AEMO Commercial Load Model

User Guide

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Executive Summary

This document has been compiled as an explanatory guide to the Commercial load model developed by DeltaQ. It outlines how various data sources were aggregated, the methodology and analysis applied to the dataset, and how to use and update the files.

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List of Abbreviations and Acronyms:

DHW	Domestic Hot Water
HVAC	Heating, Ventilation & Air Conditioning
AES	Australian Energy Statistics
AER	Australian Energy Regulator
NCC	National Construction Code
NGERS	National Greenhouse Emissions Reporting Scheme
EUB	End Use Breakdown
ToU	Time of Use
NEM	National Electricity Market
PVNS	PV non-scheduled generation
MI	Major Industrial

1 Introduction

DeltaQ were engaged by AEMO to update their dynamic models of load and distributed energy resources (DER) in PSSE and PSCAD. These models underpin many of AEMO's critical functions and are used to understand the way the power system behaves during disturbances, to inform AEMO's operations.

To construct these models, it has been necessary to develop an understanding of the proportion of NEM load that is related to different types of loads, because each type of load interacts differently with the grid during power system disturbances (e.g. large motors, versus small motors, versus power electronics, etc.).

DeltaQ developed a process to estimate the composition of "commercial load" in the NEM. Commercial load as defined here is any load that is not residential and is not one of the largest ≈220 industrial loads in Australia (which AEMO tracks individually). This includes small manufacturing, office buildings, shopping centres, warehouses, hospitals, schools, universities, hotels, etc.

The commercial loads were broken down into the various types of load (e.g. HVAC, fans, pumps, office equipment, heating, CFL lighting, incandescent lighting, refrigeration, tenant plug loads, etc). Once broken into the categories, the loads were then further broken down as a function of time of day, season, and geographical climate zone (e.g. unique for each NEM region or sub region).

These load categories were then mapped against the expected categories of motor, electronic loads, and static loads (i.e. the rules of association).

2 Methodology

DeltaQ developed the time-of-use load breakdown model for the commercial sector using a combination of firm data, soft data, extrapolation, and estimation. The compilation of the model has been broken down into 7 broad stages, that are outlined below.

Starting with the total annual commercial energy consumption and load profile from AEMO for each NEM region, we apportioned this load by sector using Australian Energy Statistics and other sources. A similar exercise was conducted for the PV generation estimates (stages 1, 2, & 3). Once the total energy was allocated by region and sector, each sector was given average daily and seasonal load profiles (stages 4 & 5). This was built up from existing data where available (for example, using energy audits, NMI data from metering providers, clients and in some cases estimates for the less defined commercial categories such as mining and manufacturing (generally the flatter load shapes)).

At this point, a data validation/error check was carried out by reconciling the shape of the AEMO total commercial load profile against the 'built up' load profiles. Where the shape of the modelled load profiles did not match the AEMO data, various adjustments were made to individual sectors (particularly those with a higher degree of uncertainty).

Once the time of use load profiles had been defined, estimates of what was occurring 'behind the meter' were applied. This was done by developing the end-use categories for each sector (i.e. percentage of compressors, pumps, fans, lighting etc.) (step 6). This was achieved largely through our existing data obtained from conducting detailed energy audits of various sites. Most of the energy audits included an end-use breakdown (termed EUB). EUB data informed a large portion of the sectors energy end use. Where EUB data was not available for the less defined commercial categories such as mining; we developed reasonable estimates based on the end-use services including Extraction, Handling Crushing and grinding and Separations. Following this, we compiled the rules of association (step 7) to map each end-use category to the AEMO motor categories and load types in order to generate the model outputs in the required AEMO format.

To complete the model, we defined the upper and lower estimates for each motor type, and then estimated what the peak demand and minimum demand scenarios would be.

Figure 1 and Figure 2 on the next 2 pages illustrate this overall process. A detailed description of each stage is outlined in the remaining sub-sections of this chapter.

