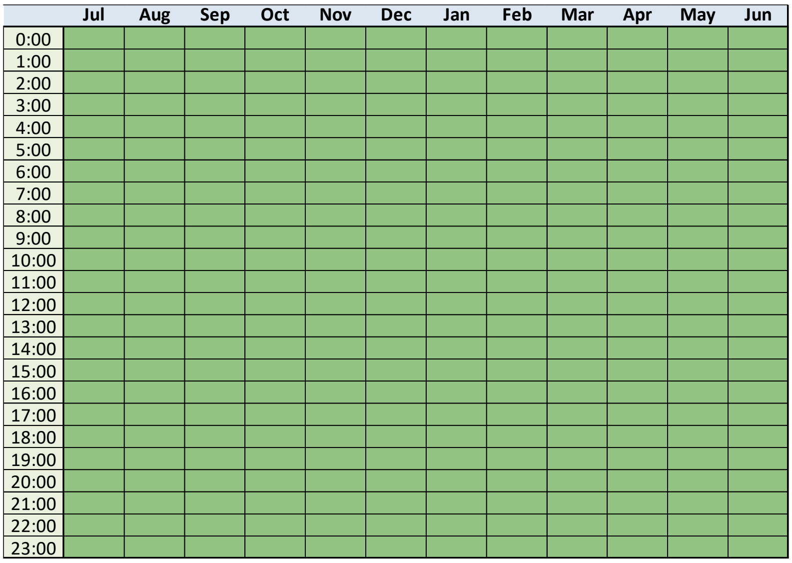
[26] National Electricity Rules as in Force in the Northern Territory Version 96 Section 6.18.7

Figure 6 – DKIS Weekday Peak Period



Source: Energeia Modelling

Figure 7 – DKIS Weekend Peak Period



Source: Energeia Modelling

Coincident Maximum Demand

Figure 8 and Figure 9 show the mapping of P10 weather normalised and 5-year trended maximum demand for each hour, month, and day type, expressed as a percentage of the maximum demand across all hours, i.e. the system maximum demand. Hours where the maximum annual demand was forecast as greater than 90% of the annual maximum hour was defined as being a peak event. This was to allow for the random variation in demand, which could have resulted in any of these periods being the maximum.

Figure 8 – DKIS Normalised CMD by Hour and Month for Weekdays

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	43%	45%	83%	59%	59%	54%	56%	57%	62%	53%	44%	48%
1:00	41%	42%	79%	56%	55%	55%	53%	55%	59%	50%	41%	46%
2:00	40%	41%	78%	55%	54%	48%	51%	54%	57%	47%	40%	44%
3:00	39%	41%	78%	55%	52%	46%	50%	54%	56%	46%	39%	43%
4:00	39%	40%	78%	55%	51%	47%	53%	51%	55%	46%	38%	43%
5:00	40%	41%	78%	58%	51%	52%	56%	51%	54%	47%	40%	44%
6:00	45%	47%	82%	60%	56%	58%	61%	58%	63%	52%	44%	49%
7:00	51%	56%	80%	69%	64%	62%	69%	70%	68%	59%	58%	60%
8:00	56%	57%	65%	71%	69%	64%	71%	69%	73%	62%	54%	58%
9:00	58%	59%	63%	66%	71%	66%	68%	69%	76%	65%	55%	56%
10:00	53%	59%	62%	67%	73%	67%	65%	65%	72%	66%	56%	55%
11:00	55%	60%	64%	68%	75%	67%	64%	65%	66%	68%	58%	56%
12:00	56%	61%	66%	76%	73%	69%	68%	66%	68%	66%	60%	58%
13:00	57%	62%	68%	76%	74%	82%	67%	68%	69%	69%	61%	61%
14:00	58%	63%	70%	76%	75%	87%	67%	69%	71%	72%	62%	60%
15:00	59%	63%	69%	78%	78%	90%	70%	71%	72%	72%	62%	61%
16:00	63%	64%	77%	78%	80%	94%	79%	74%	72%	75%	63%	62%
17:00	61%	65%	80%	77%	83%	97%	84%	73%	72%	74%	64%	68%
18:00	60%	68%	81%	78%	84%	92%	86%	74%	75%	72%	66%	70%
19:00	62%	68%	83%	80%	85%	94%	86%	74%	75%	74%	68%	71%
20:00	59%	63%	79%	76%	80%	91%	83%	72%	74%	73%	67%	72%
21:00	54%	58%	73%	70%	74%	87%	77%	68%	70%	67%	66%	67%
22:00	50%	53%	67%	64%	67%	74%	69%	63%	64%	62%	60%	62%
23:00	46%	48%	62%	58%	61%	59%	62%	57%	57%	57%	54%	56%

No Peak Events

Network Peak Event Occurs

Source: Energeia Modelling

Figure 9 – DKIS Normalised CMD by Hour and Month for Weekends

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	42%	46%	51%	51%	55%	56%	64%	54%	58%	61%	44%	52%
1:00	40%	43%	47%	49%	52%	60%	61%	53%	55%	59%	41%	49%
2:00	38%	42%	46%	47%	50%	51%	58%	50%	53%	57%	39%	47%
3:00	37%	41%	45%	46%	49%	50%	56%	49%	52%	56%	38%	45%
4:00	37%	40%	45%	45%	49%	49%	55%	49%	51%	57%	37%	45%
5:00	37%	41%	46%	46%	49%	51%	56%	49%	52%	57%	37%	43%
6:00	44%	43%	49%	48%	50%	54%	57%	50%	54%	44%	38%	44%
7:00	55%	46%	53%	51%	53%	55%	56%	51%	57%	57%	40%	48%
8:00	53%	47%	56%	52%	56%	53%	58%	53%	61%	47%	43%	46%
9:00	53%	46%	53%	56%	59%	56%	59%	55%	59%	49%	45%	42%
10:00	53%	46%	54%	56%	60%	58%	59%	55%	56%	50%	46%	42%
11:00	49%	45%	54%	58%	62%	59%	60%	56%	56%	51%	53%	42%
12:00	50%	46%	54%	60%	63%	60%	57%	56%	57%	53%	56%	42%
13:00	52%	46%	56%	60%	65%	61%	57%	61%	63%	56%	57%	44%
14:00	53%	48%	57%	62%	67%	63%	59%	61%	61%	60%	60%	46%
15:00	55%	52%	59%	64%	69%	66%	62%	61%	59%	60%	61%	47%
16:00	60%	55%	61%	67%	72%	83%	72%	65%	61%	62%	65%	52%
17:00	59%	61%	68%	72%	75%	84%	74%	74%	68%	65%	66%	57%
18:00	59%	64%	71%	75%	78%	85%	75%	78%	73%	76%	70%	60%
19:00	59%	63%	72%	75%	78%	86%	77%	82%	75%	76%	71%	59%
20:00	56%	59%	69%	72%	74%	86%	77%	80%	72%	73%	70%	56%
21:00	52%	55%	67%	67%	69%	80%	74%	75%	67%	69%	65%	53%
22:00	48%	51%	67%	61%	63%	73%	70%	68%	63%	64%	62%	50%
23:00	43%	48%	64%	55%	59%	60%	65%	60%	57%	57%	57%	46%

Source: Energeia Modelling

Non-Coincident Maximum Demand

Energeia's projected weather normalised non-coincident peak demand at the zone substation level found that the occurrence of zone substation peak demand was forecast to be centred around December afternoons on weekdays. Consistent peaking of a small percentage of zone substations outside of the peak period were predominantly driven by industrial and large commercial loads. There was not a significant number of zone substations that simultaneously experience peak events on the weekend.

Figure 10 – Percentage of DKIS ZSs Experiencing a Peak Event by Hour and Month for Weekdays

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%
1:00	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%
2:00	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%
3:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7:00	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
8:00	0%	0%	0%	1%	0%	0%	0%	0%	1%	0%	0%	0%
9:00	6%	0%	1%	2%	11%	0%	0%	0%	21%	0%	0%	0%
10:00	1%	6%	1%	1%	10%	0%	0%	0%	13%	0%	0%	0%
11:00	0%	1%	0%	2%	7%	0%	0%	0%	3%	0%	0%	0%
12:00	0%	6%	1%	2%	0%	11%	0%	0%	9%	0%	0%	0%
13:00	0%	6%	1%	3%	18%	36%	0%	0%	9%	0%	0%	0%
14:00	0%	0%	0%	1%	18%	37%	0%	1%	3%	0%	0%	0%
15:00	0%	7%	1%	1%	19%	52%	0%	10%	11%	0%	0%	0%
16:00	6%	1%	12%	1%	28%	78%	9%	0%	2%	0%	0%	0%
17:00	6%	0%	2%	1%	29%	77%	0%	0%	0%	0%	0%	0%
18:00	0%	0%	1%	1%	24%	62%	5%	0%	5%	0%	0%	0%
19:00	0%	1%	1%	6%	44%	69%	5%	0%	6%	0%	0%	0%
20:00	0%	1%	0%	6%	17%	61%	0%	0%	6%	0%	0%	0%
21:00	0%	0%	1%	1%	0%	11%	0%	0%	2%	0%	0%	0%
22:00	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%
23:00	0%	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	0%

- 0% of ZS Experiencing Peak Events
- 0%-25% of ZS Experiencing Peak Events
- 25%-50% of ZS Experiencing Peak Events
- >50% of ZS Experiencing Peak Events

Source: Energeia Modelling

Figure 11 – Percentage of DKIS ZSs Experiencing a Peak Event by Hour and Month for Weekends

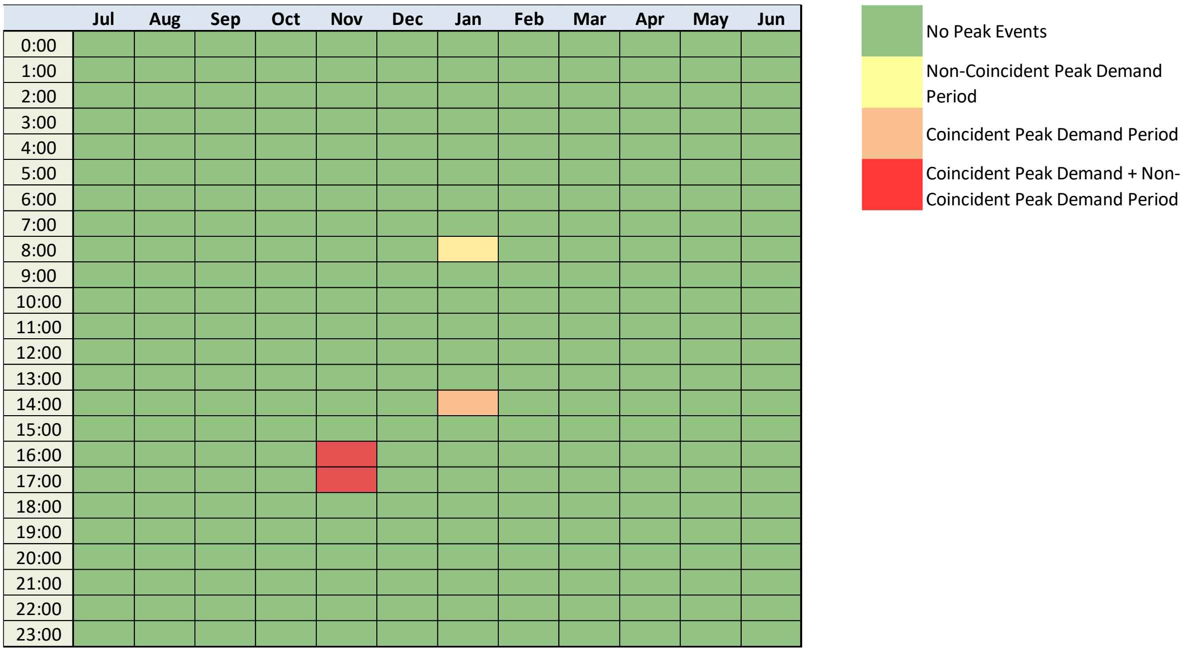
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%
1:00	0%	0%	0%	3%	3%	3%	0%	0%	0%	0%	0%	0%
2:00	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%
3:00	0%	0%	0%	0%	3%	0%	3%	0%	0%	0%	0%	0%
4:00	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%
5:00	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%
6:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8:00	3%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%
9:00	3%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%
10:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11:00	3%	0%	0%	1%	0%	0%	0%	0%	0%	0%	3%	0%
12:00	3%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%
13:00	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%
14:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
15:00	0%	6%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%
16:00	0%	0%	0%	1%	0%	12%	6%	0%	0%	0%	6%	0%
17:00	0%	0%	0%	1%	0%	12%	0%	0%	0%	0%	0%	0%
18:00	0%	0%	0%	1%	0%	21%	0%	0%	0%	0%	0%	0%
19:00	0%	0%	0%	1%	16%	21%	0%	0%	0%	0%	0%	0%
20:00	0%	0%	0%	3%	3%	13%	0%	0%	0%	0%	0%	0%
21:00	0%	0%	0%	3%	3%	4%	3%	0%	0%	0%	0%	0%
22:00	0%	0%	0%	3%	3%	3%	0%	0%	0%	0%	0%	0%
23:00	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%

