



Future Energy System Outlook

Draft

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Appendix A | Part 1

Demand Forecasting
Methodology



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Introduction

This document provides an overview of Western Power’s methodology for forecasting long term demand across the SWIS. Western Power develops long term demand forecasts (referred to as scenarios) to support grid planning studies such as the Transmission System Plan (TSP). Scenarios are also developed as directed by other energy sector stakeholders to support planning studies such as the Future Energy System Outlook (FESO).

Context

Demand forecasting in the SWIS address a range of areas including short term forecasting (hours | days) for operational purposes and medium-term forecasting (1 – 10 years) for distribution and operational planning. Long term forecasts are applied out to 10+ years to support the development of investment plans for high value, long life assets such as transmission network expansion and major facilities (e.g. customer connected generation / storage and network expansion). Forecasting demand over a range of timescales requires modelling tools that address the very different challenges each of these presents as illustrated in Figure 1.

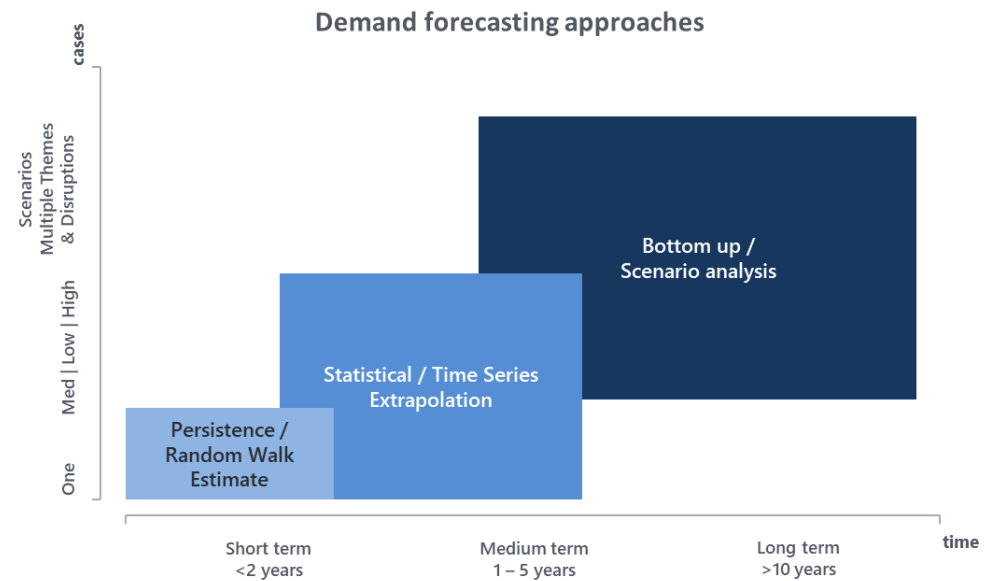


Figure 1. Demand forecasting horizons & approaches

Solution overview

A conceptual view of the long term demand simulation system is shown in Figure 2. Distribution Core demand is modelled using uSim, a software application developed by Energeia. uSim is an agent-based modelling solution that provides bottom-up demand forecasting over long time-frames; it is well suited for modelling disruptive change enabling key customer behaviours to be represented at 30-minute time intervals to determine the emergent impact across the grid. Major loads are modelled separately to reduce cycle time for scenario development – this approach reflects the significant impact that Major loads have on the overall demand profile at the system level.

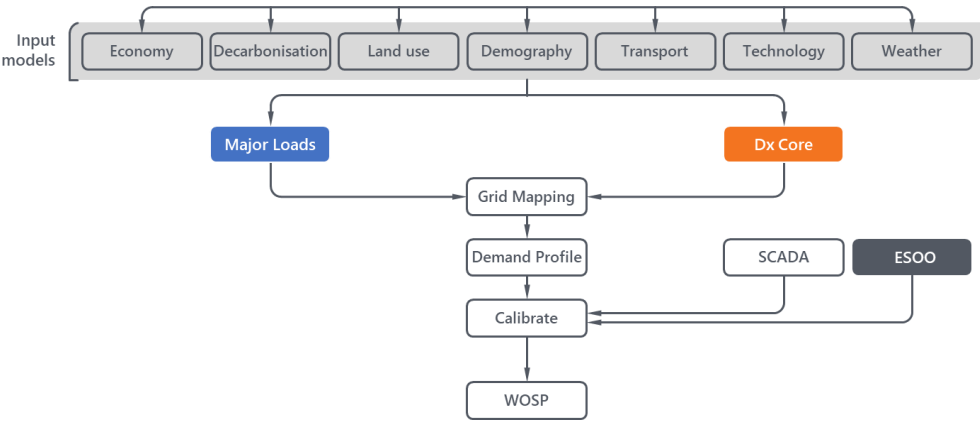


Figure 2. Long term demand forecasting overview

Intended use

Long term demand forecasts are critical inputs to electricity system planning due to the high value and long life of the electricity network infrastructure. Once built, modification of an electricity network is a costly exercise placing a premium on making the right choices at the time of design. Long term demand forecasts can be used to inform immediate investment decisions; they are not well suited for use in other areas (e.g. operational planning) as indicated in Figure 1. The intended use cases for the long term demand forecast are provided in Table 1 – other use cases not shown may be applicable.

Use case	Application
Distribution Planning (Augmentation)	20 yr max min forecast → Network sizing design 30 min x 20 yr profile → Alternative solution options
Distribution Planning (Build & Rebuild)	20 yr max min forecast → Network sizing design & network type selection
Transmission Planning	20 yr max min forecast → Network sizing design 30 min x 20 yr profile → Network sizing design 30 min x 20 yr profile → Generation optimisation
System Planning	20 yr max min forecast → System reserve sizing interconnector sizing 30 min x 20 yr profile → Generation & network solution optimisation 30 min x 20 yr profile → DER orchestration

Table 1. Long term demand forecasting uses cases

Major loads

Major Loads include transmission and distribution feeder connected customers – a small number of low voltage connected customers with average daily consumption >10 MWh are also included. In 2025 approximately 630 existing Major Loads (290 unique business entities) accounted for 9 TWh of operational energy consumption on the SWIS – this represents more than 50% of operational energy consumption with the balance spread across 1.1 million Distribution Core customers.

Existing major loads

Existing major loads have a combined Contracted Maximum Demand (CMD) of 2.0 GW excluding a small contribution from Major Loads not on a CMD tariff. The contribution of major loads to the highest recorded SWIS demand of 4.7 GW was 0.7 GW noting that Demand Side Management (DSM) and mechanisms such as Individual Reserve Capacity Requirement (IRCR) result in demand lowering by up to 0.4 GW during peak periods.

Existing major loads are forecast using a 12 month snapshot of demand intervals as a reference profile. Major load behaviour over the past 5 years is analysed to determine if the reference profile will not be representative of future demand patterns. Exits that are known are applied to the existing major load forecast. Key limitations of this approach that may be addressed in future methodology improvements include:

- Reference profiles include planned and unplanned outages.
- Reference profiles include DSM and IRCR.
- Dispatchable embedded generators mask underlying demand.

Major Load Activity Group	Consumption %
Agriculture	2.2%
Government and Social Services	6.9%
Mining Industry	52.6%
Manufacturing Mining	3.9%
Mining	48.7%
Bauxite	2.7%
Coal	0.3%
Gold	23.0%
Iron Ore	6.5%
Lithium	4.1%
Mineral Sands	12.0%
Nickel	0.1%
Non-Government Services	9.4%
Non-Mining Industry	28.8%
Electricity, Gas, Water and Waste Services	13.9%
Manufacturing Non-Mining	9.3%
Other Non-Mining Industry	0.1%

Table 2. Existing Major Load consumption share (2025)

Future major loads

Western Power has 1.7 GW (CMD) of potential Major Loads (28 projects) in the connections pipeline; of which 0.4 GW are approaching or in construction. Additional Major Load opportunities are identified for each scenario – these are aligned to the scenario narrative and are based on industry consultation undertaken by Government agencies including DEED and AEMO.