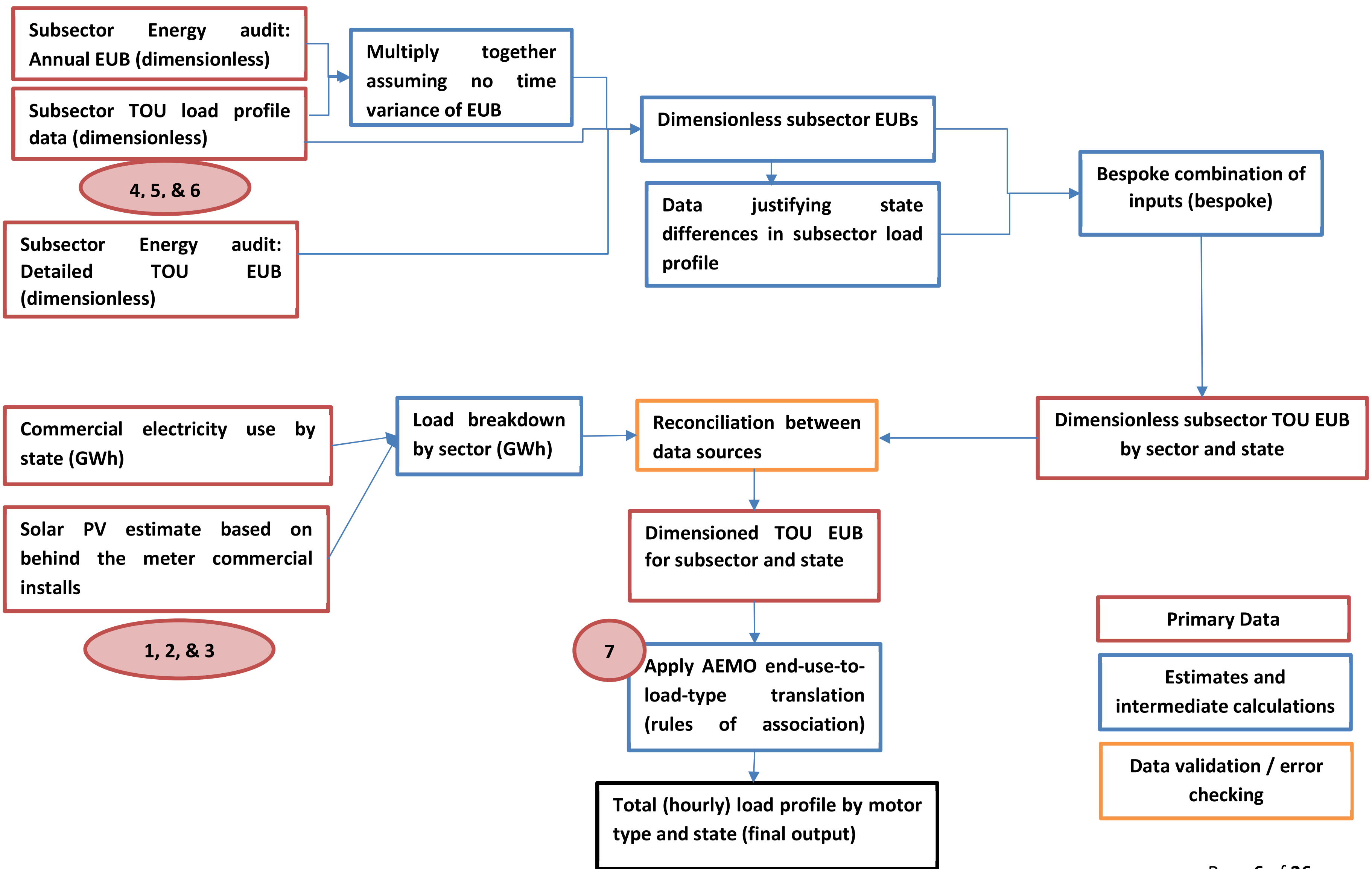


Figure 1: Workflow process for compiling the model

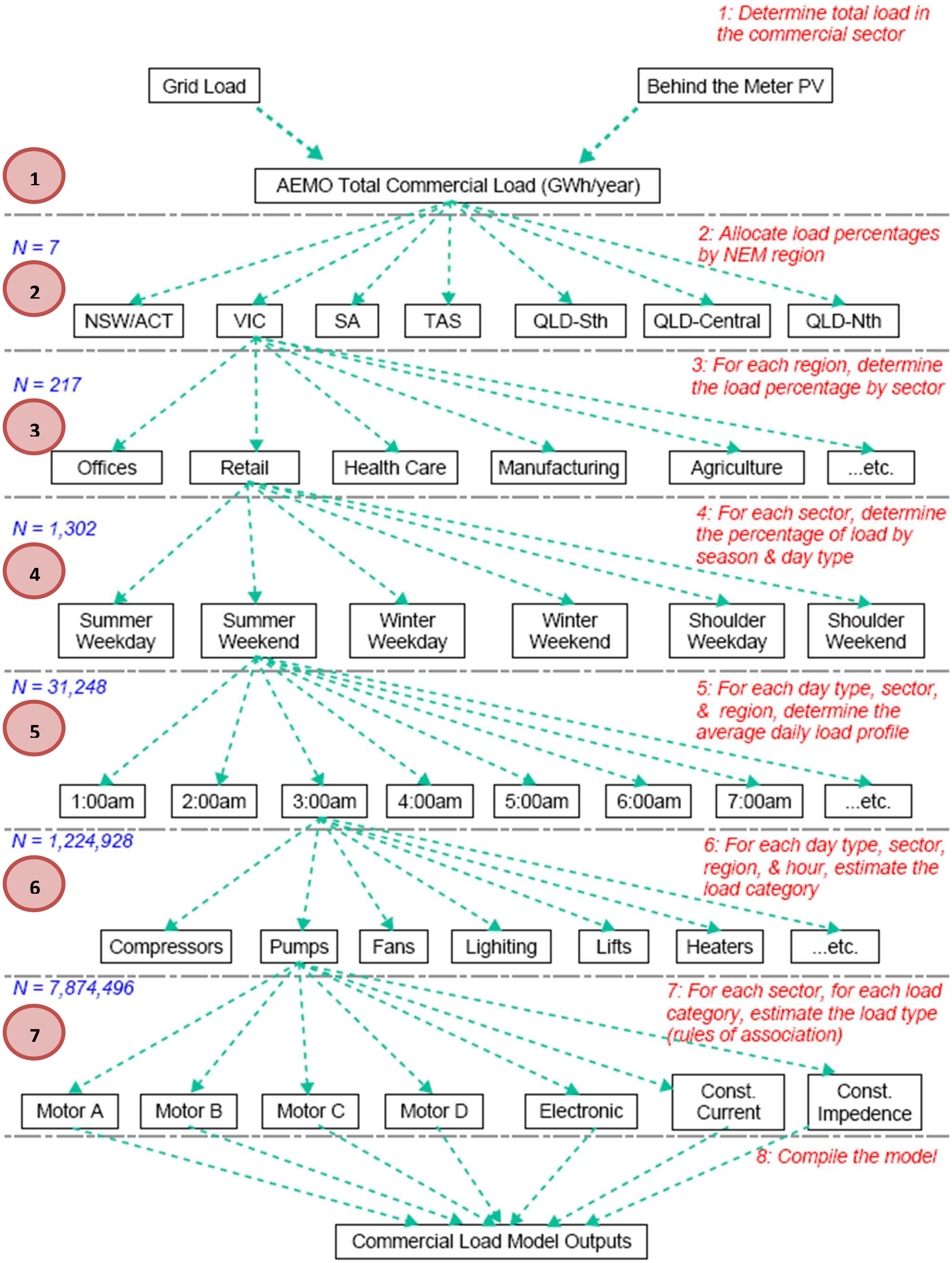


Figure 2: Diagram illustrating how the model is calculated and compiled

2.1 Total Commercial Energy (Stages 1 & 2)

2.1.1 Grid Energy Breakdown

The total FY2017/2018 half hourly load data was provided by AEMO. This half hourly data was broken down by NEM region, and by major category (Residential vs. Commercial vs. Major Industries). With this data is was relatively straightforward to determine the commercial load breakdown by NEM region.

2.1.2 PV Energy

The estimate of 'behind the meter' commercial PV generation was taken from two sources:

- AEMO FY18 Half-hourly Rooftop PV Generation Data (from systems up to 100kW in size)
- AEMO FY18 Half-hourly non-scheduled PV generation (PVNS) data (for systems between 100kW and 30MW in size)

The above data sources included a state-by-state breakdown.

The generation data included small residential systems, as well as large MW scale solar farms, so the following assumptions were applied in order to estimate the PV generation attributable to the commercial sector only:

- For systems under 100kW, 80% of this generation is residential and the remaining 20% is commercial
    - This is consistent with the assumption that systems up to 10kW are rooftop residential systems, and systems between 10kW and 100kW are rooftop commercial systems
- For systems between 100kW and 30MW, we have assumed that anything less than 5MW, and systems larger than 5MW are stand-alone solar farms
    - Using data from the Australian PV Institute on the installed capacity of PV systems, this translates to approximately 44% of this PVNS generation being attributable to the commercial sector

Note that the total estimated commercial PV generation estimate was only ≈1,950GWh across the entire NEM. When compared to the total commercial grid load (86,507GWh), PV generation is only estimated to account for approximately 2% of the commercial sector.

2.2 Sector Energy Breakdown (Stage 3)

With the annual state totals calculated as per the previous section, an energy breakdown by sector was estimated using the following data sources:

- AEMO's internal data
- Australian Energy Statistics (AES)
- Australian Energy Regulator's RIN data
- National Construction Code (NCC) building class
- National Greenhouse and Energy Reporting Scheme (NGERS)

To determine the Energy totals by commercial sub-sector (for each NEM region), the approach was broken into 6 sub-stages:

1. Summarise AES electricity consumption data by ANZSIC division/sub-division for 2017-18
2. Exclude ANZSIC 26 (electricity sector) from Division D
    a. AEMO 'energy deliveries' data does not include consumption of electricity by this sector (which comprises at least parasitic loads in power stations, transmission and distribution losses, and (most likely) unmetered consumption such as streetlights
3. Adjust the revealed AES values to:
    a. Estimate the extent which Major Industrial consumption (large 220) is included in the above data, and then
    b. Deduct the MI (Major Industrial) values, and
    c. Made minor adjustments to respond to unique conventions used by AES to maintain confidentiality of sectors. For example, some smaller sub-sectors have limited consumers, and therefore AES preserve anonymity by omitting data for that sub-sector. Where appropriate these values were estimated.
4. Distribute QLD electricity consumption by ANZSIC code into the three NEM regions (North, Central and South), using AEMO observations of total deliveries to each QLD region
5. Fit the adjusted AES totals to balance with AEMO commercial delivered energy totals, in order to estimate the composition of AEMO-defined commercial electricity by ANZSIC code
6. Decompose the AES 'commercial and services' values (defined as ANZSIC divisions F, G, H, J, K, L, M, N, O, P, Q, R, and S) into a number of commercial building types

The initial results of steps 1-5 are summarised in Table 1 on the following page.