Source: Energeia Modelling

4.1.2. Alice Springs

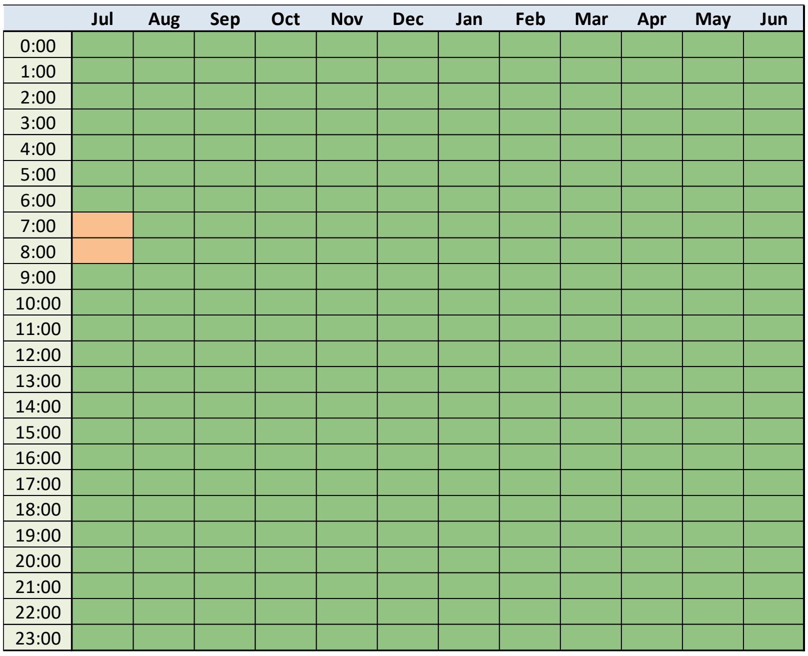
The peak demand results shown in Figure 12 and Figure 13 indicate that the Alice Springs system peak events are projected to occur from 4pm to 6pm on weekdays during November under both CMD and NCMD methods. An additional NCMD peak event is projected to occur in January at 8 am and a CMD event at 2 pm. Alice additionally has a forecasted CMD peak event during the early hours of the morning during the summer season in July between 7am and 9am on weekends.

Figure 12 – Alice Springs Weekday Peak Period



Source: Energeia Modelling

Figure 13 – Alice Springs Weekend Peak Period



Source: Energeia Modelling

Coincident Maximum Demand

Figure 14 and Figure 15 below show the results of projected, weather normalised system maximum peak demand by month, day type and hour. The modelling found that total system demand is projected to exceed 90% of the global hourly maximum in November on weekdays between four and six pm. During the winter month of July, demand peaks including the CMD is forecasted to occur between 7am and 9am on weekends, when the colder Alice climate drives additional residential heating load in the morning.

Figure 14 – Alice Springs Weather Normalised CMD by Hour and Month for Weekdays

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	48%	38%	44%	49%	62%	60%	70%	56%	53%	37%	42%	49%
1:00	49%	37%	43%	46%	57%	56%	68%	57%	50%	35%	39%	47%
2:00	51%	37%	43%	43%	56%	55%	66%	55%	48%	35%	37%	45%
3:00	51%	37%	44%	43%	54%	54%	62%	54%	47%	33%	37%	43%
4:00	52%	38%	44%	42%	52%	53%	59%	54%	46%	33%	37%	44%
5:00	53%	41%	45%	41%	52%	55%	59%	53%	46%	32%	40%	46%
6:00	67%	59%	45%	44%	54%	57%	62%	56%	51%	35%	45%	56%
7:00	86%	75%	47%	53%	67%	65%	72%	60%	62%	40%	59%	75%
8:00	81%	69%	52%	65%	77%	75%	83%	66%	73%	42%	68%	78%
9:00	56%	51%	50%	71%	71%	78%	61%	66%	78%	46%	57%	72%
10:00	48%	48%	53%	74%	62%	80%	64%	65%	61%	47%	51%	53%
11:00	48%	41%	52%	78%	73%	78%	78%	69%	66%	48%	49%	44%
12:00	49%	40%	54%	83%	76%	79%	83%	72%	72%	51%	50%	42%
13:00	57%	39%	55%	85%	78%	80%	86%	74%	78%	55%	51%	41%
14:00	61%	39%	58%	84%	77%	81%	90%	76%	82%	63%	50%	41%
15:00	51%	40%	56%	83%	77%	80%	83%	81%	87%	69%	51%	42%
16:00	49%	40%	59%	81%	92%	84%	86%	80%	88%	71%	51%	45%
17:00	50%	42%	56%	77%	93%	81%	81%	83%	85%	72%	54%	48%
18:00	61%	52%	57%	78%	84%	83%	78%	82%	83%	68%	57%	56%
19:00	65%	58%	56%	75%	81%	81%	76%	80%	82%	67%	61%	63%
20:00	61%	63%	53%	70%	78%	77%	76%	76%	80%	62%	60%	64%
21:00	55%	60%	46%	64%	71%	70%	71%	71%	69%	56%	55%	61%
22:00	50%	54%	46%	58%	65%	65%	63%	64%	61%	49%	51%	55%
23:00	47%	44%	47%	51%	58%	62%	59%	60%	55%	44%	45%	49%

No Peak Events

Network Peak Event Occurs

Source: Energeia Modelling

Figure 15 – Alice Springs Weather Normalised CMD by Hour and Month for Weekends

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	47%	42%	31%	48%	66%	71%	55%	66%	56%	41%	43%	47%
1:00	45%	40%	31%	41%	62%	67%	50%	62%	54%	39%	40%	45%
2:00	44%	39%	30%	37%	61%	63%	48%	57%	52%	36%	39%	45%
3:00	46%	40%	30%	35%	60%	61%	45%	57%	52%	34%	39%	45%
4:00	48%	40%	30%	35%	57%	59%	45%	56%	53%	34%	39%	44%
5:00	56%	44%	30%	32%	55%	59%	44%	55%	52%	33%	41%	46%
6:00	75%	52%	33%	31%	54%	57%	42%	57%	53%	31%	45%	55%
7:00	100%	58%	37%	32%	50%	62%	43%	61%	56%	33%	53%	69%
8:00	98%	57%	34%	35%	49%	66%	45%	67%	60%	40%	62%	81%
9:00	74%	47%	35%	37%	50%	77%	48%	46%	61%	38%	58%	69%
10:00	53%	44%	38%	39%	51%	52%	54%	51%	68%	39%	51%	54%
11:00	51%	38%	39%	43%	54%	61%	53%	53%	47%	39%	42%	53%
12:00	41%	34%	45%	45%	57%	66%	63%	56%	52%	43%	44%	36%
13:00	39%	34%	45%	52%	58%	71%	67%	60%	53%	46%	44%	34%
14:00	40%	36%	44%	53%	62%	78%	70%	61%	56%	48%	44%	32%
15:00	44%	36%	45%	56%	67%	75%	77%	65%	79%	52%	43%	33%
16:00	50%	36%	46%	59%	77%	80%	76%	68%	79%	56%	43%	37%
17:00	52%	35%	50%	62%	82%	88%	77%	68%	76%	56%	40%	44%
18:00	60%	50%	50%	63%	83%	90%	75%	70%	75%	53%	51%	54%
19:00	62%	52%	48%	64%	82%	88%	76%	68%	78%	52%	56%	61%
20:00	62%	50%	45%	60%	79%	86%	76%	66%	77%	46%	58%	61%
21:00	58%	49%	39%	52%	72%	84%	70%	62%	68%	42%	56%	61%
22:00	56%	46%	36%	44%	64%	74%	63%	55%	61%	38%	52%	56%
23:00	51%	41%	33%	38%	58%	68%	59%	50%	57%	34%	47%	51%

Source: Energeia Modelling

Non-Coincident Maximum Demand

The results of Energeia's NCMD analysis is shown Figure 16 and Figure 17, which projects peak events occurring on weekdays between 4pm and 6pm in November and 8am to 9am in January. No NCMD peak events were projected during weekends, with the highest-level loading of ZSs reaching only 37% in March between 3pm and 6pm. It is important to note that there were only four ZS in Alice Springs, resulting in coarser grain results.

Figure 16 – Percentage of Alice Springs Experiencing a Peak Event by Hour and Month for Weekdays

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7:00	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8:00	0%	0%	0%	0%	0%	17%	54%	0%	0%	0%	0%	0%
9:00	0%	0%	0%	0%	0%	17%	0%	0%	2%	0%	0%	0%
10:00	0%	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%
11:00	0%	0%	0%	17%	0%	17%	17%	0%	0%	0%	0%	0%
12:00	0%	0%	0%	17%	0%	17%	17%	0%	2%	0%	0%	0%
13:00	0%	0%	0%	17%	17%	17%	17%	0%	2%	0%	0%	0%
14:00	0%	0%	0%	17%	17%	17%	17%	0%	2%	0%	0%	0%
15:00	0%	0%	0%	17%	17%	17%	17%	0%	2%	0%	0%	0%
16:00	0%	0%	0%	17%	54%	17%	0%	0%	2%	0%	0%	0%
17:00	0%	0%	0%	17%	54%	17%	0%	0%	0%	0%	0%	0%
18:00	0%	0%	0%	17%	17%	17%	37%	0%	0%	0%	0%	0%
19:00	0%	0%	0%	17%	17%	17%	37%	0%	0%	0%	0%	0%
20:00	0%	0%	0%	0%	17%	17%	37%	0%	0%	0%	0%	0%
21:00	0%	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%
22:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
23:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

- 0% of ZS Experiencing Peak Events
- 0%-25% of ZS Experiencing Peak Events
- 25%-50% of ZS Experiencing Peak Events
- >50% of ZS Experiencing Peak Events

Source: Energeia Modelling

Figure 17 – Percentage of Alice Springs ZSs Experiencing a Peak Event by Hour and Month for Weekends