Future Major Load profiles (17,520 intervals) are derived from existing Major Loads by activity group. A diversity adjustment is injected into future Major Load profiles to better reflect observed demand patterns.

Major load expansion

Major load expansion enables an increase (or decrease) in demand over the forecasting period for both existing and future major loads. Available expansion drivers are:

- Population growth – WA Tomorrow Band A → E
- Economic growth – Treasury forecast
- Productivity & efficiency – fixed for all scenarios
- Transport electrification – informed by DEED
- Process electrification – informed by DEED
- Generation – informed by DEED
- Storage – not set

Expansion drivers are varied across activity groups. Mining related manufacturing (e.g. mineral processing) is separated from other manufacturing. Alumina processing is given a separate segment due to the significant scale of demand that may be associated with this activity in the future. Major load consumption has grown steadily from 2020 to 2025 at a compound annual growth rate of 3.0% exceeding population growth over the same period (see Figure 3). This trend is expected to continue and is a point of reference for determining expansion factors.

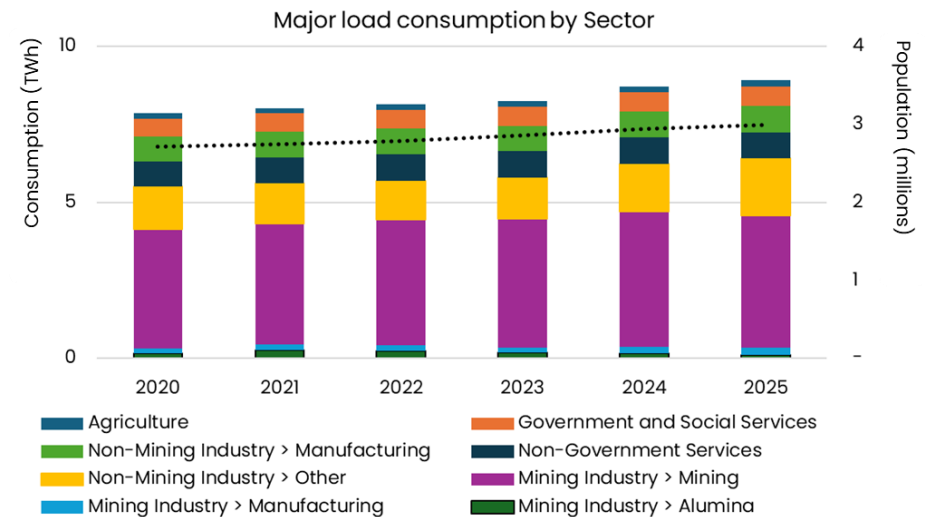


Figure 3. Major load expansion by sector 2020 – 2025

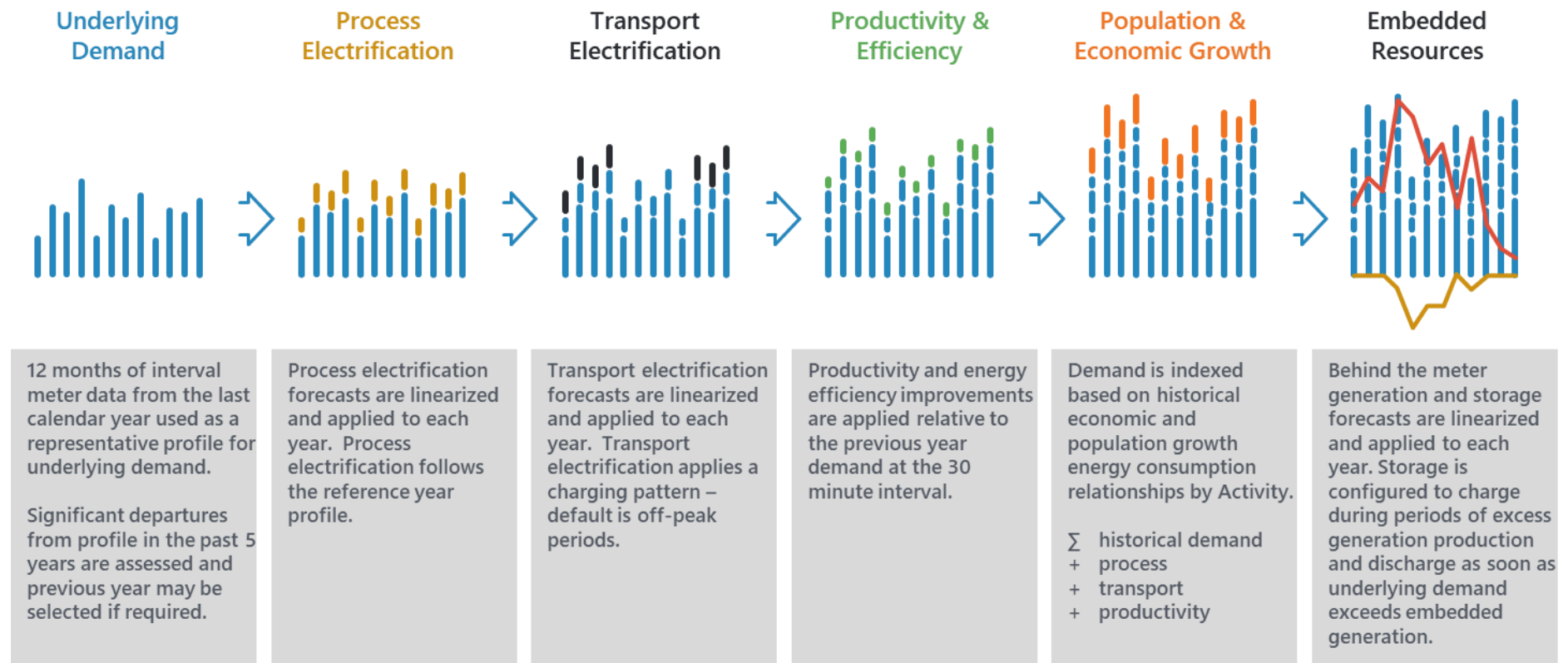


Figure 4. Major load expansion methodology

Distribution core

Distribution core demand is simulated using uSim, an agent based, long term demand modelling system developed by Energeia. Western Power has licensed uSim and engaged Energeia to provide modelling support services to deliver long term demand forecasts for a range of strategy and planning activities. Demand scenarios required for the WOSP and TSP are key modelling inputs that are developed using uSim.

uSim models independent agents – this means that behaviour of one agent will not impact behaviour of any other agent in the system at the discrete interval level. While not always a true reflection of energy use behaviours, this is a reasonable and necessary simplification to reduce compute times across the simulation. Figure 5 illustrates the high level modelling methodology applied to develop a Distribution Core demand forecast for one or more scenarios.

For each scenario developed in uSim a set of input data and parameters is prepared – this is documented in a report that provides a summary of parameters and comparative analysis across scenarios.

Key features of uSim that make it well suited to the challenge of distribution demand forecasting are:

- Simulates a full time series trace per agent – for WOSP and TSP studies this is typically a 30-minute interval (17,520 intervals per year).
- Provides a detailed decomposition of agent demand enabling separating of any sub-load component that is modelled e.g. storage, solar PV, electric vehicle charging, hot water heating, space heating.
- Enables simulation of future customer behaviours for which no historical pattern exists.
- Includes agent DER and appliance purchasing decision logic reflecting socio-economic factors, building type and the return on investment / features of emerging technologies over time.
- Addresses agent energy usage patterns across intervals that reflect tariffs, VPP product availability / pricing, appliance operation and DER operation.

Energeia provides a detailed uSim report for each modelled demand scenario that supplements this document.