Table 1: Commercial Electricity Consumption (non-residential, non-MI) fitted to AEMO totals, GWh, 2017-18, by Region

Sector/sub-sector	NSW /ACT	VIC	SA	TAS	QLD South	QLD Central	Qld North	QLD Total
Div. A Agriculture, forestry and fishing	**563**	**625**	**191**	**82**	**301**	**54**	**41**	**396**
Div. B Mining	**3,543**	**665**	**105**	**0**	**1,435**	**255**	**197**	**1,887**
06 Coal mining	1,818	114	0	0	163	29	22	214
07 Oil and gas extraction	0	313	0	0	780	139	107	1,025
08-10 Other mining	1,725	239	105	0	493	88	68	648
Div. C Manufacturing	**6,073**	**3,564**	**850**	**34**	**1,850**	**329**	**254**	**2,433**
11-12 Food, beverages and tobacco	1,783	1,703	381	15	1,040	185	143	1,367
13 Textile, clothing, footwear and leather	108	99	118	19	49	9	7	65
14 Wood and wood products	233	144	103	0	178	32	25	235
15-16 Pulp, paper and printing	1,619	873	189	0	89	16	12	117
20 Non-metallic mineral products	2,164	578	11	0	458	81	63	603
23-24 Machinery and equipment	167	167	48	0	35	6	5	46
Div. D Electricity, Gas, Water & Waste Services (excl. electricity generation)	**0**	**539**	**328**	**0**	**366**	**65**	**50**	**481**
27 Gas supply	0	6	0	0	11	2	1	14
28-29 Water supply, sewerage and drainage services	0	533	328	0	355	63	49	467
Div. E Construction	**201**	**22**	**3**	**1**	**31**	**6**	**4**	**41**
Commercial and services	**21,142**	**17,446**	**4,258**	**2,029**	**11,376**	**2,023**	**1,562**	**14,961**
Div. I Transport, postal & warehousing	**1,467**	**897**	**62**	**28**	**1,212**	**215**	**166**	**1,594**
46 Road transport	6	5	1	0	2	0	0	3
47 Rail transport	990	580	6	0	922	164	127	1,213
50-53 Other transport, services and storage (incl. warehouses)	471	311	55	28	287	51	39	378
Total	**32,988**	**23,758**	**5,796**	**2,173**	**16,570**	**2,946**	**2,276**	**21,793**
Balance with AEMO Commercial	100%	100%	100%	100%	100%	100%	100%	100%

It can be seen from the table above that the 'Commercial and Services' sector is by far the largest sector for commercial energy use in each NEM region. This is why the 6th step was necessary in order to breakdown this load into smaller sub-sectors for better resolution.

This was done using the recently updated models for the commercial building energy consumption, which is resolved by National Construction Code (NCC) building class, as an input to the ongoing COAG Energy Council existing buildings project (not yet published). This work represents the latest estimates available of energy (including electricity) consumption by building type and jurisdiction.

The other Commercial and services sectors were proportioned into the various sub-sectors based on the projected totals for FY2018 in the 2012 Commercial Building Baseline Study (prepared by the predecessors of DeltaQ and SPR)[1]. This source expected the split to be as shown in Table 2 again fitting this data to commercial and services totals by region.

Some further adjustments were nevertheless required. The estimate for Education/Assembly buildings was further broken down into the corresponding types schools, tertiary and other public buildings.

[1] http://www.energyrating.gov.au/document/report-residential-baseline-study-australia-2000-2030

Table 2: Estimated Commercial and Services Sector NEM Region, GWh, 2017-18

Sector/sub-sector	NSW /ACT	VIC	SA	TAS	QLD South	QLD Central	Qld North	QLD Total
Commercial and services	**21,142**	**17,446**	**4,258**	**2,029**	**11,376**	**2,023**	**1,562**	**14,961**
Accommodation	1,029	926	233	111	930	165	128	1,223
Offices	6,998	4,654	1,049	368	2,433	433	334	3,200
Retail	6,785	6,362	1,433	840	4,394	781	603	5,779
Carparks	63	59	14	6	31	5	4	40
Laboratories, industrial	117	99	27	8	51	9	7	67
Healthcare	2,021	1,756	506	166	1,148	204	158	1,510
Education/Assembly	3,711	3,230	890	486	2,302	409	316	3,027
of which, Schools	1,286	1,119	308	168	797	142	110	1,049
of which, Tertiary	2,104	1,831	504	275	1,305	232	179	1,716
of which, Other public buildings	321	280	77	42	199	35	27	262
Aged care	417	360	106	43	88	16	12	116

With the grid electricity fully apportioned by sector/sub-sector, the PV generation was also apportioned, using the following assumptions:

- Estimated generation from the larger-scale PVNS systems (i.e. systems between 100kW and 5MW) was proportionately distributed amongst the Div. A (Agriculture, forestry and fishing), Div. B (Mining) and Div. C (Manufacturing) sectors based on their relative percentage of grid consumption for each NEM regions.
- Estimated generation from the smaller-scale systems (i.e. systems between 10kW and 100kW) was proportionately distributed amongst the 'commercial and services' sectors as well as Div. I (Transport, postal & warehousing) based on their relative percentage of grid consumption for each NEM regions.

The solar apportioning is shown in Table 3 and Table 4 below

Table 3: PV Generation (non-residential, non-MI) apportioned by AEMO totals, GWh, 2017-18, by Region

Sector/sub-sector	NSW /ACT	VIC	SA	TAS	QLD South	QLD Central	Qld North	QLD Total
Div. A Agriculture, forestry and fishing	**6.8**	**8.3**	**6.3**	**4.5**	**6.6**	**1.2**	**1.2**	**9.0**
Div. B Mining	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
06 Coal mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
07 Oil and gas extraction	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
08-10 Other mining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Div. C Manufacturing	**73.4**	**47.0**	**27.9**	**1.9**	**40.7**	**7.2**	**7.7**	**55.5**
11-12 Food, beverages and tobacco	21.6	22.5	12.5	0.8	22.9	4.1	4.3	31.2
13 Textile, clothing, footwear and leather	1.3	1.3	3.9	1.1	1.1	0.2	0.2	1.5
14 Wood and wood products	2.8	1.9	3.4	0.0	3.9	0.7	0.7	5.4
15-16 Pulp, paper and printing	19.6	11.5	6.2	0.0	2.0	0.3	0.4	2.7
20 Non-metallic mineral products	26.2	7.6	0.3	0.0	10.1	1.8	1.9	13.8
23-24 Machinery and equipment	2.0	2.2	1.6	0.0	0.8	0.1	0.1	1.0
Div. D Electricity, Gas, Water & Waste Services (excl. electricity generation)	**0.0**	**7.0**	**10.8**	**0.0**	**7.8**	**1.4**	**1.5**	**10.7**
27 Gas supply	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-29 Water supply, sewerage and drainage services	0.0	7.0	10.8	0.0	7.8	1.4	1.5	10.7

Div. E Construction	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Commercial and services	**545.1**	**360.7**	**284.8**	**25.6**	**326.0**	**58.0**	**47.4**	**431.4**
Div. I Transport, postal & warehousing	**12.1**	**6.4**	**3.7**	**0.4**	**8.2**	**1.5**	**1.2**	**10.9**
46 Road transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47 Rail transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50-53 Other transport, services and storage (incl. warehouses)	12.1	6.4	3.7	0.4	8.2	1.5	1.2	10.9
Total	**637.5**	**429.5**	**333.4**	**32.3**	**389.3**	**69.2**	**59.0**	**517.5**
Balance with AEMO Commercial	100%	100%	100%	100%	100%	100%	100%	100%

Table 4: Further solar breakdown for the Commercial and Services Sector NEM Region, GWh, 2017-18