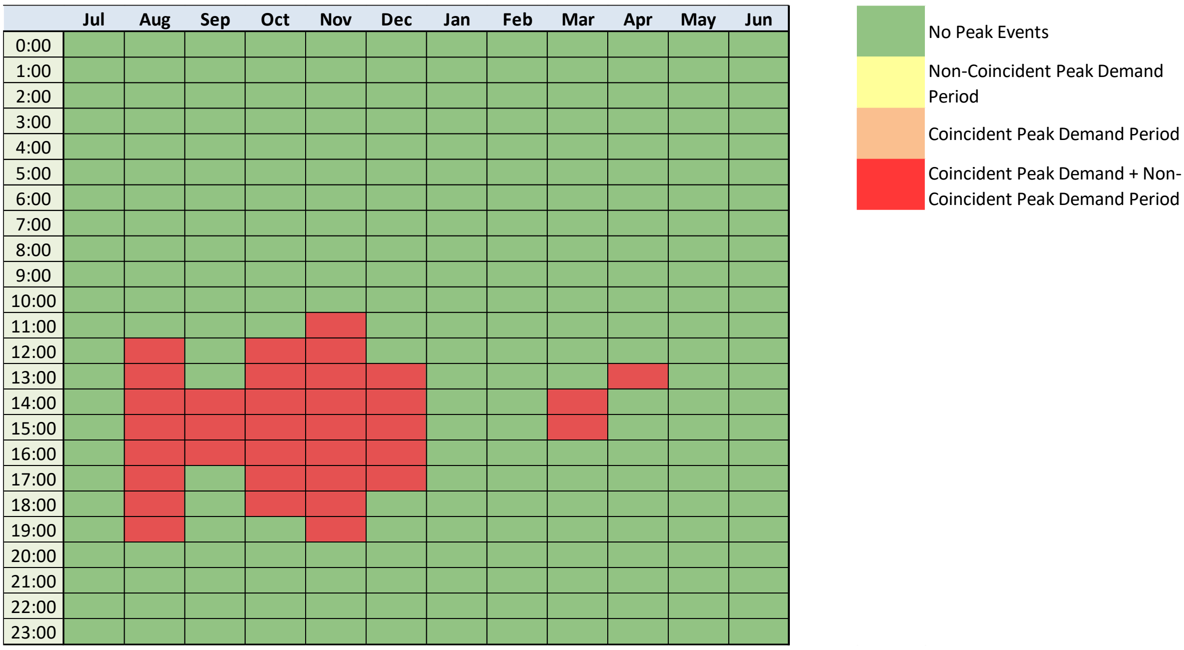
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
4:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7:00	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9:00	0%	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%
10:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
11:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
13:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
14:00	0%	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%
15:00	0%	0%	0%	0%	17%	0%	0%	0%	37%	0%	0%	0%
16:00	0%	0%	0%	0%	17%	0%	0%	0%	37%	0%	0%	0%
17:00	0%	0%	0%	0%	17%	17%	0%	0%	37%	0%	0%	0%
18:00	0%	0%	0%	0%	17%	17%	0%	0%	0%	0%	0%	0%
19:00	0%	0%	0%	0%	17%	17%	0%	0%	0%	0%	0%	0%
20:00	0%	0%	0%	0%	17%	17%	0%	0%	0%	0%	0%	0%
21:00	0%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%	0%
22:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
23:00	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: Energeia Modelling

4.1.3. Tennant Creek

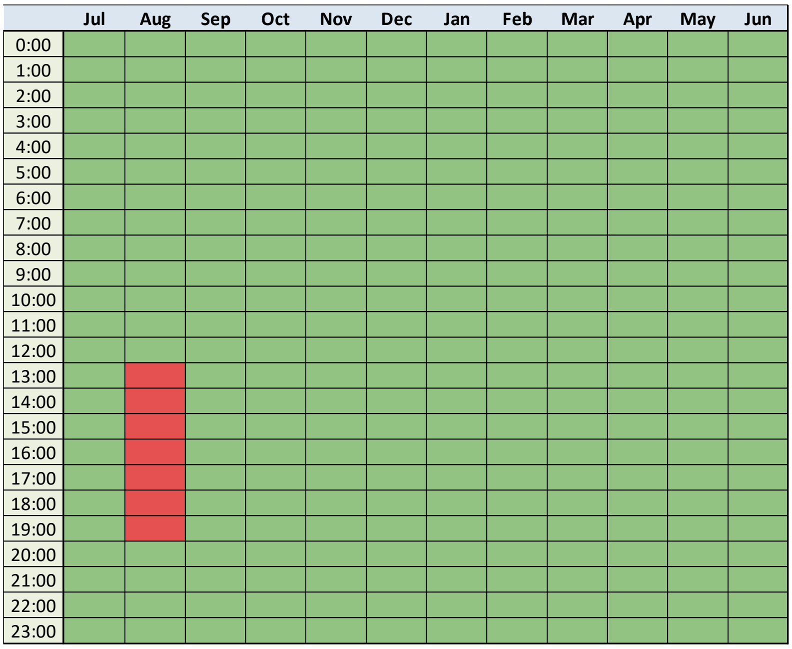
Tenant Creek has one substation, so CMD and NCMD are the same. Energeia's modelling results shown in Figure 18 and Figure 19 project Tennant Creek's peak demand period mainly to occur on weekdays between noon and 7pm during the August to December period, with some exceptions. A small number of peak demand event periods also are forecasted to occur on weekdays in the early afternoon during March and April, and between 1pm to 8pm on weekends.

Figure 18 – Tennant Creek Weekday Peak Period



Source: Energeia Modelling

Figure 19 – Tennant Creek Weekend Peak Period



Source: Energeia Modelling

Coincident Maximum Demand

Figure 20 and Figure 21 report on the results of Energeia's CMD analysis as a heat map. The results match the summary figures above due to the existence of only one ZS in the Tennant Creek network.

Figure 20 – Tennant Creek Normalized CMD by Hour and Month for Weekdays

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	55%	65%	53%	60%	59%	70%	64%	62%	57%	55%	45%	39%
1:00	49%	58%	52%	57%	57%	62%	62%	62%	57%	53%	42%	36%
2:00	49%	48%	51%	53%	55%	60%	58%	61%	57%	52%	46%	33%
3:00	56%	52%	49%	50%	54%	58%	57%	61%	57%	51%	40%	33%
4:00	57%	50%	47%	48%	53%	56%	56%	61%	57%	50%	40%	37%
5:00	56%	50%	47%	45%	54%	56%	56%	61%	61%	51%	38%	37%
6:00	54%	50%	50%	46%	56%	59%	57%	61%	61%	48%	45%	40%
7:00	55%	50%	56%	51%	62%	61%	56%	61%	61%	53%	53%	44%
8:00	60%	60%	66%	67%	71%	71%	63%	68%	57%	56%	55%	50%
9:00	60%	72%	71%	75%	77%	76%	81%	78%	67%	68%	56%	44%
10:00	63%	81%	74%	80%	81%	81%	80%	72%	70%	73%	62%	42%
11:00	62%	90%	80%	86%	91%	84%	79%	80%	78%	76%	57%	45%
12:00	67%	96%	87%	90%	92%	89%	86%	80%	85%	87%	58%	49%
13:00	74%	102%	89%	94%	94%	93%	87%	81%	89%	92%	65%	53%
14:00	79%	108%	94%	95%	98%	96%	90%	82%	95%	85%	64%	56%
15:00	79%	110%	93%	97%	99%	95%	89%	87%	93%	87%	65%	56%
16:00	78%	103%	92%	96%	98%	96%	84%	84%	90%	90%	64%	58%
17:00	76%	95%	89%	94%	96%	93%	86%	83%	89%	86%	61%	54%
18:00	72%	96%	87%	90%	95%	89%	82%	82%	88%	75%	59%	49%
19:00	65%	91%	86%	85%	91%	87%	84%	80%	84%	72%	60%	47%
20:00	64%	87%	82%	73%	84%	87%	80%	82%	75%	69%	57%	46%
21:00	61%	84%	76%	63%	82%	87%	78%	72%	70%	69%	54%	44%
22:00	57%	78%	69%	59%	75%	72%	73%	65%	64%	63%	53%	42%
23:00	53%	72%	52%	55%	70%	70%	69%	62%	58%	61%	53%	40%

No Peak Events

Network Peak Event Occurs

Source: Energeia Modelling

Figure 21 – Tennant Creek Normalized CMD by Hour and Month for Weekends

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	64%	67%	47%	55%	62%	66%	65%	69%	52%	58%	43%	40%
1:00	61%	61%	49%	52%	59%	64%	62%	65%	46%	58%	44%	41%
2:00	58%	56%	44%	49%	58%	60%	59%	64%	43%	56%	44%	36%
3:00	56%	54%	47%	45%	56%	57%	55%	64%	41%	56%	42%	35%
4:00	57%	52%	49%	42%	54%	56%	53%	64%	40%	55%	40%	33%
5:00	57%	52%	50%	42%	53%	54%	55%	64%	42%	55%	40%	34%
6:00	57%	55%	51%	40%	50%	53%	53%	64%	43%	54%	41%	39%
7:00	60%	60%	54%	44%	53%	55%	51%	61%	42%	51%	43%	45%
8:00	64%	72%	62%	46%	56%	59%	52%	60%	45%	56%	45%	53%
9:00	71%	73%	67%	50%	61%	64%	60%	62%	51%	65%	47%	51%
10:00	76%	81%	71%	56%	67%	70%	67%	67%	58%	70%	50%	46%
11:00	76%	82%	76%	52%	70%	75%	77%	70%	71%	71%	53%	45%
12:00	79%	87%	82%	56%	73%	79%	69%	71%	77%	73%	54%	42%
13:00	81%	91%	86%	58%	77%	81%	67%	74%	78%	81%	59%	41%
14:00	81%	93%	87%	59%	79%	83%	70%	74%	81%	88%	58%	46%
15:00	80%	93%	85%	62%	81%	84%	69%	76%	86%	89%	58%	53%
16:00	81%	93%	87%	79%	83%	84%	67%	81%	90%	89%	56%	51%
17:00	78%	90%	86%	75%	86%	86%	69%	81%	88%	88%	55%	49%
18:00	80%	96%	83%	71%	83%	86%	71%	82%	85%	82%	54%	44%
19:00	77%	91%	80%	67%	83%	84%	65%	81%	67%	80%	56%	46%
20:00	80%	87%	77%	63%	81%	83%	64%	79%	62%	78%	53%	46%
21:00	77%	84%	71%	62%	75%	77%	61%	66%	56%	73%	51%	42%
22:00	73%	78%	67%	57%	69%	72%	59%	66%	54%	67%	47%	41%
23:00	68%	72%	63%	53%	64%	69%	60%	66%	51%	61%	46%	39%

Source: Energeia Modelling

4.2. Minimum Demand

Energeia's analysis of the export period is based on our projection of weather normalised hourly demand by month and day type. While we are projecting demand over the next five[27] year period, we expect the combination of electrification, rooftop solar and BTM storage to potentially result in

[27] Projections are relatively simple forecasts and should not be applied for more than 3-5 years.

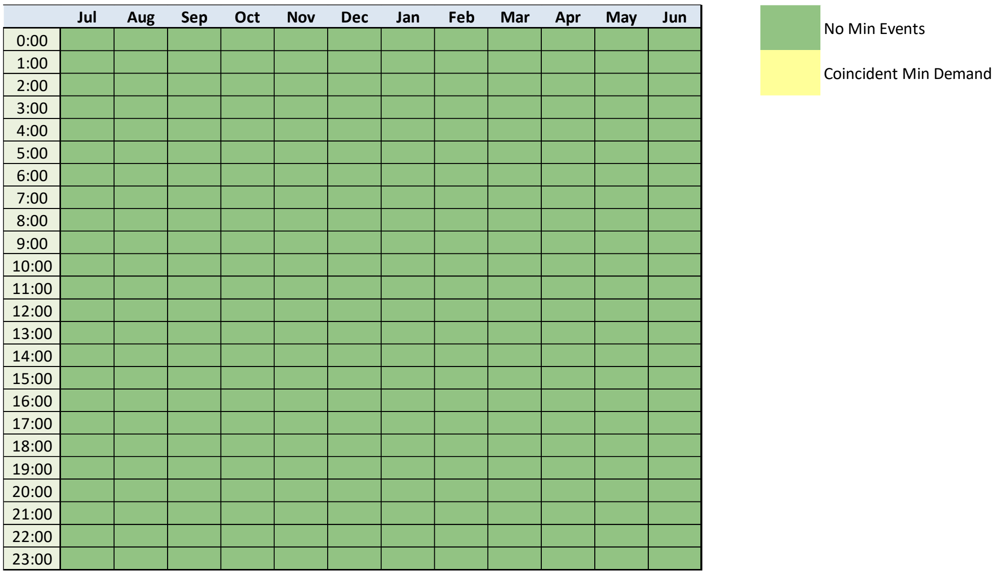
significantly different periods of maximum demand over time. Energeia recommends undertaking a more sophisticated peak export period assessment to improve its accuracy in the future.