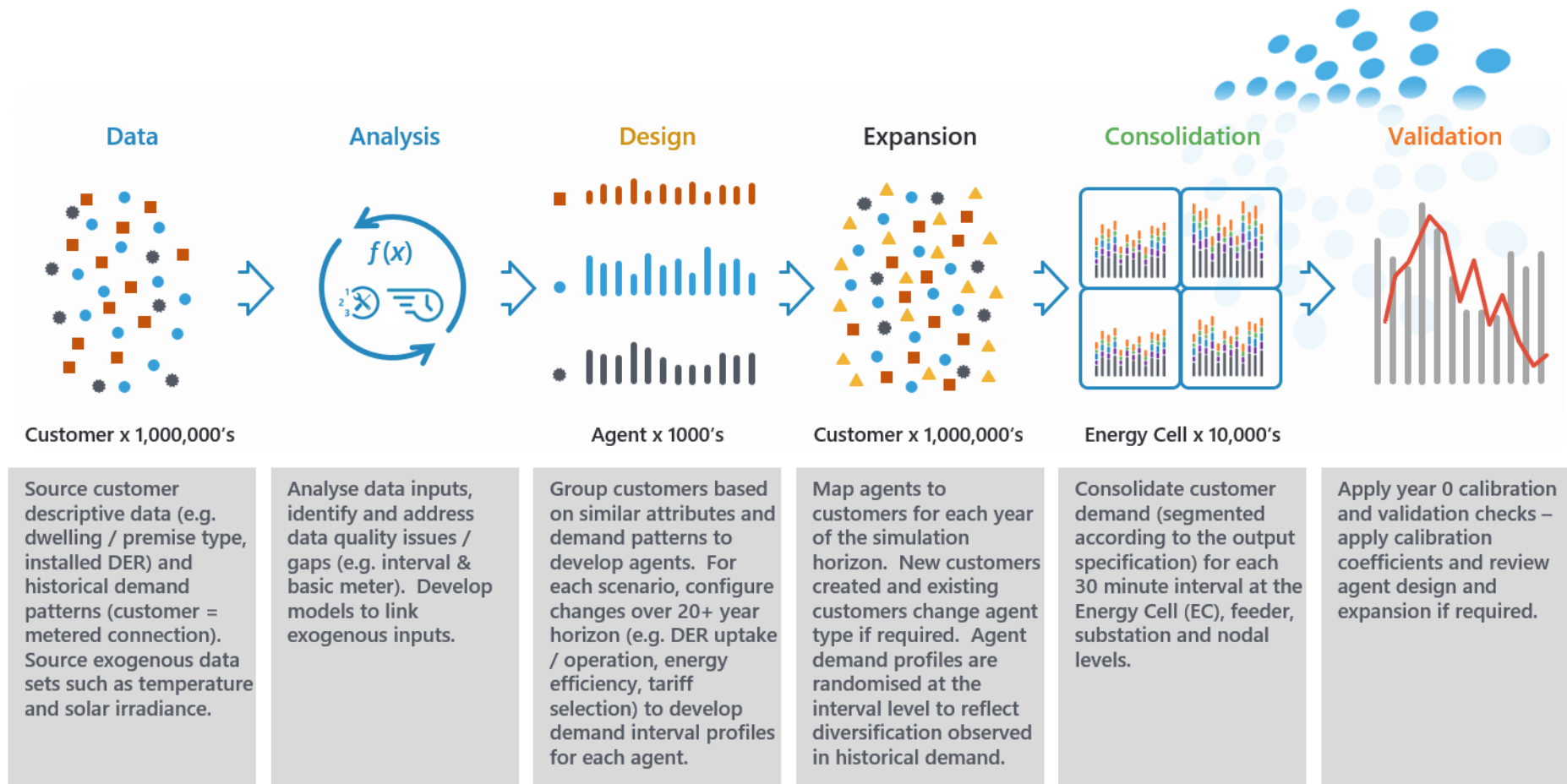


Figure 5. High level Distribution Core demand modelling methodology

Economy

Historically there is a strong correlation between economic activity and energy demand. While economic activity is one of many factors that influence electricity demand on the SWIS, it is recognised to be one of the most prominent and to have a direct causal relationship. For this reason, economic modelling inputs to demand forecasting are tightly coupled to the following inputs:

- Population growth and distribution modelling; the volume of new customers created in each year is aligned to economic activity while the spatial distribution of these agents is driven by WA Tomorrow forecasts.
- Heavy and light transport activity has a direct, linear relationship to population growth | distribution.

The WA State economy is strongly influenced by the resources sector and this is expected to remain the dominant economic driver out to 2050. WA resources sector is responsive to global commodity pricing and input costs – domestic economic activity is typically a response to the resources sector as illustrated in Figure 6. When formulating scenarios there is a focus on maintaining internal consistency across major load and Distribution Core that reflects a resources driven economy.

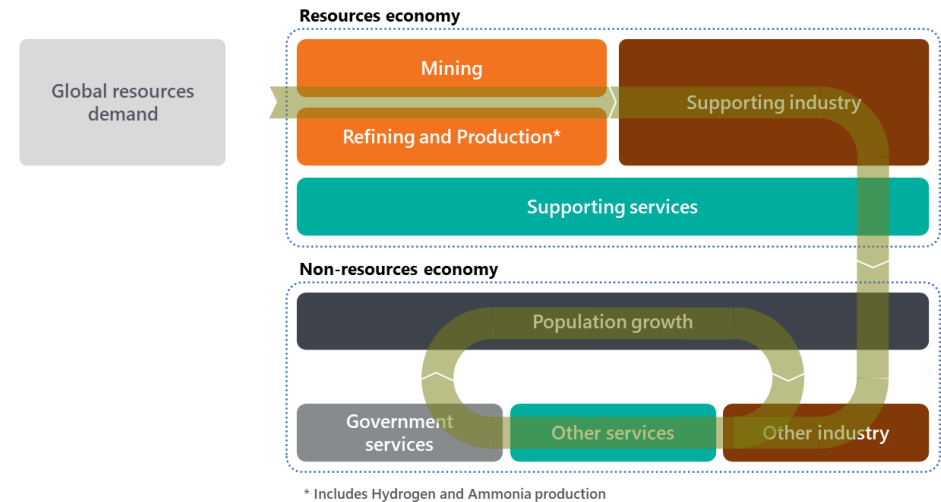


Figure 6. Resources economy concept

Decarbonisation

The WA State Government has targeted significant carbon reduction across departments and trading entities. The most significant is the retirement of coal fired power stations which has a major impact on the electricity sector and has been addressed through the SWIS Transmission Plan.

Many existing industrial customers connected to the SWIS will undertake decarbonisation driven changes to their energy use to lower product costs and in response to external factors such as shareholder direction and the potential for punitive tariffs on products in destination markets. Consultation with major customers has been undertaken by the Department of Energy and Economic Diversification (DEED) to capture quantitative inputs that reflects the intention of industry regarding future electricity use and how that may change in response to decarbonisation actions. Industry decarbonisation scenarios overlay process and transport decarbonisation trends that translate into increased electricity demand on the SWIS. Alumina refinery decarbonisation is treated separately as an existing industrial process that has potential to bring significant new electricity demand onto the SWIS.

Residential and commercial customers will take actions driven by economic benefits that contribute to decarbonisation – transport electrification is one prominent example. Federal and State government policies that may impact the rate of transition to a

low carbon future are introduced to demand scenarios as required. Specific decarbonisation related behaviours that are modelled in long term demand simulations include:

- Connection of green industries (e.g. hydrogen, green steel) to the SWIS,
- Substitution of grid supplied electricity for embedded solar PV and storage,
- Substitution of gas and diesel supplied electricity for grid supplied electricity,
- Substitution and / or bans of on gas for electricity in cooking, water heating and space heating,
- Replacement and / or bans on existing inefficient electrical appliances for cooking, water heating, and space heating with energy efficient equivalents, and
- Electrification of heavy and light transport.

Other areas not addressed may be a focus for future long term electricity demand forecasts.

Land use

Existing and future land use planning inputs determine the allowable distribution of new Major Loads and Distribution Core loads. Land use and population growth are closely coupled model inputs.

Industrial precincts and Strategic Industrial Areas (SIA) constrain the spatial distribution of future Major Loads – due to the relatively small number of facilities this can be manually set as a forecasting input for each facility.