Sector/sub-sector	NSW /ACT	VIC	SA	TAS	QLD South	QLD Central	Qld North	QLD Total
Commercial and services	**545.1**	**360.7**	**284.8**	**25.6**	**326.0**	**58.0**	**47.4**	**431.4**
Accommodation	26.5	19.1	15.6	1.4	26.6	4.7	3.9	35.3
Offices	180.4	96.2	70.2	4.6	69.7	12.4	10.1	92.3
Retail	175.0	131.5	95.8	10.6	125.9	22.4	18.3	166.6
Carparks	1.6	1.2	0.9	0.1	0.9	0.2	0.1	1.2
Laboratories, industrial	3.0	2.0	1.8	0.1	1.5	0.3	0.2	1.9
Healthcare	52.1	36.3	33.9	2.1	32.9	5.8	4.8	43.5
Education/Assembly	95.7	66.8	59.5	6.1	66.0	11.7	9.6	87.3
of which, Schools	33.2	23.1	20.6	2.1	22.8	4.1	3.3	30.2
of which, Tertiary	54.3	37.9	33.7	3.5	37.4	6.6	5.4	49.5
of which, Other public buildings	8.3	5.8	5.2	0.5	5.7	1.0	0.8	7.6
Aged care	10.8	7.5	7.1	0.5	2.5	0.4	0.4	3.3

2.3 Time of Use Profiles and End-use Breakdowns (Stages 4, 5, & 6)

To define the typical loads occurring 'behind the meter', end use load profiles were developed for each sector. This was primarily based on data sourced from various energy-audits for different types of buildings. Most of these energy audits contained data on the average load profile by season and by day type (weekday vs. weekend). Some audits also contained detailed time-of-use electricity end-use breakdowns (ToU EUBs), which gave us high quality data on what types of loads were running at different times of the day. For sectors where energy audit data was not available, the load profiles were developed using either NMI interval data from representative sites, or they were estimated.

The typical data used included (in order of data quality):

- Detailed Energy Audits (studies that include detailed hourly end-use-breakdowns for average summer, winter, and shoulder season weekdays and weekends).
- Basic Energy Audits (studies that include an annual end use breakdown only, along with average seasonal load profiles)
- Raw NMI interval data
- Research and published studies
- Estimates

Table 5 below provides a high-level summary of the data sources used for each sector. For further details refer to section 4 for a summary of the data quality and uncertainties for each sector.

Table 5: Summary of load profile data sources by sector

Division	Total GWh	%	Load Profile	Overall Uncertainty
Div. A Agriculture, forestry and fishing	**1,856**	**2.1%**	Detailed Energy Audits	Medium
Div. B Mining	**6,199**	**7.2%**		High
06 Coal mining	2,146	2.5%	NMI Data, Research & Estimates	High
07 Oil and gas extraction	1,338	1.5%		High
08-10 Other mining	2,716	3.1%		High
Div. C Manufacturing	**12,953**	**15.0%**		High
11-12 Food, beverages and tobacco	5,249	6.1%	Energy Audits, NMI data and estimates	High
13 Textile, clothing, footwear and leather	408	0.5%		High
14 Wood and wood products	715	0.8%		High
15-16 Pulp, paper and printing	2,798	3.2%		High
20 Non-metallic mineral products	3,355	3.9%		High
23-24 Machinery and equipment	428	0.5%		High
Div. D Electricity, Gas, Water & Waste Services (excl. electricity generation)	**1,348**	**1.6%**		Medium
27 Gas supply	20	0.0%	Estimates	High
28-29 Water supply, sewerage and drainage services	1,328	1.5%	Detailed Energy Audits	Medium
Div. E Construction	**268**	**0.3%**	Estimates	High
Commercial and services	**59,836**	**69.2%**		Low
Accommodation	3,522	4.1%	Detailed Energy Audits	Low
Offices	16,268	18.8%	Detailed Energy Audits, NMI Data	Low
Retail	21,199	24.5%	Detailed Energy Audits	Low
Carparks	182	0.2%	NMI Data	Low
Laboratories, industrial	318	0.4%	Estimates	Medium
Healthcare	5,960	6.9%	Basic Energy Audits, NMI Data	Medium
Education/Assembly	11,344	13.1%		Medium
of which, Schools	3,930	4.5%	NMI Data	Medium
of which, Tertiary	6,431	7.4%	NMI Data, Audits	Medium
of which, Other public buildings	982	1.1%	NMI Data, Audits	Medium
Aged care	1,043	1.2%	Detailed Energy Audits	Low
Div. I Transport, postal & warehousing	**4,048**	**4.7%**		High
46 Road transport	16	0.0%	Estimates	High
47 Rail transport	2,789	3.2%	Research & Estimates	High
50-53 Other transport, services and storage (incl. warehouses)	1,243	1.4%	Detailed Energy Audits	Medium
Total	**86,507**	**100.0%**		

2.4 Rules of association (Stage 7)

Energy end-use categories are mapped to the final 'load types' via the Rules of Association into the categories defined:

- **Motor A -** Three-phase induction motors with low inertia (H = 0.1 sec) driving constant torque loads. Motors commonly found in commercial/industrial air conditioning compressors and refrigeration systems.
- **Motor B** - Three-phase induction motors with high inertia (H = 0.25-1.0 sec) driving loads whose torque is proportional to speed squared. Motors commonly found in commercial ventilation fans and air-handling systems.
- **Motor C** - Three-phase induction motors with low inertia (H = 0.1-0.2 sec) driving loads whose torque is proportional to speed squared. Motors commonly found in commercial water circulation pumps in central cooling systems.
- **Motor D** - Single-phase induction motors representing primarily residential air conditioner compressor motors. Single-phase air conditioners (residential air conditioning) driven by single-phase induction motors that run the air-compressor. These are thought to be uncommon in Australia.
- **Electronic Load** - The power electronic (inverter-based or electronically coupled) load component of the model represents an aggregate effect of power electronic loads. Small electronic constant power loads.
- **Constant Current** – Loads on a constant current power supply (i.e. fluorescent lighting)
- **Constant Impedance** – Loads that are resistive only (i.e. electric heating elements & incandescent lighting)

The rules of association are based on the those previously used in the 2014 New England Study, with various adjustments made to reflect our observations of the Australian market (for example, greater adoption of variable speed drives and less incandescent lighting loads). These estimates and assumptions are outlined withing the rules of association spreadsheet.

Note the rules of association tables have been set up to be easily edited, allowing for flexibility for users to update as improved confidence data becomes available.

2.5 Peak Demand & Minimum Demand Scenarios

Once the average scenarios were modelled for each state, the next step was to determine how the load composition was likely to vary under peak and minimum demand scenarios.

A sensitivity analysis showed that most peak demand times occurred on summer weekdays and correlated with the days that experienced the highest maximum temperatures. Meanwhile, minimum demand times either occurred on winter weekends, or on a public holiday such as Boxing day.

From these results we concluded that peak demand events are largely driven by cooling equipment in the HVAC and refrigeration categories, and therefore the 'gap' between the peak demand and the average demand is comprised of these loads. Meanwhile minimum demand events were more driven by production shutdowns and were more attributable to the manufacturing and mining sectors.

The relevant HVAC or production load compositions were extracted from the model at the time of day where the peak/minimum demand occurs. These percentages were then used to 'fill-in' the peak demand time for the model. A sample of the results (used for ACT/NSW) are shown in Table 6 below.