As mentioned earlier, outages were not available at the Zone Substation level, which limited Energeia's analysis to projecting Coincident Minimum Demand (CMD[28]). Energeia also recommends updating this analysis once zone substation level analysis is available, as minimum demand on substations and feeders are the key driver of future investment costs, more so than the system minimum demand, which, while correlated to substation minimum demand, is less accurate.

4.2.1. Darwin-Katherine Interconnected System

The results of Energeia's weather normalised, projected minimum demand analysis shown in Figure 22 and Figure 23 found no minimum demand events are expected to occur during weekdays in the DKIS network. The results indicated the peak export period to be in May between 10 am and 4 pm. This coincides, unsurprisingly, with milder daily temperatures, lower weather sensitive loads and hours of higher solar PV generation.

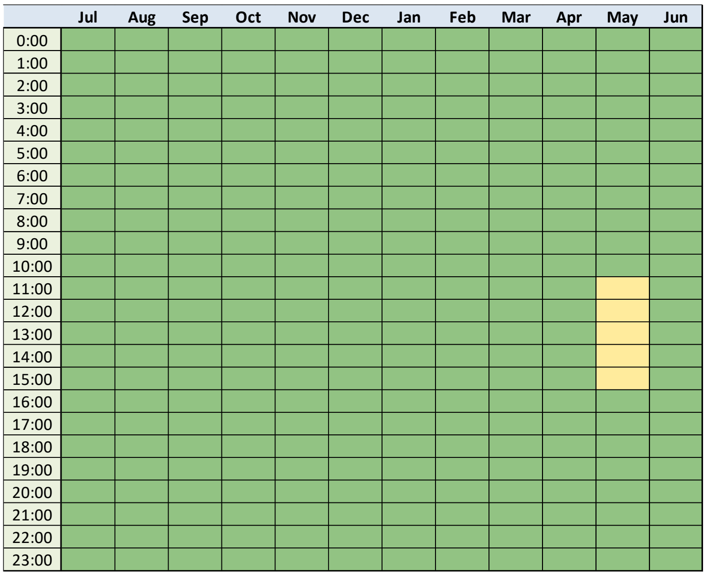
Figure 22 – DKIS Weekday Export Period



Source: Energeia Modelling

[28] CMD in the context of minimum demand or the peak export period is defined as Coincident Minimum Demand herein.

Figure 23 – DKIS Weekend Export Period



Source: Energeia Modelling

Coincident Minimum Demand

Figure 24 and Figure 25 show the weather normalised, 5-year projected hourly CMD for each month by day type, expressed as a percentage of the system-wide hourly maximum demand. Similarly to the approach adopted for peak demand events, periods where CMD is less than 10% are considered min demand events, to provide an allowance for random variation in load and solar generation.

Figure 24 – DKIS Normalized CMD by Hour/Month for Weekdays

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	29%	38%	35%	40%	46%	56%	38%	41%	40%	37%	36%	29%
1:00	27%	35%	43%	38%	43%	47%	37%	39%	38%	34%	34%	27%
2:00	26%	35%	41%	36%	38%	52%	36%	39%	37%	30%	33%	26%
3:00	26%	34%	40%	35%	38%	52%	36%	38%	36%	28%	33%	26%
4:00	26%	33%	39%	34%	39%	50%	36%	37%	37%	26%	33%	27%
5:00	28%	33%	40%	36%	41%	44%	37%	38%	39%	25%	35%	28%
6:00	31%	35%	38%	41%	45%	38%	43%	42%	46%	28%	38%	32%
7:00	34%	40%	45%	48%	49%	46%	49%	47%	50%	28%	28%	36%
8:00	32%	39%	49%	48%	50%	53%	47%	47%	48%	33%	44%	37%
9:00	30%	37%	50%	60%	52%	53%	46%	47%	46%	33%	40%	34%
10:00	38%	36%	49%	59%	52%	53%	46%	44%	44%	31%	38%	31%
11:00	36%	33%	48%	56%	55%	52%	47%	43%	44%	29%	27%	29%
12:00	35%	34%	49%	48%	59%	45%	50%	44%	44%	42%	26%	29%
13:00	36%	36%	50%	51%	61%	39%	44%	48%	45%	47%	25%	31%
14:00	38%	38%	51%	55%	61%	48%	54%	48%	51%	35%	23%	33%
15:00	42%	40%	55%	59%	63%	47%	47%	52%	53%	35%	28%	38%
16:00	38%	46%	53%	59%	72%	48%	61%	52%	60%	35%	29%	41%
17:00	44%	52%	57%	60%	76%	47%	53%	51%	69%	37%	36%	46%
18:00	47%	59%	59%	63%	77%	48%	58%	52%	65%	41%	42%	50%
19:00	48%	61%	59%	64%	76%	50%	62%	53%	67%	43%	42%	52%
20:00	44%	58%	54%	60%	72%	49%	61%	50%	64%	43%	40%	47%
21:00	40%	52%	49%	55%	67%	48%	56%	46%	59%	43%	37%	42%
22:00	36%	48%	44%	52%	63%	59%	50%	43%	54%	44%	34%	37%
23:00	32%	42%	39%	48%	59%	39%	45%	39%	48%	42%	31%	33%

No Min Events

Coincident Min Demand

Source: Energeia Modelling

Figure 25 – DKIS Normalized CMD by Hour/Month for Weekends

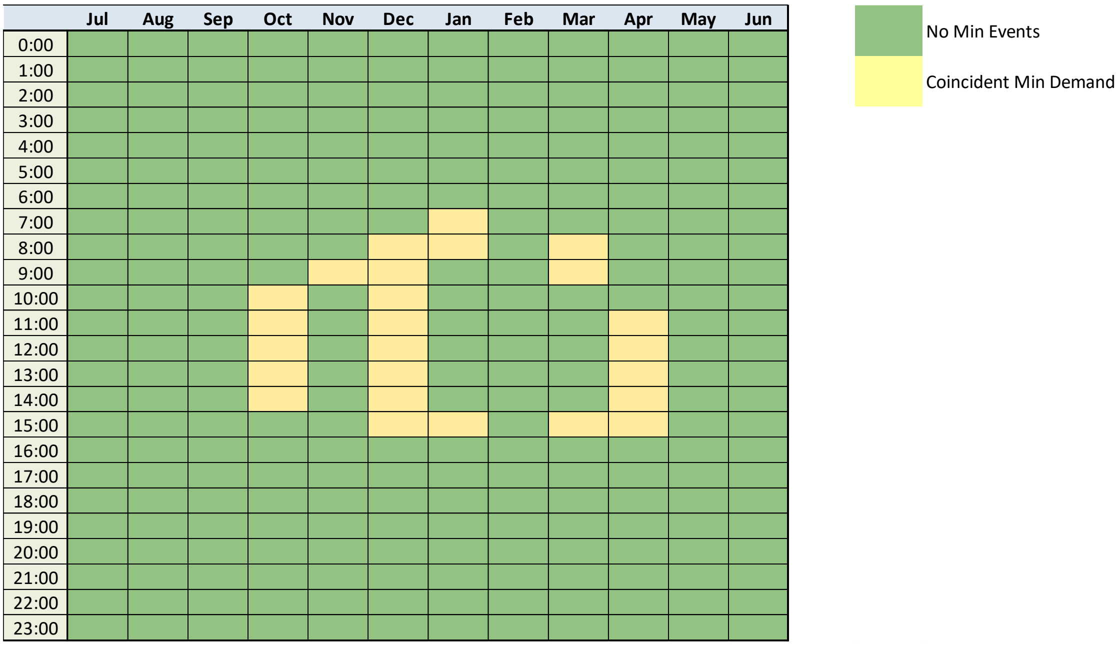
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	34%	33%	46%	51%	41%	47%	43%	48%	34%	31%	39%	24%
1:00	32%	32%	44%	49%	38%	36%	41%	45%	33%	28%	37%	23%
2:00	31%	31%	43%	48%	37%	44%	39%	43%	32%	26%	35%	22%
3:00	30%	30%	41%	47%	36%	43%	38%	43%	32%	24%	35%	22%
4:00	31%	30%	40%	46%	36%	43%	37%	33%	32%	23%	35%	22%
5:00	32%	30%	40%	46%	36%	35%	39%	35%	31%	23%	36%	22%
6:00	33%	32%	41%	47%	37%	37%	40%	37%	32%	40%	37%	24%
7:00	33%	35%	41%	47%	37%	37%	40%	40%	34%	23%	39%	26%
8:00	33%	35%	41%	46%	37%	45%	41%	42%	35%	40%	39%	27%
9:00	31%	33%	40%	46%	39%	43%	43%	39%	34%	37%	36%	36%
10:00	27%	29%	39%	46%	45%	44%	40%	41%	37%	33%	32%	32%
11:00	29%	29%	40%	46%	47%	43%	38%	43%	40%	31%	12%	29%
12:00	29%	28%	42%	48%	51%	45%	42%	43%	43%	31%	6%	29%
13:00	30%	29%	45%	50%	54%	48%	44%	42%	45%	34%	4%	31%
14:00	33%	31%	49%	53%	53%	54%	43%	52%	47%	37%	4%	33%
15:00	38%	31%	53%	57%	54%	57%	45%	47%	51%	41%	10%	37%
16:00	39%	38%	58%	62%	57%	43%	45%	57%	54%	48%	19%	34%
17:00	46%	45%	54%	70%	62%	46%	49%	61%	57%	56%	28%	40%
18:00	50%	48%	58%	72%	62%	45%	54%	62%	57%	40%	34%	43%
19:00	51%	49%	58%	72%	62%	45%	56%	56%	59%	44%	34%	43%
20:00	48%	46%	54%	69%	61%	42%	56%	56%	57%	43%	33%	39%
21:00	44%	43%	49%	66%	57%	41%	54%	53%	53%	40%	31%	36%
22:00	42%	40%	45%	62%	53%	40%	51%	46%	49%	38%	29%	33%
23:00	38%	36%	41%	57%	50%	50%	46%	42%	44%	36%	28%	30%

Source: Energeia Modelling

4.2.2. Alice Springs

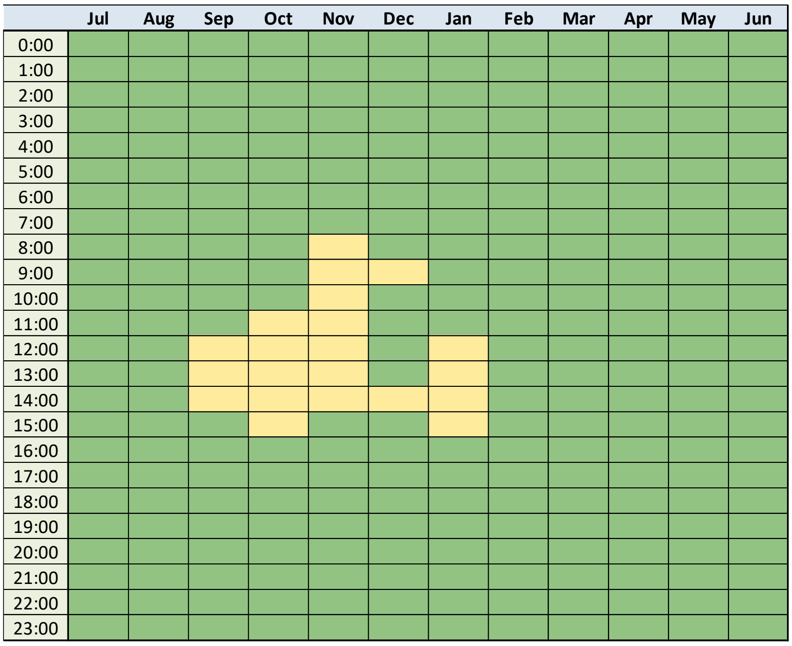
The results of Energeia's minimum demand analysis shown in Figure 26 and Figure 27 indicate that minimum demand events in Alice are expected to occur during both weekdays and weekends, but to varying degrees. The results show minimum demand periods occurring between 7am and 4pm in summer on weekdays. Minimum demand events on weekends were forecast to be focused between 8am and 4pm between September and January (Spring and Summer seasons). Although there are currently gaps between 10am and 2pm in some months, we expect rising solar PV generation will eventually fill these in over time.