Energy cells

Distribution Core expansion needs to accommodate a large volume of future connections (up to 1 million new customers) with a diverse spatial distribution. Energy Cells (EC) are a spatial construct based on a regular square mesh at 250m x 250m covering the SWIS footprint; the purpose is to enable granular meter level data to be aggregated for simulation. Another key use of energy cells is for disaggregation of spatial layers (inputs) that are presented in coarser spatial forms e.g. transport and demographic data sets at SA2. State and Local Government planning schemes, Australian Bureau of Statistics (ABS) and WA Tomorrow data sets are presented in spatial layers that are disaggregated to energy cells for input into Distribution Core modelling as illustrated in Figure 7.

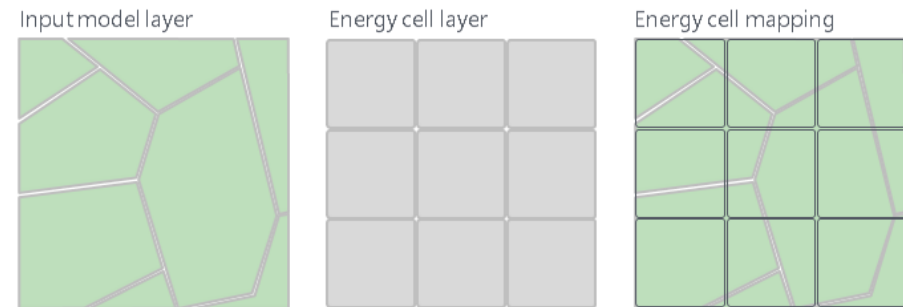


Figure 7. Energy cell mapping of spatial layers

Energy cells are mapped to network following the distribution network topology i.e. Meter → Energy Cell → LV network → MV Feeder → Substation → Tx Zone → System.

Planning schemes & strategies

Planning schemes and government strategies direct the location of population growth. Landgate and Department of Planning, Lands and Heritage (DPLH) are primary sources of spatial planning layers; these are disaggregated to energy cells to enable more granular spatial location of new customers. Government strategies are applied where available – this includes industrial development (e.g. SIA) and urban development initiatives (e.g. Perth & Peel at 3.5 million station precincts).

Population

Population growth inputs are drawn from WA Tomorrow 12 (WAT12) demographic modelling. WAT12 provides a spatial growth forecast across 5 bands (A through to E) for a 10-year period – each band is extrapolated to address longer modelling horizons if required for studies such as the WOSP.

WAT12 population forecasts are presented at SA2 level and disaggregated to Energy Cells. Each Energy Cell has an existing fill based on the current distribution of customer connections and a maximum fill based on the current usable land area and zoning (see Figure 8). Existing population to connection ratios are used to translate population growth to connections.



Figure 8. Energy cell capacity

When the forecast fill of an Energy Cell exceeds the maximum fill, the growth is spilled to adjacent cells to better reflect the spatial distribution of future growth. Growth in Energy Cells is prioritised toward areas identified in the Urban Land Development Outlook¹. This approach balances the need to reflect infill development which drives capacity augmentation with greenfield expansion that drives extension of network reach. The application of this approach is illustrated in Figure 9. The Energy Cell fill is indicated by the size of the green dot – orange dots are Energy Cells that have reached capacity and have spilled growth into adjacent Energy Cells.

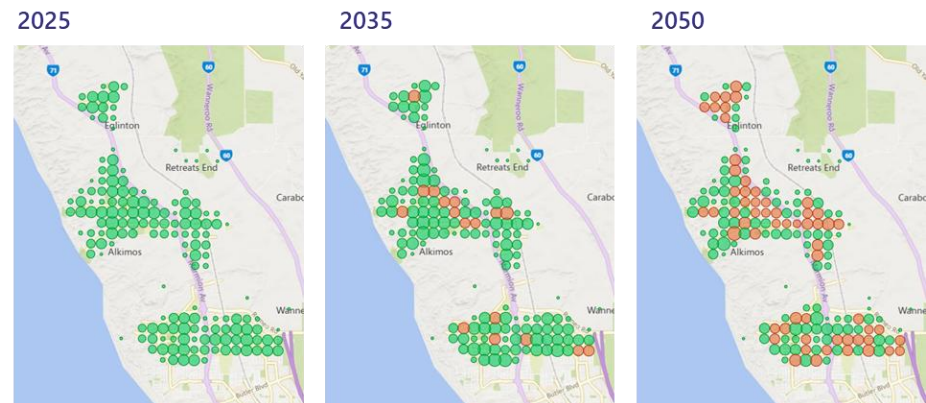


Figure 9. Energy cell growth

¹ <https://www.wa.gov.au/system/files/2025-06/perth-and-peel-uldo-tables.pdf>

Weather & climate

Weather has a significant impact on electricity system performance across a range of areas:

- **Generation.** Wind generation production is driven by wind patterns that vary spatially and across intervals. Solar generation production is driven by solar irradiance and is impacted by cloud cover. Wind and solar generators can be derated based on ambient temperature.
- **Demand.** Demand is strongly influenced by temperature with wind and humidity also playing a role. Historically high temperatures have driven periods of peak demand on the SWIS and there is potential for similar peak demand events to emerge due to low temperatures if existing gas water and space heating systems are electrified.
- **Network.** Network line ratings are influenced by temperature, wind and humidity which can impact the rate of thermal energy exchange (cooling) of an overhead conductor.

A Synthetic Weather Year (SWY) is intended to model weather events that are coincident across multiple critical state drivers. The SWY captures weather patterns that impact generation, network and demand simultaneously over multiple days. This addresses a potential limitation of rolling weather reference years where demand response to weather varies across years.

A key feature of the SWY is injection of extreme events that will stress electricity system performance in scenarios where more than 80% of electricity supply is from wind and solar generation. Appendix C outlines the SWY development methodology.

Critical states

Critical states have been defined to complement the Probability of Exceedance (POE) approach to addressing demand sensitivity – it is also applied to generation and draws on the credible contingency concept applied to system planning. A key driver for departing from the widely used POE approach is the ability to reasonably project historical event probabilities forward for periods of up to 25 years with respect to weather, contingencies and demand impacts.

System peak demand

Extreme heat events have historically driven system peak demand critical states on the SWIS. The high usage of gas appliances for hot water and space heating has resulted in lower winter electricity demand than would be expected if this energy was supplied from the SWIS. Electrification of these heating loads has the potential to drive peak demand events on the SWIS during winter months i.e. extreme cold event impacting peak system demand.

System low demand

Periods of low demand that are associated with high levels of asynchronous generation can give rise to low demand critical states on the SWIS. These critical states are commonly associated with sunny, moderate days where heating and cooling demand is minimal and DPV output is high.

Demand ramp

Demand ramping relates to the rate of increase or decrease in operational demand across a single interval. The SWY does not currently address demand ramping beyond what is present in the base weather year.

Technology

Technology addresses behind the meter appliances that impact operational demand – these may also be referred to as behind the meter resources or DER / CER if they can be actively controlled as a Virtual Power Plant (VPP). A customer may control technology directly at the appliance level or via a Home Energy Management System (HEMS).

Technology is modelled in uSim for Distribution Core customers; Major customers are addressed in the Major load model. uSim models the uptake and use of a range of appliances for each agent (a discrete agent corresponds to a single metered connection) to determine agent demand profiles. A key feature of the uSim technology model is replacement of technology due to age or obsolescence. Technology uptake and operation in uSim is based on cost, energy consumption, tariff / time and socio-economic factors. Typical technology modelling parameters that are configurable for each scenario are illustrated in Figure 10.