Table 6: Estimate of the load composition sensitive to peak and minimum demand – ACT/NSW

Load Type	Peak Demand (HVAC Driven) (Summer Weekday)	Minimum Demand (Production Driven) (Boxing Day)
Motor A (%)	42.85%	23.58%
Motor B (%)	33.70%	18.98%
Motor C (%)	0.37%	19.31%
Motor D (%)	0.63%	1.39%
Electronic (%)	22.11%	25.15%
Constant Current (%)	0.00%	3.10%
Constant Impedance (%)	0.34%	8.49%
Total	**100.00%**	**100.00%**

These % figures were derived using the following methodology:

- For peak/min demand events driven by HVAC loads:
    - Create a new copy of the state spreadsheet and unprotect the "02 State Sector EUB U Profiles" Tab
    - Filter by category (Column D) and select all the categorist that are not one of the following 7 categories: Chillers, Compressors, Cooling Towers, Other HVAC, Refrigeration, Refrigeration & Process Cooling, and Supply Air Fans
    - Select and delete all the % load allocation data in rows G through to FR for these categories
    - Recalculate the spreadsheet
    - The model now only has data for HVAC driven loads, in the "05 Hourly Data Output" tab, extract the percentages for the relevant day type/hour where peak demand occurs
- For peak/min demand events driven by production loads:
    - Create a new copy of the state spreadsheet and unprotect the "02 State Sector EUB U Profiles" Tab
    - Filter by sector (Column C) and select the following 11 categories: Accommodation, Aged Care, Car Parks, Gas Supply, Healthcare, Offices, Public Buildings, Rail Transport, Retail, Road Transport and Water Supply
    - Select and delete all the % load allocation data in rows G through to FR for these categories
    - Recalculate the spreadsheet
    - The model now only has data for production driven loads, in the "05 Hourly Data Output" tab, extract the percentages for the relevant day type/hour where peak demand occurs

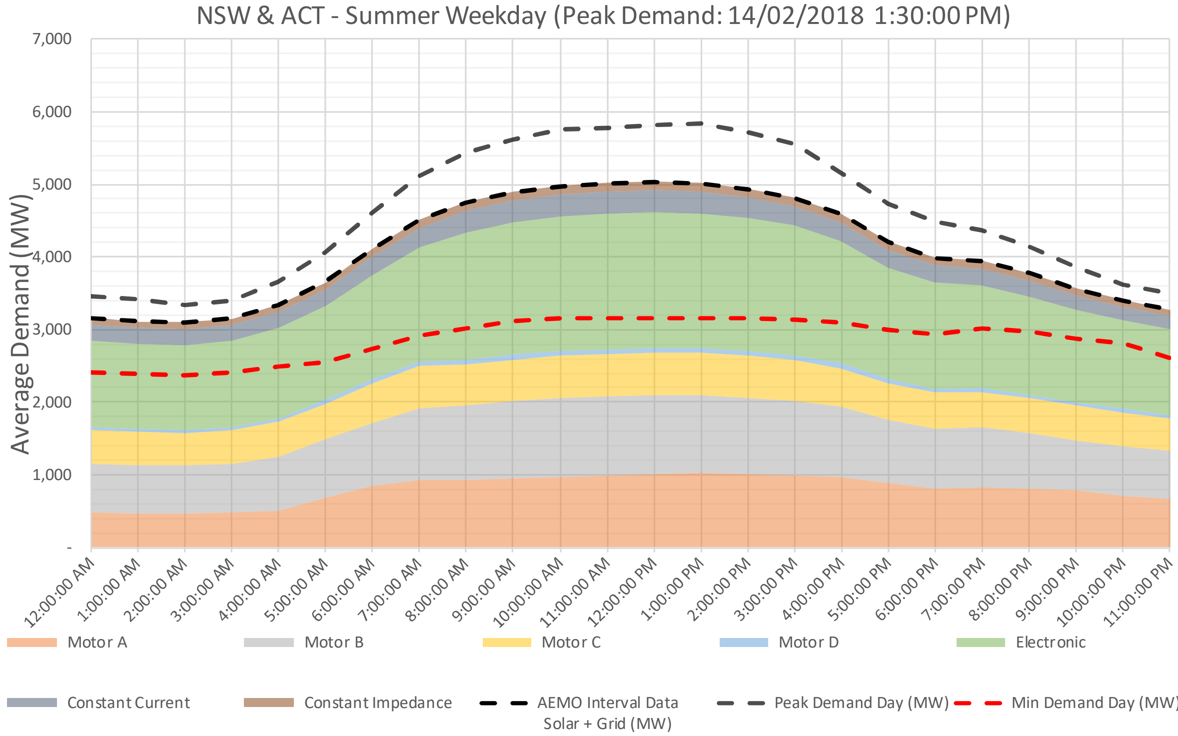


Figure 3: Average summer weekday results, compared to the load profiles with the peak and minimum demand occured (ACT/NSW)

2.6 Upper and Lower Estimates

The upper and lower estimates are calculated via the rules of association. For example, in the lower estimate scenarios, the rules of association for each sector/load category add up to less than 1.00, and in the upper estimates the rules of association add up to more than 1.00.

The upper and lower estimates were calculated by applying both a 'percentage uncertainty' and an 'absolute uncertainty' to each row, with explanatory notes provided in the Colum to the right.

- The percentage uncertainty indicates the error/uncertainty with regards to that particular sector/load type
  - For example, +/- 5% uncertainty has been applied to the accommodation sector rules of association to represent the uncertainty around how much this sector accounts for the total NEM load
- The absolute uncertainty indicates the error/uncertainty within categories
  - For example, +/- 0.10 uncertainty has been applied to the lighting and plug loads rules of association for aged care, to represent the uncertainty around how much this load is constant current vs. how much is electronic load

3 Using the Model & Updating the Rules of Association

3.1 Folder Structure and File Links

The model consists of 24 spreadsheets – 8 spreadsheets each for the central, upper and lower estimates. Each central, upper and lower estimate comprises 7 models (1 model per NEM region which includes NSW & ACT, QLD-C, QLD-N, QLD-S, SA, TAS and VIC), as well as the relevant rules of association.

The relevant rules of association spreadsheets are linked to the appropriate model, such that any updates to the rules of association spreadsheet will be reflected in the model. ***The rules of association directory in each model will need to be updated prior to the model working (see Section 3.5).***

3.2 File Sizes

The rules of association spreadsheets have a file size of approximately 300 kB, while the central, upper and lower estimate models are approximately 23 MB in size.

Note that the central, upper and lower estimate models contain over 7.8 million calculation + links to external spreadsheets which update on opening and saving. This means that each model will require some time to open or save. This can be sped up by using a computer with faster processing power.

3.3 Opening the Model

Each workbook model comprises 6 sheets. The first 3 sheets (01 State Sector A Load Profiles, 02 State Sector EUB U Profiles and 03 Rules of Association) are input tabs that compile all the information necessary to build the model. Sheet 4 (04 Processing Data) processes the input tabs, while sheet 5 (05 Hourly Data Output) and tab 6 (06 Graphs) are the output sheets.

Note that the first 4 sheets have been protected to prevent accidental edits. To make changes to a protected sheet, navigate to 'Review' in the excel ribbon and click 'Unprotect Sheet'. We recommend not making any changes to a protected sheet.

3.4 Using the Model

Each sheet is made up of the following:

- 01 State Sector A Load Profiles
    - This sheet contains the load profiles for each sector for each weekday type (scrolling left to right). Each load profile has been pasted as values from off-site spreadsheets which multiply the TOU load profile, the expected weekday type percentage and the actual energy consumption of that sector. This sheet has been protected. See notes in Section 3.3 to unprotect if necessary. Note all units are in MW unless otherwise specified.
- 02 State Sector EUB U Profiles
    - This sheet contains the unitless end-use-breakdown of each sector for each weekday type (scrolling left to right). The sum of each sector per hour will add up to 100%; the sum of sector **&** weekday type will add up to 2400 % (i.e. 24 hours per daytime). This sheet has been protected. See notes in Section 3.3 to unprotect if necessary. Note all units are in percentages unless otherwise specified.