Figure 26 – Alice Springs Weekday Export Period



Source: Energeia Modelling

Figure 27 – Alice Springs Weekend Export Period



Source: Energeia Modelling

Coincident Minimum Demand

Figure 28 and Figure 29 below show the minimum demand by hour, day type and month, as a percentage of the system peak. As mentioned in the previous section, Energeia expects rising solar PV adoption over time to continue to reduce demand in the 11am to 3pm period over time. However, our modelling suggests this is not likely to occur over the next 5 years of the projection period.

Figure 28 – Alice Springs Normalized CMD by Hour and Month for

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	33%	28%	34%	24%	11%	11%	15%	21%	11%	26%	28%	31%
1:00	31%	26%	32%	23%	12%	11%	14%	20%	12%	24%	27%	29%
2:00	30%	26%	30%	22%	10%	10%	13%	18%	12%	24%	26%	28%
3:00	30%	25%	30%	23%	11%	11%	13%	18%	12%	23%	25%	27%
4:00	30%	25%	31%	23%	12%	11%	13%	19%	11%	25%	24%	26%
5:00	32%	25%	31%	24%	14%	12%	13%	19%	13%	25%	25%	27%
6:00	35%	28%	33%	29%	15%	11%	13%	21%	16%	25%	26%	27%
7:00	37%	20%	37%	29%	14%	10%	7%	23%	17%	27%	27%	27%
8:00	38%	23%	31%	20%	12%	5%	-1%	21%	6%	22%	26%	26%
9:00	33%	21%	26%	13%	9%	3%	29%	19%	0%	16%	24%	31%
10:00	30%	20%	24%	9%	10%	3%	30%	16%	15%	11%	24%	27%
11:00	26%	21%	19%	7%	10%	4%	21%	17%	14%	6%	21%	25%
12:00	23%	21%	15%	6%	13%	6%	21%	19%	10%	4%	15%	25%
13:00	21%	22%	15%	7%	13%	5%	24%	22%	10%	5%	14%	26%
14:00	22%	22%	15%	9%	16%	5%	21%	25%	10%	5%	13%	26%
15:00	25%	24%	19%	14%	27%	8%	9%	29%	5%	8%	14%	27%
16:00	32%	31%	24%	21%	29%	13%	18%	35%	10%	15%	21%	31%
17:00	42%	37%	29%	28%	30%	21%	27%	41%	20%	24%	31%	36%
18:00	52%	47%	40%	38%	40%	28%	38%	44%	23%	33%	41%	37%
19:00	52%	43%	47%	40%	38%	30%	38%	43%	24%	40%	47%	42%
20:00	49%	42%	44%	39%	34%	31%	37%	40%	21%	41%	42%	43%
21:00	44%	39%	41%	37%	31%	28%	31%	40%	20%	40%	38%	42%
22:00	40%	34%	39%	33%	27%	26%	27%	38%	18%	35%	35%	40%
23:00	36%	31%	37%	30%	23%	23%	24%	34%	18%	30%	32%	36%

No Min Events
Coincident Min Demand

Source: Energeia Modelling

Figure 29 – Alice Springs Normalized CMD by Hour and Month for Weekends

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	31%	24%	31%	25%	11%	19%	38%	25%	22%	31%	27%	26%
1:00	29%	24%	29%	24%	12%	17%	37%	23%	21%	29%	25%	25%
2:00	28%	23%	28%	24%	10%	15%	30%	22%	19%	27%	24%	24%
3:00	27%	22%	28%	24%	11%	15%	30%	22%	19%	27%	23%	23%
4:00	27%	21%	29%	25%	12%	14%	30%	22%	18%	27%	23%	22%
5:00	28%	22%	29%	26%	15%	14%	30%	21%	19%	27%	22%	21%
6:00	27%	26%	30%	27%	15%	15%	30%	20%	20%	29%	24%	22%
7:00	25%	24%	28%	26%	13%	14%	29%	16%	21%	29%	25%	22%
8:00	28%	24%	26%	22%	5%	10%	33%	10%	18%	27%	24%	24%
9:00	32%	21%	22%	18%	3%	5%	29%	31%	16%	27%	24%	24%
10:00	30%	19%	14%	14%	1%	23%	30%	31%	11%	24%	25%	21%
11:00	26%	20%	12%	9%	2%	24%	36%	31%	24%	20%	23%	22%
12:00	25%	19%	7%	8%	4%	27%	8%	34%	24%	16%	17%	20%
13:00	23%	16%	8%	2%	8%	32%	4%	37%	30%	16%	16%	20%
14:00	24%	16%	9%	1%	9%	7%	6%	40%	32%	15%	16%	22%
15:00	27%	19%	12%	6%	13%	13%	9%	22%	16%	17%	18%	24%
16:00	32%	26%	19%	14%	18%	21%	11%	30%	20%	22%	26%	27%
17:00	38%	35%	24%	22%	29%	30%	22%	40%	29%	30%	35%	31%
18:00	42%	39%	33%	29%	34%	37%	35%	46%	34%	37%	39%	33%
19:00	42%	40%	38%	33%	32%	38%	35%	44%	35%	41%	44%	35%
20:00	41%	36%	38%	33%	32%	37%	34%	41%	30%	42%	41%	32%
21:00	38%	34%	37%	32%	29%	33%	32%	38%	29%	39%	38%	30%
22:00	33%	31%	35%	31%	26%	29%	30%	33%	25%	36%	35%	28%
23:00	31%	30%	33%	30%	23%	25%	27%	30%	23%	32%	32%	26%

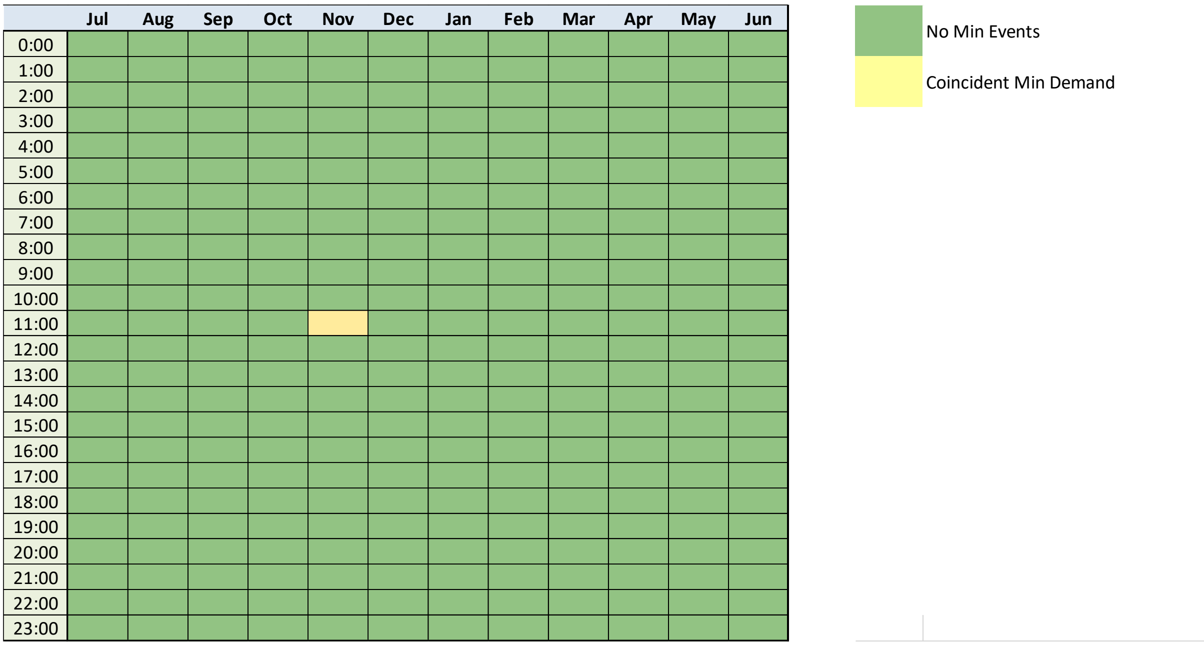
Source: Energeia Modelling

Alice Springs networks minimum demand periods were a more common occurrence than the Darwin-Katherine Interconnected System (DKIS) and Tennant Creek network because Alice Springs already has a much higher solar PV penetration. Energeia expects DKIS and Tennant Creek to become more like Alice Springs over time, however, very different types of loads in DKIS and Tennant Creek and their associated daily and monthly profiles mean that the future timing of minimum demand could still vary between the systems.

4.2.3. Tennant Creek

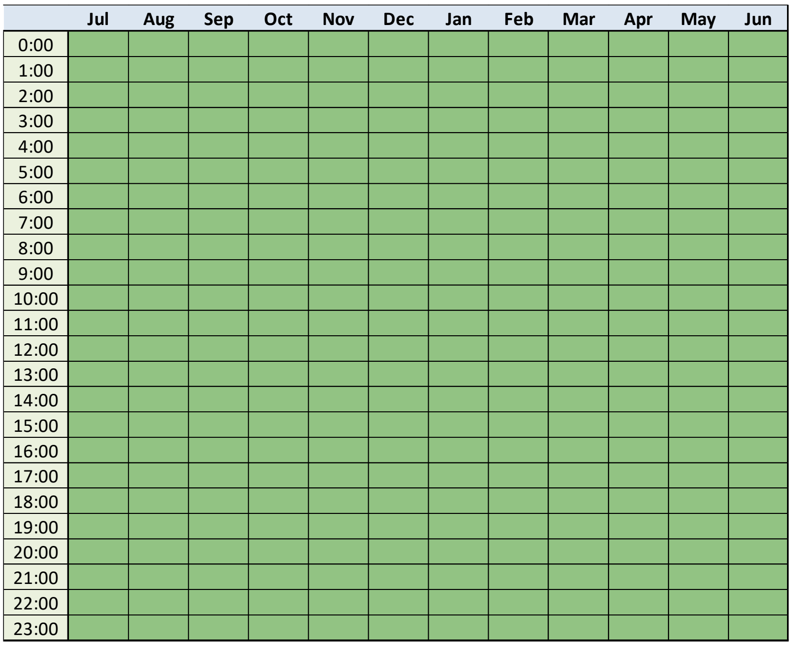
The results of Energeia's analysis of projected, weather normalised minimum demand in Tennant Creek reported in Figure 30 and Figure 31 shows that the Tennant Creek system is expected to experience its minimum demand event at 11am to noon on a weekday in November over the next five years. However, as is the case with Alice Springs, Energeia expects rising BTM solar PV uptake to lead to widespread reductions in minimum demand over the 11am to 2pm period over the longer-term.

Figure 30 – Tennant Creek Weekend Export Period



Source: Energeia Modelling

Figure 31 – Tennant Creek Weekend Export Period



Source: Energeia Modelling

Coincident Minimum Demand

Figure 32 and Figure 33 shows the above analysis including the level of minimum demand by hour as a percentage of the system peak demand hour. Any hour that is less than 10% of the system peak is considered a minimum demand event and included for consideration as a period of peak export demand.