Setting	Description
Electric Vehicles	Uptake cost – retail
	EV up front purchase cost compared to ICE equivalent
	Charging infrastructure
	Public charging infrastructure availability – 100% = Saturation
	Model availability
Electric Vehicles	ICE ban
	EV model availability compared to ICE equivalent (e.g. Utility, Luxury SUV ...)
	Year that ban on purchasing new ICE vehicles comes into effect
	Coordination incentive
Electric Vehicles	\$ income for customer from DSO for VPP participation
	Year that incentive for coordination is forecast to commence
Solar PV	Uptake cost – subsidy
	PV up front purchase subsidy
	Connection limit
	Maximum inverter size
Solar PV	Coordination incentive
	\$ income for customer from DSO for VPP participation
Solar PV	Coordination commence
	Year that incentive for coordination is forecast to commence
Storage	Uptake cost – subsidy
	BS up front purchase subsidy
	Coordination incentive (purchase)
	\$ incentive for customer to participate in VPP at purchase
Storage	Coordination incentive
	\$ income for customer from DSO for VPP participation
Storage	Coordination commence
	Year that incentive for coordination is forecast to commence
Appliances	Uptake cost – retail
	DR appliance up front purchase cost compared to non-DR equivalent
	Gas appliance ban
	Year that ban on purchasing new gas appliances comes into effect
Appliances	Coordination incentive
	\$ income for customer from DSO for VPP participation
Appliances	Coordination commence – HVAC
	Year that incentive for coordination is forecast to commence for HVAC
Appliances	Coordination commence – DHW
	Year that incentive for coordination is forecast to commence for DHW
System	Population
	Population forecast input
	Fossil fuel price
	Transport, thermal and generation fossil fuel price trajectory
	Tariff – option availability
	Year of shift to tariff with Cost Reflective Pricing – not mandatory
	Tariff – feed in
System	\$ income for PV or BS feed into grid – not coordinated
	DER uptake propensity
	Overall DER uptake sentiment – willingness of customer to purchase
	DSO DOE initiation
System	Commencement year for DSO and DOE application
	DOE export limit
	Electricity export limit set by DOE

Figure 10. Distribution Core technology setting overview

Virtual power plants

Virtual power plant participation is modelled for distributed PV, storage and electric vehicles. This includes up front purchase and revenue incentives that impact uptake propensity. A Distribution Service Operator (DSO) is assumed to provide VPP orchestration and market engagement.

Distributed PV

Distributed PV (DPV) uptake is modelled in uSim based on an existing installed base reflecting changes to pricing, incentives, connection limits (inverter sizing / export) and tariff. All solar PV installed from 2022 onwards is assumed to be controllable, solar PV installed before 2022 is treated as legacy and cannot be controlled. Legacy solar PV is progressively phased out of the system over the forecasting period as these systems reach economic / operating end of life and are replaced or removed. Controllable solar PV is presented as a resource in the 30-minute demand trace separately to legacy PV enabling it to be managed under a VPP. Emergency solar management is a mode of solar PV curtailment that is applied alongside VPP.

Storage

Storage uptake and operation is modelled in uSim based on an existing installed base reflecting changes to pricing, incentives, connection limits (inverter sizing / export) and tariff.

Electric vehicles

Electric vehicle uptake and charge / discharge behaviour is modelled in uSim based on an existing installed base reflecting changes to pricing, model availability, fuel cost, incentives and tariff. Vehicle to Grid (V2G) and Vehicle to Home (V2H) interactions where an EV discharges to the grid is not modelled; however, this will be explored in a separate case study and / or future system and grid planning studies.

Appliances

Appliance uptake and operation is modelled in uSim based on an existing installed base reflecting changes to pricing, incentives and tariff. Modelled appliance sub-loads include:

- Water heating – gas | resistive | heat pump
- Space heating – gas | reverse cycle air conditioner
- Space cooling – air conditioner
- Lighting – incandescent | fluorescent | LED
- Cooking – gas | resistive | induction

Calibration

Distribution core

The agent model approach that is applied to Distribution Core demand forecasting aims to simulate SWIS demand patterns that mimic current customer behaviour at the 30-minute interval across the entire SWIS. The first year of the simulation is used to compare against historical demand intervals for calibration purposes – this equates to approximately 20-billion data points over a year (no. customers x no. intervals) with each data point comprising up to 10 load elements. To simplify calibration to a tractable problem it is performed at the feeder level. Agents are aggregated to feeders, and the annual feeder intervals are calibrated against aggregated meter data and feeder SCADA data.

Calibration operations distort the bottom-up modelling of time series traces based on a coefficient that is applied to each operation. The calibration algorithm applies a standard set of operations for a range of preset coefficients and the best fit is selected from the resultant traces. Calibration coefficients are post-checked to ensure the simulated traces are not over-calibrated which can drive changes to the source simulation. Calibration coefficients are reduced over a 5-year period indexing down by 20% each year such that by year 6 of a simulation no calibration is being applied.

Major load

The Major Load model does not require calibration as it explicitly models each customer.

ESOO alignment

Alignment to the latest ESOO Expected demand forecast is addressed by adjusting the underlying scenario settings for both Distribution Core and Major load. The focus of ESOO alignment is primarily on the first year and the final year of the demand forecast i.e. year 10. Key points of alignment include:

- Maximum demand,
- Electricity consumption,
- DER uptake, and
- Population.

Activity groups

Activity groups (illustrated in Figure 11) are applied to Major Loads to support sectoral analysis and forecasting.

Government Services	Mining Industry	Non-Mining Industry	
Public Administration and Safety	Mining	Manufacturing Non-Mining	Transport, Postal and Warehousing
Education and Training	Bauxite	Cement	Road Transport
Health Care and Social Assistance	Coal	Hydrogen	Rail Transport
Arts and Recreation Services	Copper	Ammonia	Marine Transport
	Gold	Other Chemicals	Air and Space Transport
	Iron Ore	Food and Drink	Delivery Services
	Lithium	Machinery and Equipment	Transport Support Services
	Mineral Sands	Metal Products	Warehousing and Storage Services
	Nickel	Non-Metallic Mineral Products	Other Transport
	Oil and Gas	Paper	Wholesale Trade
	Other Mining	Other Manufacturing	
	Manufacturing Mining	Construction	
	Alumina Production	Electricity, Gas, Water and Waste Services	
	Aluminium Smelting	Electricity Generation	
	Iron Smelting and Steel Manufacturing	Electricity Transport	
	Lithium Refining	Gas Transport	
	Mineral Sands Refining	Water Transport and Treatment	
	Petroleum and Coal Refining	Waste Transport and Processing	
	Other Smelting and Refining	Utility Retail and Other Utilities	

* Aligned to ANZSIC Divisions

Figure 11. Major load activity groups



Appendix A Part 2 - Large load methodology

1. Background

Large loads¹ are a significant component of electricity consumption on the South West Interconnected System (SWIS). Large loads include transmission-connected loads, customers connected to the distribution network at high voltage, and a small number of low-voltage connected customers with average daily consumption greater than 10 megawatt-hours (MWh). Existing large loads account for approximately half of operational electricity consumption on the SWIS and therefore represent a key input to the FESO 2027 demand forecast.

The purpose of the large load demand methodology is to develop demand projections for existing and future large loads that are consistent with the FESO 2027 scenarios. Large loads are modelled separately from the broader “distribution core²” demand forecast, as outlined in APPENDIX A part 1 – Western Power’s Transmission System Plan demand forecasting methodology. This enables demand associated with large industrial facilities and major developments to be explicitly represented and aligned with scenario narratives.