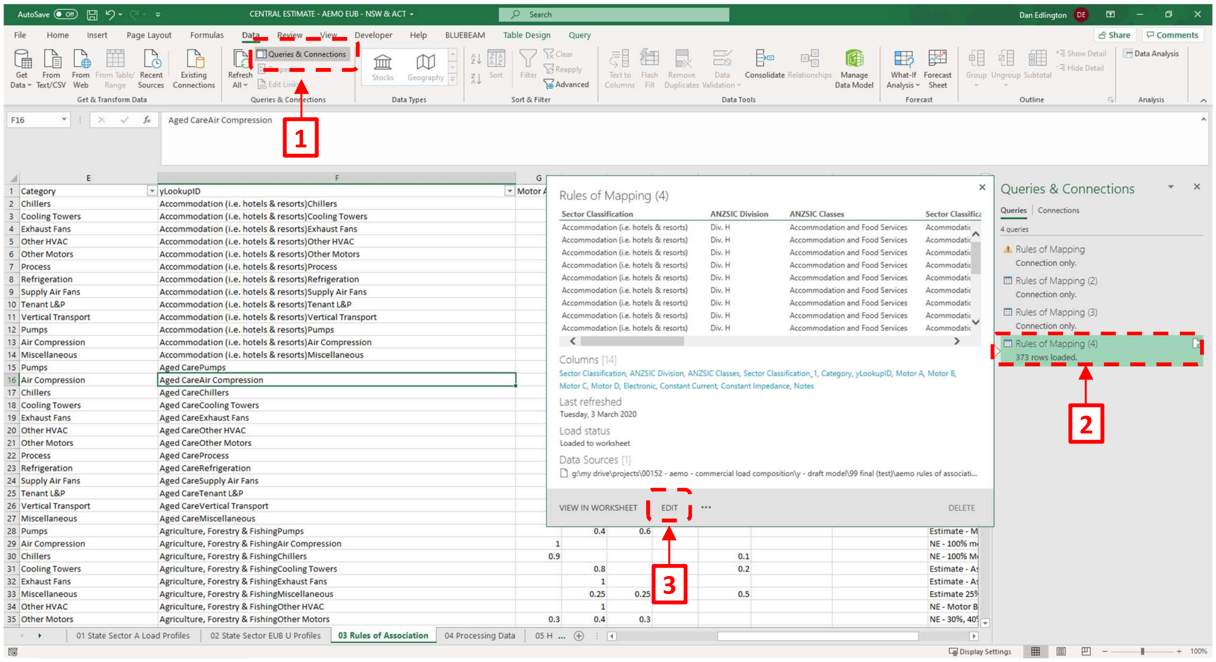
- 03 Rules of Association
    - This sheet contains the rules of association. This sheet has been brought into the model from an external spreadsheet source (provided in the main folder). To update/modify the rules of association, we recommend editing the separate rules of association workbook and then refreshing the links on this sheet using the steps outlined in Section 3.5 below. This sheet has been protected. See notes in Section 3.3 to unprotect if necessary. **This tab is required to be adjusted prior to the model working. The steps are outlined in Section 3.5 below.**
- 04 Processing Data
    - This sheet contains the calculations required to generate the required output data. The formula uses a series of index matches to find the appropriate multiplier in the first 3 sheets. The first index match returns the lookup value of the State Sector A Load Profiles sheet, the second index match returns the lookup value of the State Sector EUB U Profiles sheet and the third index match returns the lookup value from the Rules of Association sheet. The sector motor types per hour are summed in the far right of this tab in columns JB to JH.
- 05 Hourly Data Output
    - This sheet contains the output of the model in the format required by AEMO. The MW value & percentage of each load type is presented per season and weekday type. For the central estimate, the sum of all the motors per season & weekday sum to the interval data (after behind the meter solar is considered) – for the upper and lower estimates, the motor summation will be more than and less than AEMOs totals respectively.
- 06 Graphs
    - This sheet provides a graphical representation of 05 Hourly Data Output.

3.5 Updating Excel Power Queries

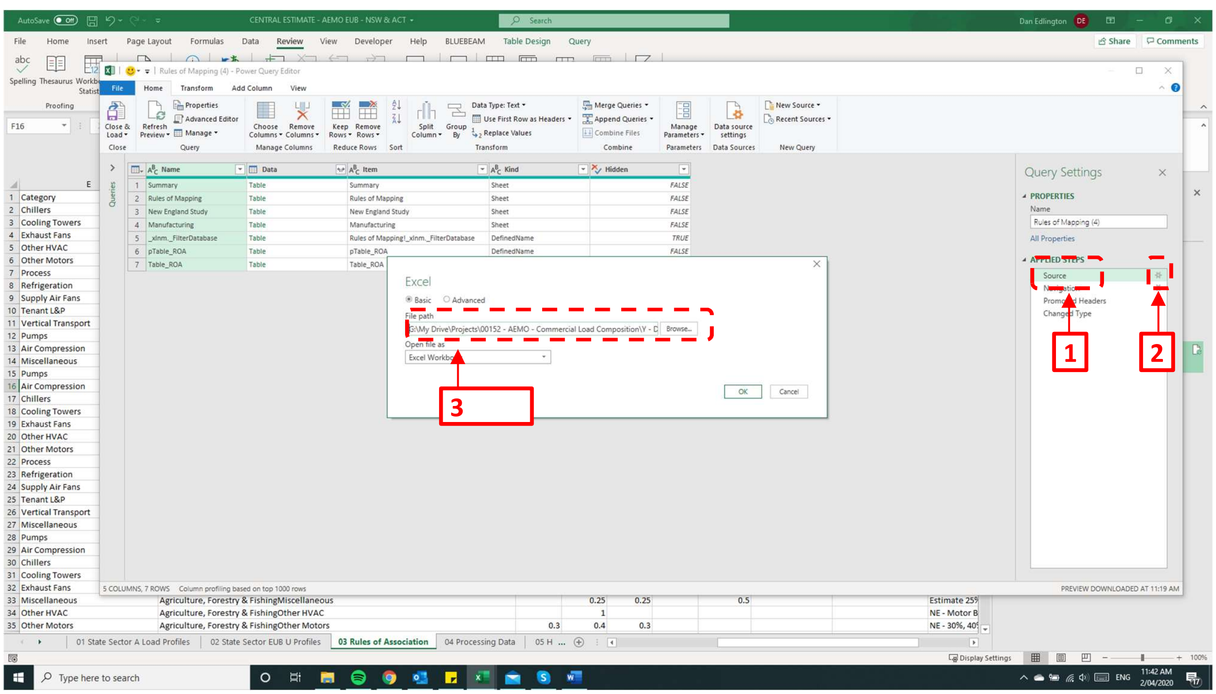
The model has been built to give the user the ability to modify the rules of association. To do this, we have used Excels 'Power Query' function, which allows external data to be exported into the spreadsheet.