Figure 32 – Tennant Creek Normalized CMD by Hour and Month for Weekdays

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	17%	18%	22%	17%	32%	30%	45%	22%	33%	20%	22%	25%
1:00	14%	15%	20%	16%	31%	23%	42%	20%	31%	17%	16%	23%
2:00	16%	13%	14%	16%	31%	22%	39%	22%	30%	11%	11%	20%
3:00	14%	13%	11%	14%	29%	22%	41%	23%	31%	12%	13%	17%
4:00	15%	13%	12%	13%	30%	23%	41%	23%	30%	10%	14%	18%
5:00	22%	15%	14%	17%	30%	25%	40%	23%	19%	18%	13%	19%
6:00	29%	27%	26%	16%	34%	9%	35%	26%	18%	25%	27%	21%
7:00	28%	28%	30%	17%	33%	28%	34%	31%	19%	22%	23%	22%
8:00	31%	31%	30%	13%	35%	36%	36%	32%	39%	17%	22%	24%
9:00	30%	32%	28%	8%	14%	39%	49%	30%	41%	13%	22%	24%
10:00	25%	26%	26%	10%	12%	40%	49%	35%	23%	29%	15%	29%
11:00	17%	21%	28%	21%	-12%	41%	47%	38%	28%	40%	13%	22%
12:00	9%	22%	30%	11%	7%	41%	48%	42%	30%	13%	14%	24%
13:00	2%	20%	30%	14%	9%	36%	46%	46%	30%	11%	11%	21%
14:00	-1%	20%	34%	19%	11%	37%	51%	47%	32%	8%	9%	16%
15:00	-1%	20%	38%	22%	10%	38%	49%	47%	18%	7%	11%	20%
16:00	1%	23%	41%	26%	12%	40%	50%	49%	23%	9%	15%	23%
17:00	11%	28%	41%	27%	12%	44%	33%	34%	29%	11%	21%	28%
18:00	23%	28%	40%	26%	19%	46%	44%	40%	26%	17%	27%	33%
19:00	29%	33%	42%	27%	23%	48%	51%	38%	29%	18%	30%	40%
20:00	28%	32%	38%	12%	20%	45%	52%	37%	29%	17%	29%	39%
21:00	26%	30%	33%	23%	20%	40%	50%	33%	28%	17%	27%	40%
22:00	21%	27%	28%	20%	18%	38%	48%	35%	18%	17%	24%	30%
23:00	19%	24%	22%	16%	14%	35%	45%	33%	19%	19%	20%	28%

No Min Events
Coincident Min Demand

Source: Energeia Modelling

Figure 33 – Tennant Creek Normalized CMD by Hour and Month for Weekends

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
0:00	20%	17%	22%	15%	33%	33%	41%	27%	29%	22%	27%	25%
1:00	18%	19%	19%	15%	30%	32%	38%	24%	29%	21%	25%	17%
2:00	14%	18%	19%	14%	30%	30%	37%	21%	28%	20%	25%	19%
3:00	15%	16%	18%	14%	30%	31%	36%	21%	27%	16%	23%	16%
4:00	14%	17%	19%	15%	30%	30%	36%	23%	26%	15%	26%	13%
5:00	17%	18%	20%	17%	31%	30%	35%	20%	28%	18%	23%	14%
6:00	23%	19%	22%	17%	28%	25%	33%	19%	25%	21%	28%	19%
7:00	23%	16%	24%	17%	31%	30%	35%	20%	24%	24%	28%	20%
8:00	18%	16%	26%	17%	32%	30%	36%	20%	28%	26%	30%	22%
9:00	26%	18%	24%	16%	38%	31%	39%	37%	32%	23%	25%	24%
10:00	22%	12%	23%	10%	33%	36%	40%	24%	33%	15%	28%	27%
11:00	24%	22%	24%	29%	32%	35%	34%	27%	23%	39%	14%	26%
12:00	24%	24%	24%	31%	27%	35%	43%	35%	24%	41%	16%	28%
13:00	22%	20%	25%	33%	26%	36%	47%	41%	24%	39%	19%	27%
14:00	17%	25%	27%	33%	30%	35%	47%	44%	21%	10%	17%	25%
15:00	24%	30%	26%	36%	35%	35%	48%	44%	18%	11%	17%	27%
16:00	27%	32%	31%	9%	36%	37%	52%	45%	23%	12%	17%	27%
17:00	33%	32%	37%	12%	39%	41%	52%	45%	26%	14%	21%	31%
18:00	35%	27%	36%	17%	44%	45%	50%	45%	25%	18%	26%	34%
19:00	35%	31%	33%	20%	47%	43%	50%	44%	41%	21%	28%	37%
20:00	30%	30%	30%	23%	44%	42%	50%	41%	41%	20%	30%	37%
21:00	26%	27%	28%	20%	40%	39%	46%	36%	38%	21%	27%	30%
22:00	24%	27%	25%	20%	37%	38%	43%	27%	37%	20%	24%	30%
23:00	21%	22%	24%	20%	34%	35%	40%	24%	34%	20%	25%	25%

Source: Energeia Modelling

5. Recommendations

Based on the results of our analysis of projected, weather normalised minimum and maximum hourly demand over the year by system, the review of Australian DNSP methodologies for determining peak demand and export periods, and consultation with PWC, Energeia developed the recommended peak demand and export periods detailed in this section.

It is important to note that DKIS and Alice Springs were heavily prioritised due to their size and customer base in the recommended peak and export period definitions. Tennant Creek's results did not impact on the final recommendations due to the system's marginal impact on incremental PWC network costs.

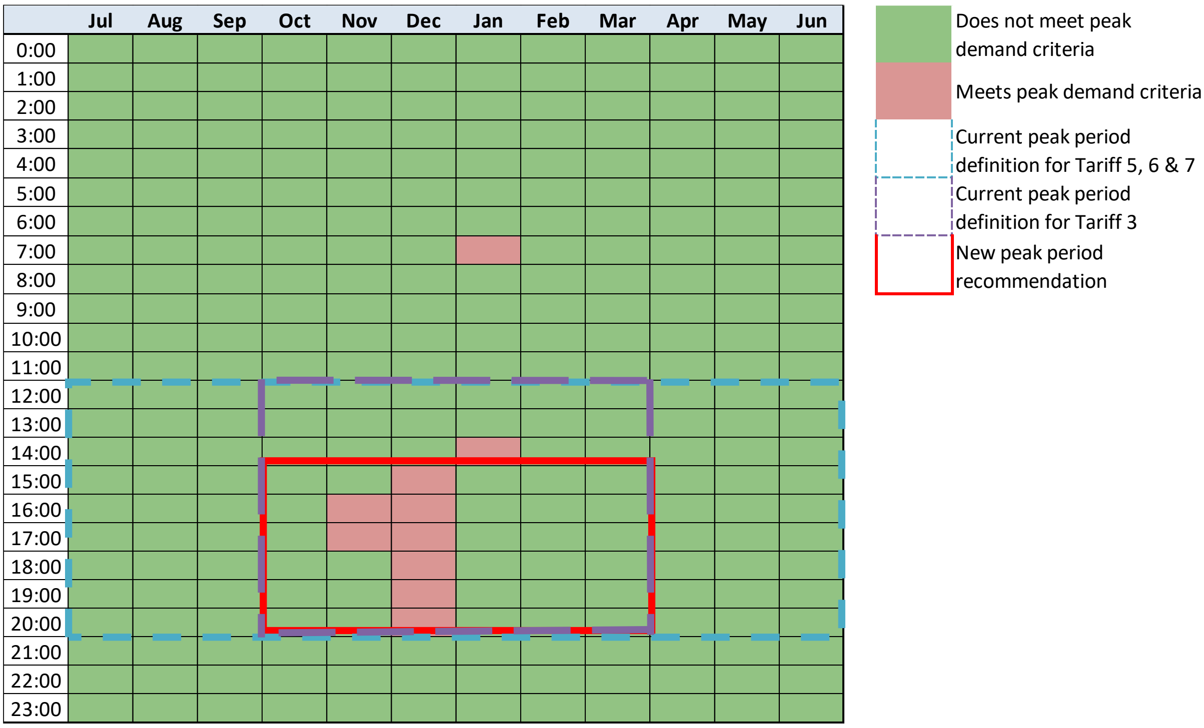
5.1. Period of Peak Load

Energeia's recommended peak load period combines the modelling results of both DKIS and Alice Springs. The combined chart of peak events for both networks can be seen in Figure 34 and Figure 35 below.

Based on our analysis, Energeia's recommended peak period is defined as 3pm to 9pm on weekdays from October to March. This peak period definition captures the seasonal period that is driving peak demand and expected to exhibit a longer-term influence.

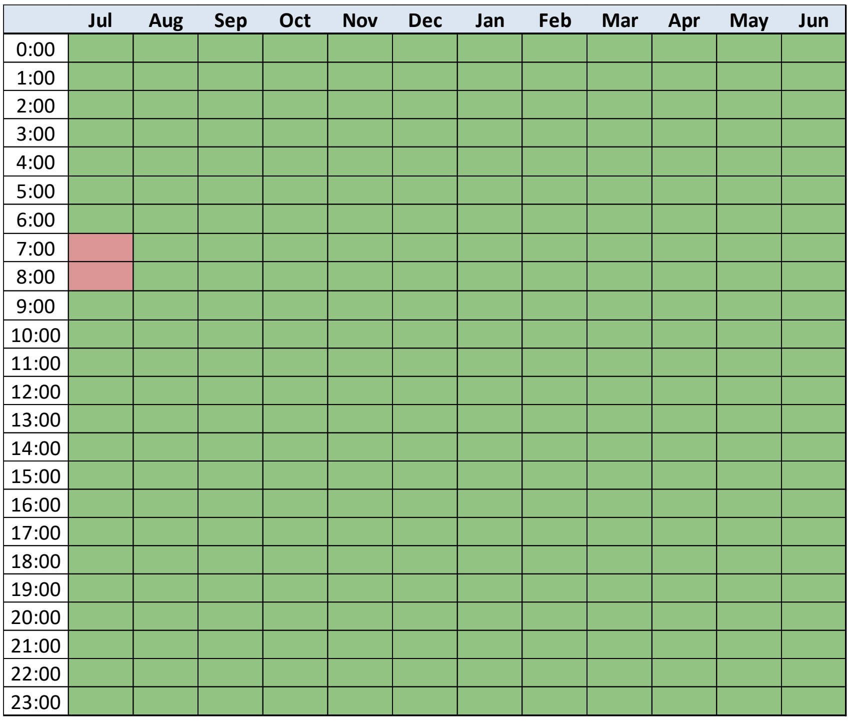
Energeia's recommended peak load period definition differs from the current approach, as shown in Figure 34 and Figure 35. The current peak period is longer, starting at 12 pm, and is in place year-round for customers consuming > 750 MWh pa (Tariff 5 – 7), and seasonally for remaining small customers on a peak demand tariff (Tariff 3).

Figure 34 – Peak Period Definition Weekday



Source: Energeia Modelling

Figure 35 – Peak Period Definition Weekend



Source: Energeia Modelling

The period has been set to start after the peak export period, which is discussed in the next section, and therefore does not take in the peak load events at 7am and 2pm in January, or 7am and 8am during the weekend in July, which is mainly due to Alice Springs' particular combination of tourist base load.