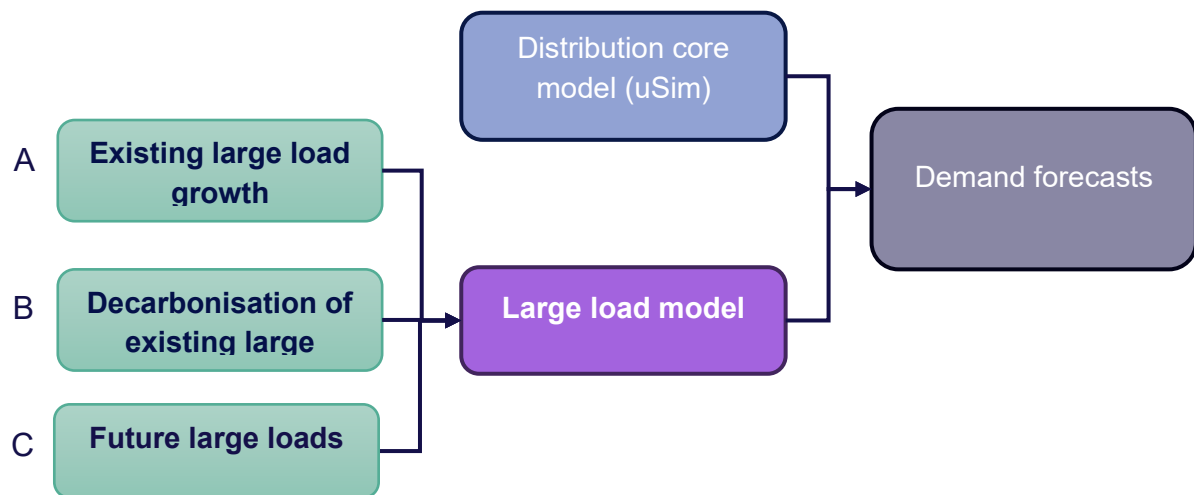
1.1. Methodology overview

The large load methodology combines quantitative data analysis, stakeholder engagement and scenario-based assumptions to develop demand projections for large loads. The approach is intended to focus detailed analysis and engagement on sectors and projects most likely to materially influence future electricity demand while avoiding complex individual forecasting exercises for several hundred large load customers. Three categories of large loads are considered based on the primary driver of future electricity demand growth:

- A. Existing large load growth;
- B. Decarbonisation of existing large loads; and
- C. Future large loads.

¹ Note large loads are referred to as major loads in Western Powers TSP methodology Appendix A part 1

² “Distribution core” demand refers to the sum of small individual loads from residential, commercial, and smaller industrial consumers.



A - Existing large load growth

This category includes demand growth arising from the expansion of industries already established within the SWIS. The detailed methodology for applying growth rates according to a variety of economic factors is included in APPENDIX A part 1 – Western Power’s Transmission System Plan demand forecasting methodology, and the draft inputs in the I&A workbook.

B - Decarbonisation of existing large loads

This category captures additional electricity demand resulting from the electrification and decarbonisation of existing industrial facilities. The demand assessment of SWIS large load electrification (DASLLE) model methodology is detailed in APPENDIX A part 3 and the DASLLE output trajectories included in the I&A workbook.

C – Future large loads

Future large loads are assigned forecast treatments according to their stage of development and confidence level.

This category also captures demand associated with industries that do not currently exist at material scale on the SWIS. Demand associated with these new industries can be represented as discrete loads. Forecast assumptions are informed by:

- major project pipelines;
- industrial development strategies;
- Strategic and priority industrial area development;
- industry engagement; and

- input from relevant government agencies.

The methodology recognises that these projects are often characterised by high uncertainty and long development lead times. Accordingly, treatment varies according to project maturity, confidence and alignment with scenario narratives.

1.2. Connection pipeline

Information from Western Power's connection pipeline and stakeholder engagement is incorporated to identify potential future demand in each scenario. Pipeline information is used as an input to assess:

- project maturity;
- likely commissioning timeframes;
- geographic location;
- demand magnitude; and
- scenario suitability.

Pipeline inclusion does not automatically result in forecast inclusion. Projects are assessed according to development confidence and scenario alignment.

1.3. Advanced and committed developments

Large loads with a high degree of development maturity are assessed individually and may be incorporated into forecast demand using project-specific assumptions regarding:

- commissioning timing;
- ramp-up profile;
- operational demand;
- expected utilisation; and
- demand flexibility.

Where applicable, assumptions for advanced and committed developments will be aligned with projects included in AEMO's WEM ESOO Step Change demand forecast for the near-term outlook to support consistency across major SWIS

planning processes. Consultation has focused on loads or projects that represent a potential step change in demand.

1.4. Prospective and long-term opportunities

Projects that remain subject to commercial, regulatory, infrastructure or market uncertainty are subject to a qualitative assessment that is shaped by each scenario narrative. Factors considered include:

- development approvals;
- commercial commitment;
- infrastructure availability;
- electricity supply requirements;
- market conditions;
- policy settings; and
- stated project timelines.

Projects may be represented differently across scenarios where stakeholder consultation indicates materially different development outcomes.

Some prospective developments have the potential to materially influence future electricity demand on the SWIS but remain subject to significant uncertainty regarding technology pathways, commercial viability, policy settings, infrastructure availability and project timing.

These opportunities are typically represented within the Category B (decarbonisation of existing industry) and Category C (new energy-intensive industry) classifications and may include:

- large-scale electrification of existing industrial processes;
- green hydrogen production;
- green iron or steel;
- critical minerals processing;
- major data centre developments; and

- industrial development within strategic industrial areas and emerging industrial precincts.

Unlike advanced or committed developments, these projects are generally characterised by long development lead times, staged deployment pathways and a wide range of potential demand outcomes. In some cases, individual projects may be sufficiently large to materially affect SWIS demand forecasts, generation requirements or network development outcomes.

Given the uncertainty associated with these projects, most long-term opportunity loads are not automatically incorporated into the core demand forecast as discrete project forecasts. Instead, their potential impact is considered through the treatment of Category B and Category C loads within the FESO scenarios, where assumptions regarding the scale, timing and uptake of industrial electrification and emerging industries vary in accordance with the scenario narratives.

For opportunities with the potential to create a significant SWIS demand and/or consumption uplift, FESO may also utilise targeted case studies or sensitivity analysis to assess the implications of alternative development pathways, connection configurations and levels of SWIS utilisation. This approach enables the potential system impacts of highly material but uncertain developments to be explored without overstating confidence in individual project outcomes in the core scenarios.

Two notable exceptions of this, where discrete block loads **have** been included to varying degrees in the core scenarios are:

- loads associated with electrification of alumina refining; and
- data centres.

The approach for these specific load categories has been outlined below.

1.4.1. Alumina sector

The alumina sector is treated separately within the methodology due to its scale and concentration over a small number of facilities.

Alumina currently forms limited electricity demand with process heat requirements predominantly met through non-electric fuels. The potential proportion of process heat that could be electrified is substantial, although highly uncertain.

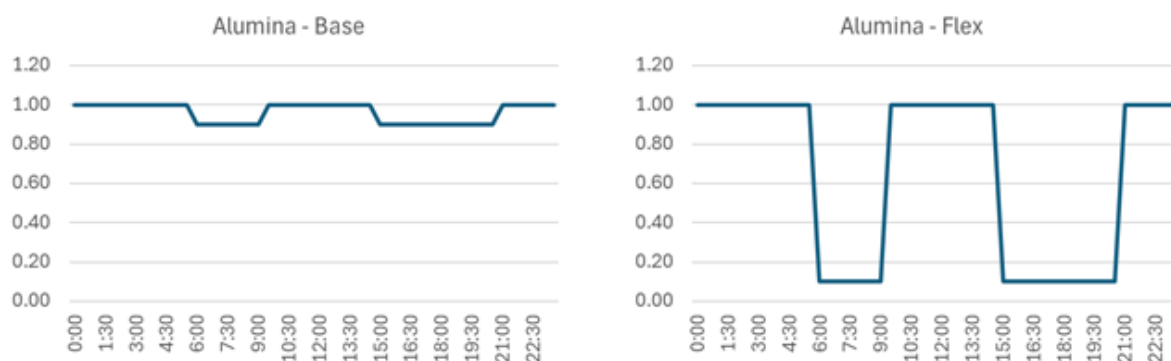
Given the scale of potential demand growth, alumina electrification assumptions are developed as timelines for electrification using existing but non-commercial

technology, with input from alumina producers. These are placed into the large loads list.

Unlike alumina smelting, which is fully electric, there are only a few practical options for electrifying alumina production process. Three components of the load are considered: the Bayer process, calcination, and drives.