NOTE: ***ALL QUERIES WILL NEED TO BE UPDATED PRIOR TO USING THE SPREADSHEETS FOR THE FIRST TIME. EACH QUERY POINTS TO A FIXED DIRECTORY, WHICH UNFORTUNATELY DOES NOT UPDATE AS FOLDERS ARE MOVED / RENAMED. TO UPDATE THE QUERIES, FOLLOW THE INSTRUCTIONS LISTED BELOW.***

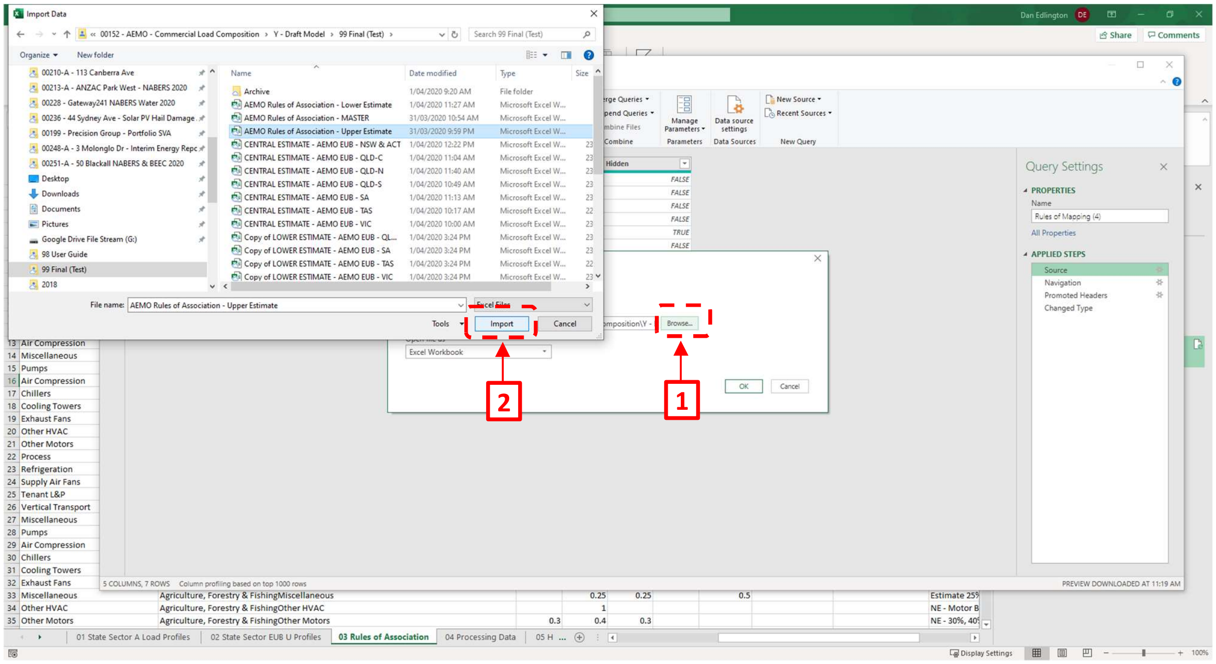
- Step 1: Navigate to sheet 3 (03 Rules of Association). As the sheet is protected, it will need to be unprotected first. In the excel ribbon, click on 'Review' and click 'unprotect sheet'.
- Step 2: In the excel ribbon, click on 'Data' and then click on 'Queries & Connections' (1). In the right-hand column, hover the mouse over the current 'Rules of Mapping' (2) and click edit (3). See screenshot below.
    - When the files are first copied onto a server or local PC, they will retain the old file path links to where the rules of association were previously stored
    - These file paths are what needs to be updated for the model to work



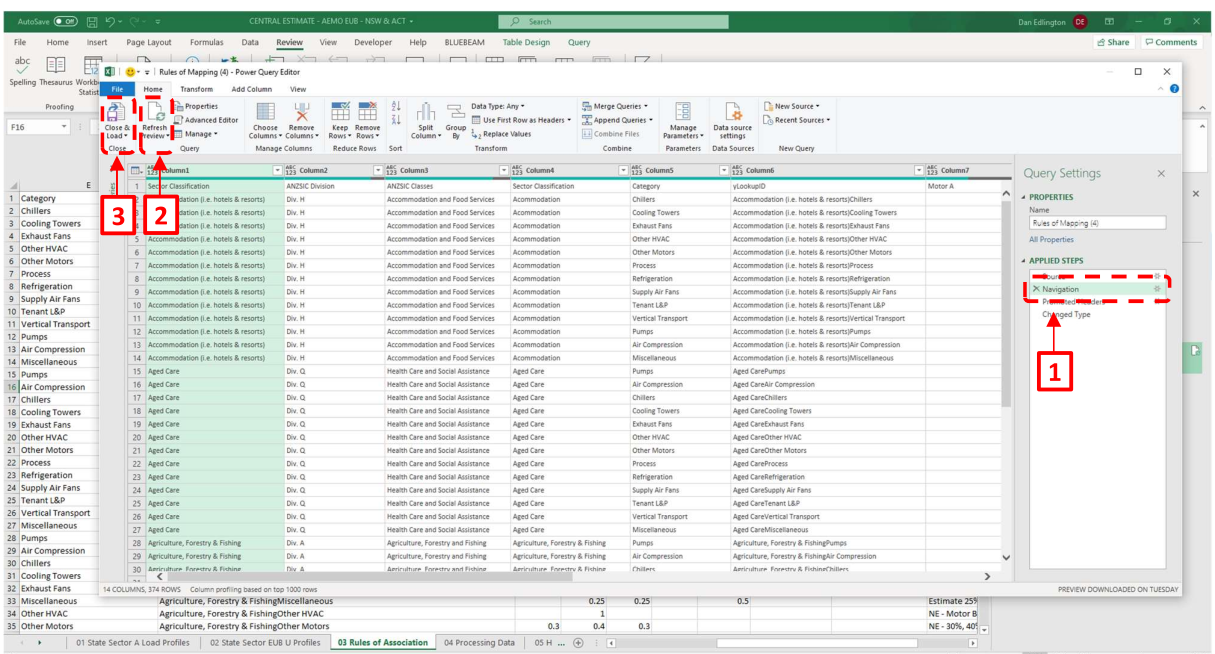
- Step 3. The Power Query window will open. In the right hand column under Query Settings, click ‘Source’ (1) and then the gear icon next to source (2). This will open an excel window with the file path of the source document (3). See screenshot below.



- Click ‘Browse’ and navigate to the directory where the model is stored (1). Select the appropriate rules of association (i.e. central, upper or lower) and click import (2). See screenshot below.



- Once the rules of association have been imported, click 'Navigation' in the right hand column (1) and refresh preview in the excel ribbon (2). This will provide a preview of the selected rules of association spreadsheet. Ensure that column 7 through to column 13 contain the values for the motor types. Click 'Close & Load' (3). See screenshot below.



- The model will update automatically. If it doesn't, click on 'Formulas' in the excel ribbon and select 'Calculate Now'. Give the model a few moments to process the data. Once all calculations have complete, navigate through the 04 Processing Data sheet and check for any #N/A or # Value errors. These can quickly be identified in columns JB through to column JH. Navigate to the 05 Hourly Data Output or 06 Graphs for the final results.

4 Data Sources

4.1 Agriculture, forestry and fishing

Data for this sector was based on detailed energy audit results from several dairy farms in Victoria

4.2 Mining

For the mining sector, the total demand profiles were estimated as follows:

- Data from several NMI profiles, showing that:
  - the 24-hour demand profile of larger mines is generally flat
  - the monthly consumption profile is affected by irregular downturns, likely to be associated with maintenance and/or holiday shutdowns
- An interview with a project manager in the Australian mining industry. This interview identified the following:
  - Bigger operators typically run 24/7, only punctuated by planned shutdowns
  - Smaller operators' mines may run batch extraction to meet processing capacity, with constant processing. Planned shutdowns apply.
  - Very small operators often run to standard working-day shifts with holiday shutdowns
- The assumption that all regions have similar weighting of large/medium/small operators.