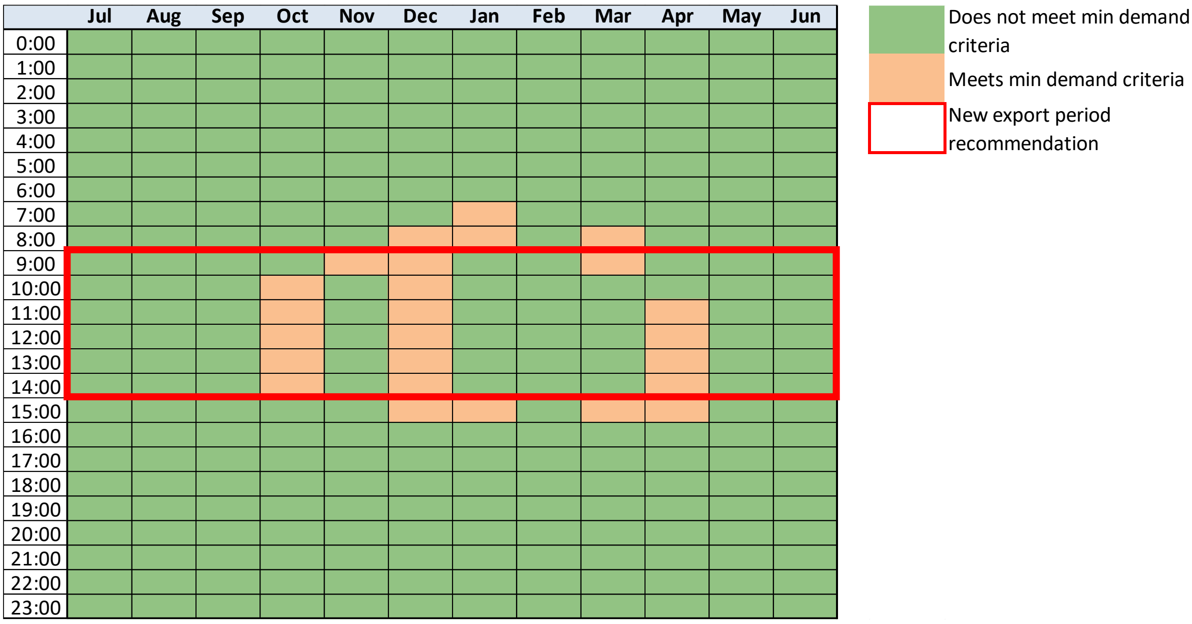
The period is longer than Energeia's modelling suggests it should be from a technical perspective and therefore includes periods that are not expected reflect a period of maximum utilisation. However, the recommended period is already less than half the current period duration, and in Energeia's view, takes customer impacts and ability to understand into account, as required under the NT NER Pricing Rules[29].

[29] National Electricity Rules as in Force in the Northern Territory Version 96 Section 6.18.5(i)

5.2. Period of Peak Export

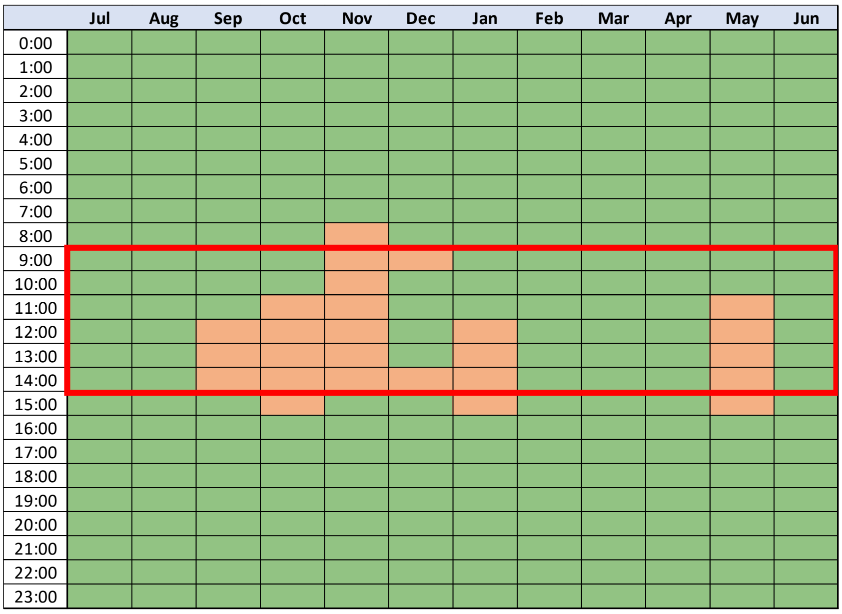
Energeia's recommend peak export period also combines DKIS and Alice Springs' minimum demand periods, which are reported in Figure 36 and Figure 37. Based on our analysis and experience, Energeia's recommended export period is defined as 9am to 3pm year-round, which captures the majority of at-risk minimum demand periods.

Figure 36 – Export Period Definition Weekday



Source: Energeia Modelling

Figure 37 – Export Period Definition Weekend



Source: Energeia Modelling

This definition is also in line with other Australian DNSPs with similar levels of solar PV penetration, e.g. South Australia Power Network's solar sponge period defined between 10am-3pm.

Appendix A – Inputs and Assumptions

Key Inputs and Assumptions

System load was provided on a 30-minute basis (load profile) over a 5-year interval and Zone Substation 30-minute loads were provided for a 4-year interval for substations in each system.

Minimum and maximum daily temperature data was supplied for each network region.

The mapping of Zone Substation to systems can be seen in Table A1 below. This was used to identify raw load profiles to a region for NCMD analysis.

Table A1 Mapping of Zone Substations to Network Region

DKIS	Alice Springs	Tennant Creek
Archer	Brewer and Sadadeen 22kV	Tennant Creek
Batchelor	Lovegrove 22-11kV	
Berrimah	Lovegrove 22kV	
Casuarina	Sadadeen (Ron Goodin)	
Cosmo Howley		
Centre Yard		
Darwin		
Frances Bay		
Humpty Doo		
Katherine		
Leanyer		
Manton		
Marrakai		
Mary River		
Palmerston		
Pine Creek 66/11kV		
Strangways		
Weddell		
Wishart		
Woolner		

Source: PWC

The raw data provided for system load profiles can be seen in the section following, as well as the treatment of load profiles under weather normalisation.

Weather Data

Weather data was provided by PWC and utilised to perform weather normalisation of demand profiles. Temperature data is reported on a probability of exceedance (P or POE) statistical measure in this reporting.

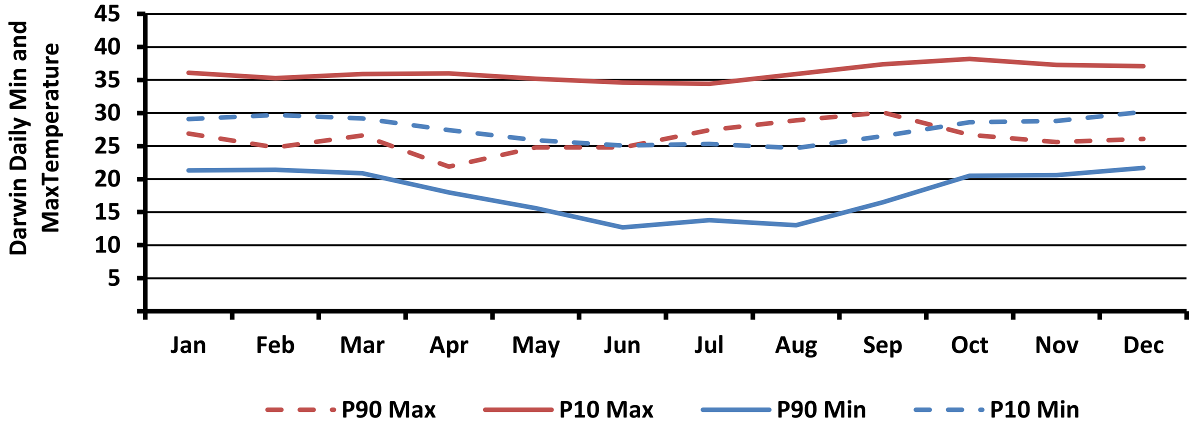
The following definition of P10 and P90 temperature were used:

- **P10** – Defined as the temperature during a month where a 10% probability of exceedance occurs, i.e. – the threshold of the warmest 10% of temperatures
- **P90** – Defined as the temperature during a month where a 90% probability of exceedance occurs, i.e. – the threshold of the coolest 10% of temperatures

Key weather data analysis can be seen in Figure A1 through Figure A3 below.

DKIS experiences the most moderate variation in daily and seasonal temperatures of the three networks.

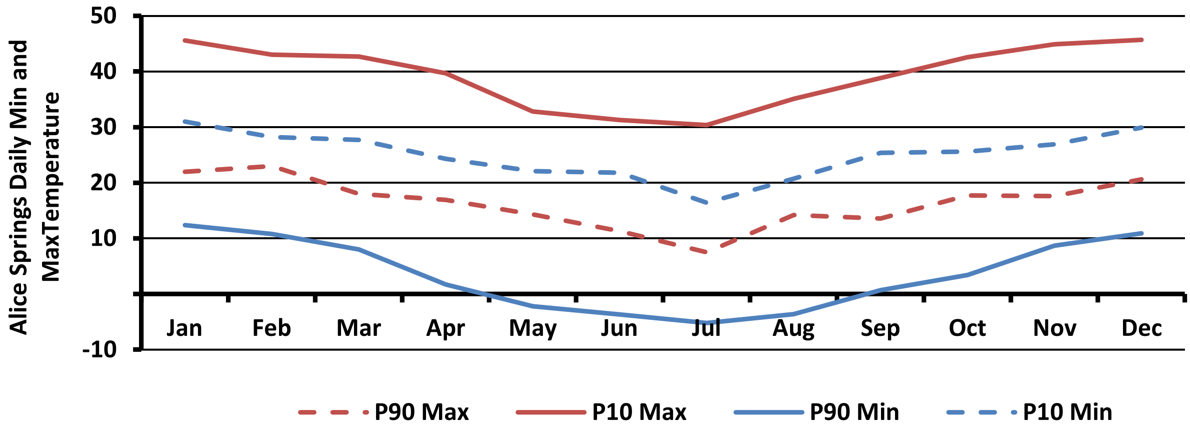
Figure A1 – DKIS Daily Temperature Variation by Probability of Exceedance



Source: PWC

Alice Springs experiences the most significant temperature variations of the three networks, with negative temperatures occurring during the dry season and a large variation between the seasonal and daily minimum and maximum temperatures observed.

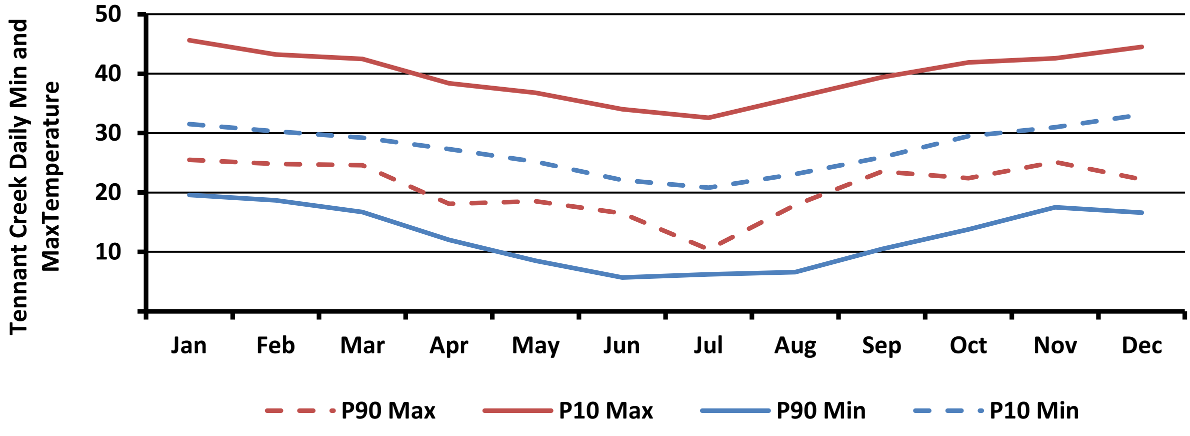
Figure A2 – Alice Springs Daily Temperature Variation by Probability of Exceedance



Source: PWC

Tennant Creek experiences a large daily temperature variation, with daily trends most similar to Alice Springs.