The Bayer process, which requires steam, can be electrified and improved in efficiency using mechanical vapour recompression (MVR) to reheat and re-pressurise waste steam. MVR has been trialled as a technology and found feasible, but not currently economic³. It is assumed that MVR is used over electric boilers as it is available sooner and reduces power consumption compared to electric boilers.

In the calcination process, a very large quantity of heat is needed to calcine alumina hydrate to remove water. Drawing this power from the grid would be cost-prohibitive during peak periods. There is mutual benefit to alumina producers and the grid in storing power during periods of high availability to use during peaks. It is assumed that electrical power is drawn flexibly, converted to heat and stored in thermal energy storage (TES) units and consumed steadily by the refinery. Power is stored by drawing at 2.5 times the base demand required by calcination processes overnight and at noon. An illustrative load profile is below, but alumina facilities will be modelled as objects optimising their own demand in response to grid conditions.



Electricity is generated behind-the-meter from gas and coal-powered cogeneration, and is used to drive motors, belts, and machinery. These loads are introduced when cogeneration is replaced with electrically driven MVR, as they must be powered from the grid. Electricity demand is calculated from a per-tonne-alumina figure for energy required for each process drawn from *Roadmap for Decarbonising Australian Alumina Refining*⁴, *Alcoa – Renewable Powered Electric Calcination Pilot*⁵, and

³ [Mechanical Vapour Recompression for Low Carbon Alumina Refining - Australian Renewable Energy Agency \(ARENA\)](#)

⁴ [roadmap-for-decarbonising-australian-alumina-refining-report.pdf](#)

⁵ [Alcoa - Renewable Powered Electric Calcination Pilot - Australian Renewable Energy Agency \(ARENA\)](#)

production information is drawn from public EPA submissions and shareholder statements. It is assumed that annual production does not change.

MVR enters from 2035 at the earliest. Electric calcination and thermal storage enter from 2040 at the earliest. Electrifying alumina production frees capacity in the Dampier to Bunbury Natural gas Pipeline, making it available for gas-powered generation.

1.4.2. By scenario

In the Central scenario, Wagerup is fully electrified. Pinjarra remains gas-powered. The four process lines of Worsley running on coal are electrified, but the two converted to gas are not.

In the Constrained scenario, Pinjarra is closed in 2042 due to age. No facilities are electrified.

In the Rapid Change scenario, two of the three process lines in Pinjarra are electrified, with one remaining on gas. Wagerup is fully electrified. Four of six boilers in Worsley are electrified.

1.4.3. Data centres

The future role of data centres in the SWIS has evolved rapidly since the FESO was launched, and it is recognised that it is likely to continue to evolve once the MISA has been finalised.

Consequently, the project team has created a forecast aligned with each of the FESO scenarios and Energy and Climate Change Ministerial Council communiques. The proposed data centre load for each scenario to 2050 is as follows:

- Constrained – 400 MW
- Central – 1050 MW
- Rapid Growth – 1,650 MW

Noting the FESO will model data centre loads that are grid connected block loads, with most assumed to be off-grid or have thin grid connections.

There is significant uncertainty regarding data centre development, and DEED is seeking to test the assumptions outlined in the MISA through the stakeholder consultation period.

2. Inputs and data sources

The methodology uses a combination of quantitative datasets and qualitative inputs to identify candidate large loads, assess future demand drivers, and develop forecast assumptions.

Key inputs include:

- SWIS Demand Assessment (SWISDA) information;
- National Greenhouse and Energy Reporting Scheme (NGERS) data;
- Western Power Connection Management System (CMS) information;
- AEMO Electricity Statement of Opportunities (ESOO) information;
- stakeholder consultation with industry participants;
- input from State Government agencies and industrial development bodies;
and
- information regarding strategic industrial areas, industrial precincts and major project pipelines.

These inputs are used to identify sectors and projects that may contribute materially to future demand growth and to establish assumptions regarding timing, scale, operating characteristics and development confidence.

3. Demand traces and load representation

The final stage of the methodology converts forecast assumptions into modelling inputs suitable for FESO 2027.

Large load demand growth is translated into half-hourly demand traces by:

- Using a base year of historical consumption characteristics of existing large loads;
- assigning custom representative demand traces to new demand categories;
- incorporating expected demand flexibility⁶ where identified; and
- aligning operational characteristics with scenario assumptions.

For **electrification trajectories** (output from DASLLE), the consumption uplift for each economic sector is spread across the historical demand trace that represents existing loads in that sector. See APPENDIX A part 3 for further detail.

For **new energy intensive industries**, demand is represented through discrete block loads using assumed operating profiles, such as for the electrified alumina loads.

The resulting large load demand traces are combined with the distribution core forecast from uSim to produce total SWIS demand projections used in FESO 2027 modelling.

⁶ The ability of large loads to reduce their electricity demand at times of high system demand.

Appendix A Part 3 - Demand Assessment of SWIS Large Load Electrification (DASLLE) Model

1 Methodology

1.1 Purpose

Electrification is expected to increase electricity consumption supplied through the SWIS. The Demand Assessment of SWIS Large Load Electrification (DASLLE) model forecasts potential demand and consumption uplift due to industrial decarbonisation.

The demand forecast is developed at the National Metering Identifier (NMI) level for large load customers and is intended to quantify future electricity demand by location year and scenario. Outputs are subsequently used to inform system and market modelling, including assessment of future electricity consumption associated with decarbonisation and fuel-switching pathways.

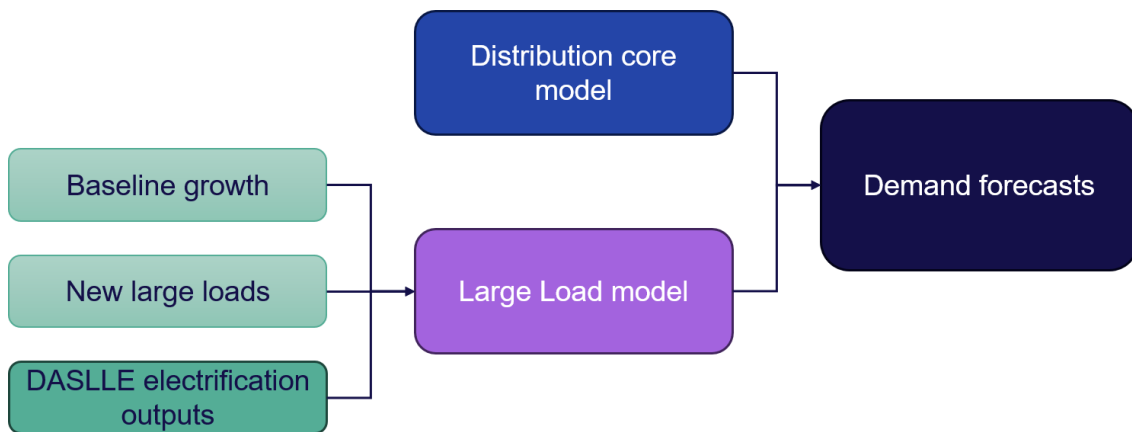
DASLLE estimates the additional SWIS electricity consumption arising from the transition of non-electric energy process uses, to electricity. The assessment uses the Clean Energy Regulator's facility-level National Greenhouse and Emissions Reporting Scheme (NGERS) data and develops sector-specific electrification trajectories that are subsequently converted into incremental SWIS electricity demand. The methodology applies a consistent framework across sectors to:

- Identify electrifiable energy consumption;
- Exclude activities unlikely to electrify through the SWIS;
- Apply sector-specific electrification trajectories;

- Convert fuel consumption to SWIS electricity consumption; and
- Generate annual consumption uplifts for incorporation into Large Load demand forecasts.

1.2 Context in the broader demand forecasting methodology

In the Large Load forecasting framework (outlined in APPENDIX A Part 1 and 2), baseline demand reflects economic growth and energy efficiency factors. Additional growth is introduced through new loads and electrification uplifts:



- **Baseline growth** - Existing demand is escalated using growth factors that reflect economic growth, energy efficiency improvements, and sector-specific growth drivers. These growth rates are applied annually and compound through the forecast period.
- **New large loads** - Additional demand is represented through block load additions consistent with Western Power methodologies for future large load connections. These loads represent known or anticipated future customers that Western Power is aware of through connection and development pipelines.
- **Electrification demand** - Electrification represents demand growth that is not captured within the previous two demand categories. The electrification component reflects non-electric energy currently consumed by industry, transport and other sectors transitioning onto the electricity network. This additional demand is modelled separately from economic growth using DASLLE.

The modelling includes SWIS-connected NMI's with annual electricity consumption greater than 10 MWh. Demand forecasts are developed for existing large loads and future large load additions identified through known connection pipelines. Demand is represented at the nodal level to support integration with PLEXOS.

1.3 Data preparation

Data is prepared for DASLLE according to the following four steps which are outlined in more detail in section 3.1. The resulting dataset groups electricity consumers by economic sector fuel type end-use category (stationary, electricity generation or transport).

1. The model is built using NGERS data for facility, Western Power demand forecasting information and project-specific economic sector mapping.
2. Facilities are mapped to an electricity network using a combination of spatial and operational information. DASLLE incorporates energy consumption from facilities mapped to the SWIS.
3. Facilities are categorised into high level economic sectors informed by Australian and New Zealand Standard Industrial Classification (ANZSIC) classifications.
4. Energy consumption is classified by economic sector, end-use category (stationary, electricity generation and transport) and fuel type.

1.4 Electrification trajectories and scenarios

For each economic sector, end-use category and fuel type assumptions are made about when, and how much of, the existing energy consumption will electrify. These assumptions align with the three narratives of the core Future Energy System Outlook (FESO) scenarios; Central, Constrained and Rapid Change. The approach to these electrification trajectory assumptions is detailed in section 3.1.3.



2 Key assumptions

Table 2.1: Key assumptions

Category	Assumption	Application
Demand coverage	Large load NMLs >10 MWh/year	Forecast dataset
Growth drivers	Economic growth and efficiency factors	Baseline demand
New demand	Western Power pipeline connections	Block load additions
Electrification	Additional demand above economic growth and new connections in Western Power's connections pipeline	Fuel switching
Generation energy use	Grid-connected generation excluded	Avoid double counting
BTM generation	Handled separately in Western Power's Large Load model.	Fuel switching results in increased SWIS consumption – further detail in section 3.1.3
Profiles	Historical 30-minute traces	Nodal load shapes
Custom facilities	Alumina and exceptional loads	Site-specific profiles
Central	Current policies aligned scenario.	Scenario Central case
Rapid Change	Accelerated decarbonisation scenario.	Scenario upper bound
Constrained	Slower growth scenario.	Scenario lower bound
Technology ceiling	ClimateWorks-informed electrification limits.	Electrification fractions upper bound for each sector, end-use, fuel type
Publication	Aggregation of confidential data	Zonal reporting

3 Detailed procedure

3.1 Data preparation

3.1.1 NGERS facilities grid mapping

Facilities were assigned to the SWIS using a combination of spatial and operational information. The process is outlined in the steps below.

1. Overlaid geographical boundaries of SWIS network for electricity distribution systems in WA to determine whether facilities are within the boundaries of any WA grids.
2. Analysed facility
 - a. Name and Activity
 - b. Description for any town names etc that could be used to assign facilities to grids
3. Facilities are assigned to a grid if they are located within its boundaries or the town name/keyword found in the facility
 - c. Name or Activity
 - d. Description is within a grid. This means that facilities can have a grid assigned even if they do not buy/sell electricity to/from a grid
4. A grid is also assigned if a facility does buy/sell from grid but does not fall within a grid's boundaries, provided it is within a couple hundred kilometres of a grid
5. Facilities that are not assigned a grid and do not buy/sell electricity from grid are labelled 'Off-grid'
6. Facilities that buy/sell electricity from grid but are not assigned to a grid by location or proximity to a grid are labelled 'Unknown grid'

This process results in some facilities being assigned to the SWIS even where electricity is not currently purchased from the network.



3.1.2 Data filtering and exclusions

The NGER dataset was filtered to isolate energy consumption relevant to electrification demand modelling. Consumption was used as the primary basis for analysis. Production-related quantities and fuel flows representing intermediate processing activities were excluded.

Facilities were assigned to sectors using ANZSIC divisions. Some ANZSIC divisions were excluded where electrification through the SWIS was considered unlikely, where they were already represented elsewhere in modelling frameworks, or where facilities were known to be closed or incorrectly classified. For example, grid-connected electricity generation is excluded from electrification calculations because electricity generation is represented in the PLEXOS model.

Table 3.1: Sector exclusions

NGERS Parameter	Value/filter	Justification
Reporting period	2024-25	Latest available NGER data
Grid	SWIS	FESO scope
Energy context	Consumption only	DASLLE forecasts potential new electricity consumption
Energy type	Stationary energy, transport energy and relevant electricity generation fuels	Use categories considered plausible to electrify
Facility name exclusions	Excludes facilities containing "office" or "corporate"	Outcomes derived from uSim distribution core model
Source type exclusions	Excludes unprocessed fuels intended for further processing, except where associated with electricity generation activities	Feedstock cannot be electrified

3.1.3 Electrification trajectory assumptions

DASLLE captures fuel switching not otherwise represented in Western Power's demand forecasts as it is intended to capture future electricity demand arising from decarbonisation of industry. Electrification trajectories compound over time and are

converted from gigajoules (GJ) of fuel consumption to electricity demand in megawatt hours (MWh) using technology efficiency assumptions.

Electrification can happen either by switching from fuel to on-grid electricity which increases demand on the grid or switching from fuel to (partial or complete) behind-the-meter (off-grid) systems which would not increase demand on the grid. The modelling assumes fuel-switching results in increased electricity consumption supplied by the SWIS. Behind the meter generation is treated separately from the electrification pathways as another input into Western Power's Large Load model so has not been discussed here.

The methodology estimates the current fuel consumption that could plausibly transition to electricity and calculates the resulting increase in SWIS electricity demand. For each economic sector, the assessment is undertaken using the following process:

1. Identifying the primary activity/activities for each fuel, end-use category within the economic sector.
2. Estimating the proportion of energy that could be electrified using industry and process specific knowledge.
 - The technological upper bound for a particular industrial process, informs the maximum electrification fuel use for a given economic sector. For example, hard to abate industries are constrained in terms of electrification potential by particular chemical processes that use fuel as a feedstock rather than for process heat. Technological upper bounds are informed by ClimateWorks research and related technology assessments. Related work in this area is currently being undertaken by the Commonwealth Department of Climate Change Energy and Environment (DCCEE), and this may be incorporated into the assumptions as information becomes available.
3. Converting electrifiable fuel consumption into electricity consumption over the forecast horizon, consistent with each scenario narrative.
4. Conversion of fuel consumption to electricity demand considers:
 - Fuel consumption measured in GJ.
 - Electricity consumption measured in MWh.
 - Efficiency improvements associated with electrification technologies.
 - The electricity requirements of replacement technologies.

5. Electrification trajectories compound over the forecast horizon and are developed separately for each sector.
 - Trajectories are informed by industry engagement with major proponents and technology assessments.
 - Generalised assumptions are applied where facility-specific information is unavailable.

To implement the trajectories, each fuel type within each end-use category within each economic sector is assigned:

1. A starting level of electrification.
2. An interim electrification level at a specified future year.
3. A maximum electrification level representing the assumed upper bound of technology deployment.

Electrification demand is then aggregated and incorporated into annual demand forecasts within Western Power's Large Load model.

3.2 Outputs

DASLLE outputs are economic sector-level, annual electrification consumption by SWIS PLEXOS node over the forecast horizon, for each core FESO scenario. Outputs from DASLLE are inputs into Western Power's Large Load model. The Large Load model is combined with the distribution core model outputs to produce the demand forecasts for each core scenario. Electrification consumption outputs included in the Inputs and Assumptions workbook are reported at a regional level to avoid disclosing confidential facility information.