Figure A3 – Tennant Creek Daily Temperature Variation by Probability of Exceedance



Source: PWC

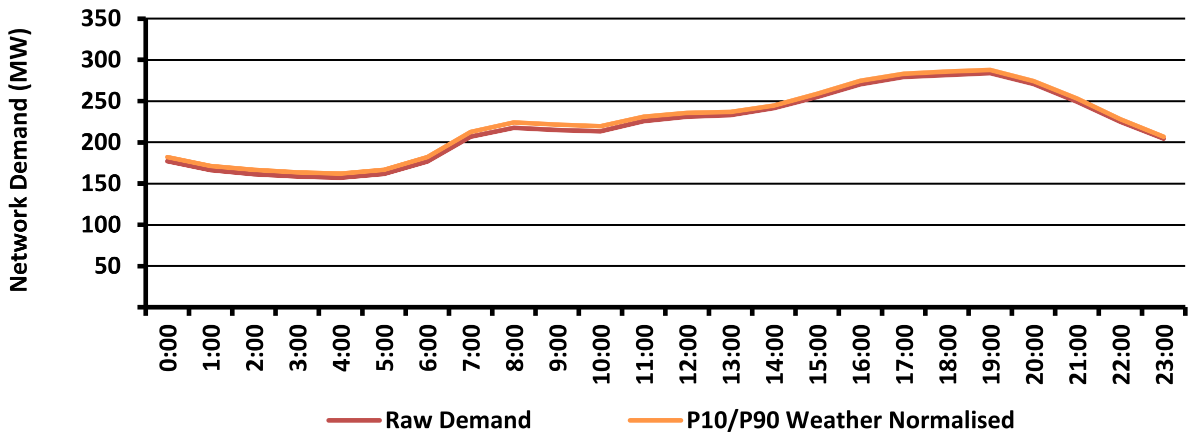
Weather Normalization Results

The following section reports on the impacts of Energeia's weather normalisation on the load profiles used by system.

Darwin-Katherine Interconnected System Load Profiles

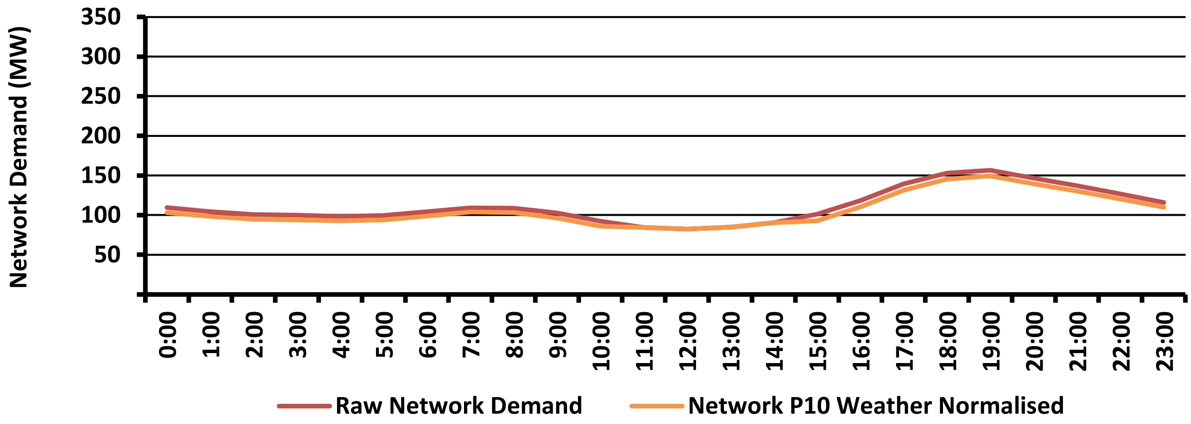
DKIS' raw load profiles can be seen for representative peak and minimum days for the DKIS system, seen in Figures A4, A5 and A6 below. The charts additionally show the weather normalised load results.

Figure A4 – DKIS Peak Day Load Profile



Source: PWC, Energeia Analysis

Figure A5 – DKIS Min Day Load Profile



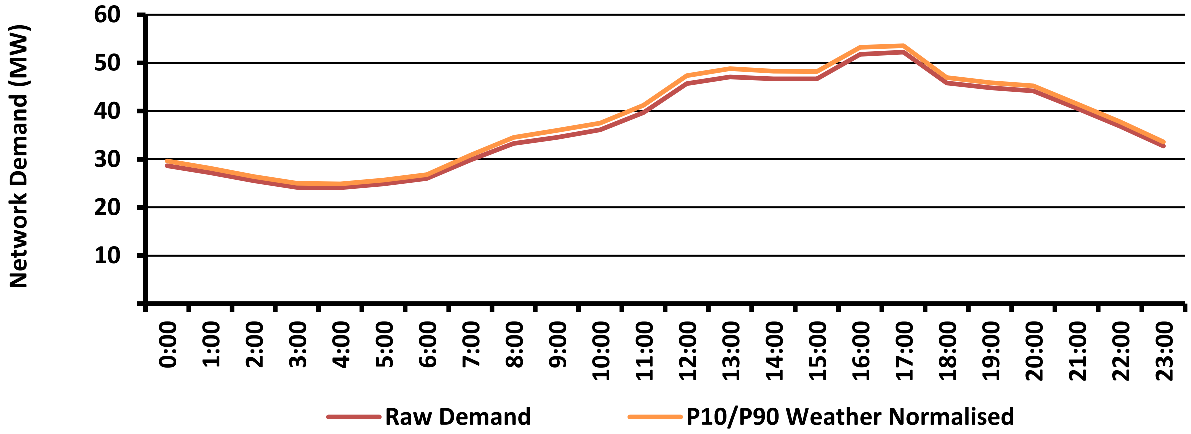
Source: PWC, Energeia Analysis

Weather normalising the demand does not result in significant changes in load due to the effect of load saturation during peak demand days, when air conditioners in particular are being run at maximum capacity. PWC has raised the need to analyse the effects of humidity, which will be taken up in a future study.

Alice Springs Load Profiles

The peak day for Alice Springs is shown in the figure below for raw and weather normalised demand. Consistent with the DKIS results, Alice Springs' maximum day show little effect from weather normalisation due to temperature sensitive load saturation.

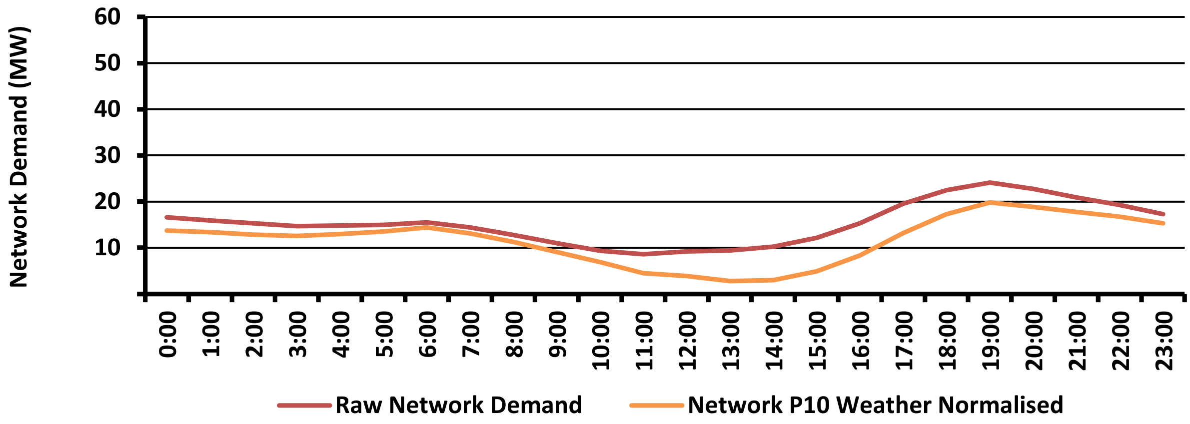
Figure A6 – Alice Springs Peak Day Load Profile



Source: PWC, Energeia Analysis

There is a greater effect of weather normalisation on Alice Spring's minimum demand, as shown in the figure below. Energeia expects the addition of solar insolation and humidity into the analysis in future studies could significantly impact on the results and is therefore a recommended next step.

Figure A7 – Alice Springs Min Day Load Profile

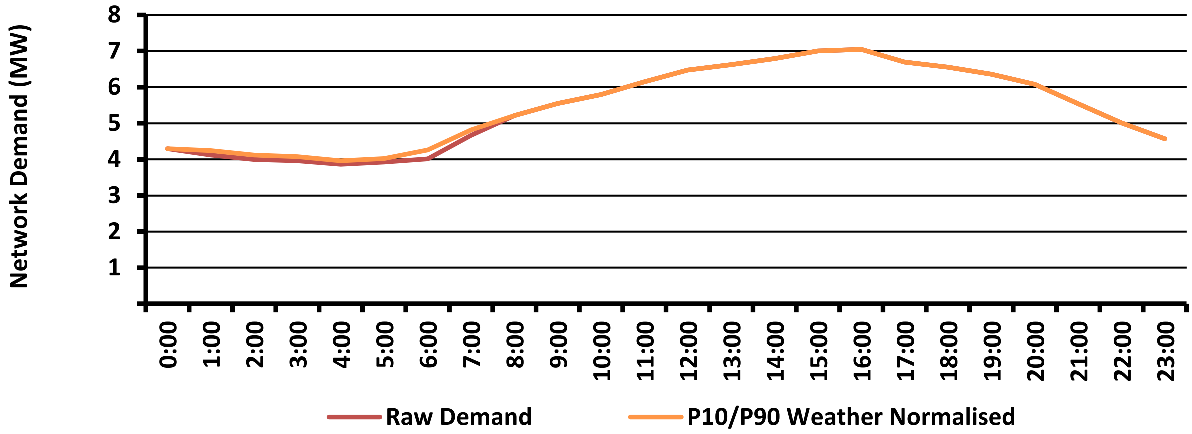


Source: PWC, Energeia Analysis

Tennant Creek Load Profiles

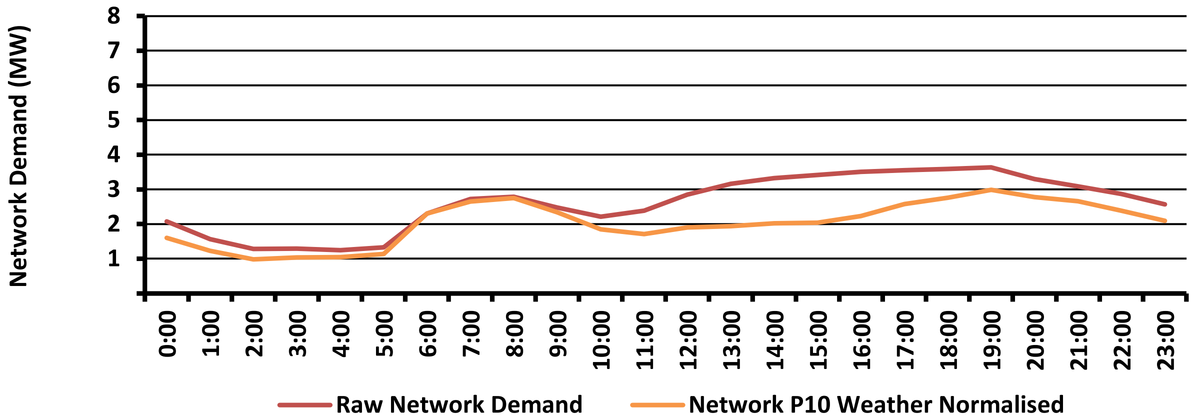
Tennant Creek load profiles before and after the weather normalisation process can be seen in the figures below for the peak and minimum demand day. Again, weather normalisation has little effect on the peak day, and a significant effect on the minimum day's load profile.

Figure A8 – Tennant Creek Peak Day Load Profile



Source: PWC, Energeia Analysis

Figure A9 – Tennant Creek Min Day Load Profile



Source: PWC, Energeia Analysis