The EUB breakdown was estimated based on the sub-sector end-use energy breakdowns outlined in the US mining industry, sourced from the document Mining Industry energy bandwidth study (Appendix B)[2]

4.3 Manufacturing

The data for the manufacturing sectors was compiled using a compilation of energy audit data, published studies, and estimates:

- Analysis of several data profiles from manufacturing sector energy audits, including:
  - Food oil processing
  - Recycled glass product manufacturing
  - Oat milling
  - Food processing
  - Plastics processing
  - Hot water tank manufacturing
- Development of 24-hour demand profiles using the above, with subsector-specific adjustments based on several process assumptions.
- Load-types for various manufacturing processes were taken from the New England end use modeling study
- The weighting of the load-type breakdowns was applied to manufacturing subsectors by apportioning process-types to each subsector. This apportioning is based on the available data from the energy audits.

[2] https://www.energy.gov/sites/prod/files/2013/11/f4/mining_bandwidth.pdf

4.4 Electricity, Gas, Water & Waste Services

Electricity
The electricity sector (ANZSIC code 26) was excluded from this analysis

AEMO ‘energy deliveries’ data does not include consumption of electricity by this sector (which comprises at least parasitic loads in power stations, transmission and distribution losses, and (most likely) unmetered consumption such as streetlights

Gas Supply
Gas supply represents a very small part of the NEM (estimated at 20 GWh or less than 0.1%) and no primary data was able to be sourced. This sector was estimated to be comprised of 80% compressor equipment and 20% lighting and other miscellaneous equipment, all operating as a flat constant 24/7 load.

Water and Sewerage
Data for this sector was taken from detailed energy audits of several water pumping stations, sewerage pumping stations, however our data does not include energy end uses from water treatment plants.

4.5 Construction

This sector represents a very small part of the NEM (estimated at 268 GWh or 0.3%) and no primary data was able to be sourced. This sector was estimated to be comprised of 80% compressor/motor equipment and 20% lighting and other miscellaneous equipment, all operating as a flat constant 24/7 load.

4.6 Commercial and Services

The majority of data for this sector came from a wide array of energy audits and NMI interval data:

Accommodation
- Detailed energy audits from a mix of 7 hotels, resorts and casinos in NSW and QLD

Offices
- Detailed energy audits of 10 commercial office buildings throughout Australia, covering all the base-building (landlord) energy end uses
- NMI data from several large office tenancies in Sydney and Melbourne

Retail
- Detailed energy audits for 5 large shopping centres covering the base-building (landlord) loads.
- NMI data from a shopping centre embedded network meter in order to estimate tenant loads

Carparks
- NMI data from two stand-alone multi story commercial car parks
- The average end use loads were estimated to be 80% lighting and 20% fan energy based on our experience working on both mechanically ventilated and naturally ventilated car parks that for part of shopping centres and office towers

Laboratories, industrial
- Detailed energy audits from 2 large laboratories in ACT (on a university campus)

Healthcare

- A detailed energy audit of a NSW private hospital
- NMI data from 7 QLD hospitals

Schools

- NMI data from 3 NMS schools

Tertiary

- Two energy audits of universities in the ACT & NSW

Other public buildings

- NMI interval data for 12 community centers and public libraries in the ACT
    - The end-use breakdown for these types of buildings was assumed to be similar to that of commercial offices
- A basic energy audit of a council-operated aquatic center in Sydney

Aged care

- Data from a detailed energy audit of an aged care facility in SA

4.7 Transport, postal & warehousing

Road Transport

Road transport represents a very small part of the NEM (estimated at 16 GWh) and no primary data was able to be sourced. This sector was estimated via an interview with Sydney Trains who confirmed their load comprised of 70% fan/ventilation equipment and 30% lighting and other miscellaneous equipment, all operating as a flat constant 24/7 load.

Rail Transport

Average demand profiles were estimated using average hourly passenger data from a 2014 Train Statistics publication released by Transport for NSW. Additional base load was estimated for depots, stations, signaling equipment and ancillary loads.

The end use breakdown was estimated following an interview with Sydney Trains identifying the following:

- Breakout between trains, stations, depots, signaling equipment and embedded network retail tenants
- Approximate sub-breakdown of the train energy load between motors, HVAC and auxiliary loads

Other Transport

It was assumed that this sector is predominantly made up of warehouses. The energy model was divided between general/logistics warehouses, and refrigerated/cold storage warehouses, as they have significantly different energy consumption profiles and loads.

Using gross floor area data taken from a recent NABERS sector expansion study, it was estimated that 73% of this sector is non-refrigerated general warehouse space, and the remaining 27% is made up of more energy intensive cold storage warehousing.

Using the above assumption, the load model for this sub-sector was built up using energy audit data from a refrigerated and a non- refrigerated warehouse facility.

4.8 Level of Uncertainty

Table 7

Stage	Activity	Data Sources	Level of Uncertainty
1	Load sector load composition	AEMO Source, AES, ABS	Low
2	State load allocations	AES electricity consumption data by ANZSIC	Low
3	Sub sector by state	AES electricity consumption data by ANZSIC division/sub-division, 2012 Commercial Building Baseline Study	Medium
4	Seasonal profiles	*<Calculated from items 1 to 3>*	Low
5	Time of use profiles	Energy Audits, End-use interval data	Low
6	End use mapping	Energy Audits (Time of Use), Industry Interviews	Medium
7	Rule of association	2014 New England Study (adjusted), Estimates	High

Levels of uncertainty are applied across the dataset, however there are sectors with a higher level of uncertainty (as outlined in Table 5 on page 13). These sectors are the "process driven" sectors, where estimating the end use load categories is hard due to the variance of the sites process load (operation). For example; sectors such as light industrial and mining were hard to estimate a uniform profile and end use breakdown, these sectors do not follow a "standard" profile for either load shape or standard end use load composition.

4.9 Improving Uncertainty

Recommended improvements to the levels of uncertainty include:

- Update the sub-sector by state energy demand allocations based on the updated Commercial Buildings Baseline Study (prepared by the Dept. Industry, Science, Energy and Resources)
- Further interviews/surveys for end-users with process driven operations; specifically, within the Mining and Manufacturing sectors.
- Engagement with motor providers to determine current motor types installed, and the current motor types as a volume and proportion of sales

Appendix A Sample Model Outputs

Appendix A.I Hourly Outputs

The output tab for the central estimates for NSW & ACT is as follows (excluding weekend results):

Commercial Load Composition:

Central Estimate

(Note the percentages in each row will sum to 100%)

State	Season	Day	Hour (Rounded)	AEMO Interval Data Solar + Grid (MW)	Motor A	Motor B	Motor C	Motor D	Electronic	Constant Current	Constant Impedance	Total MW (CHECK)	Motor A (%)	Motor B (%)	Motor C (%)	Motor D (%)	Electronic (%)	Constant Current (%)	Constant Impedance (%)	Total % (CHECK)
NSW & ACT	Annual Region **Maximum** Demand	Date: 14/02/2018 1:00:00 - 1:30:00 PM	2:00:00 PM	**5,850.59**	**1,378.23**	**1,359.37**	**583.68**	**73.39**	**2,039.72**	**292.71**	**123.49**	**5,850.59**	**23.56%**	**23.23%**	**9.98%**	**1.25%**	**34.86%**	**5.00%**	**2.11%**	**100.00%**
NSW & ACT	Annual Region **Minimum** Demand	Date: 26/12/2017 2:30:00 - 3:00:00 AM	2:00:00 AM	**2,376.04**	**359.59**	**504.67**	**356.01**	**37.36**	**900.19**	**158.45**	**59.78**	**2,376.04**	**15.13%**	**21.24%**	**14.98%**	**1.57%**	**37.89%**	**6.67%**	**2.52%**	**100.00%**
NSW & ACT	Summer	Weekday	12:00:00 AM	3,157.40	487.81	665.42	465.24	42.98	1,186.32	223.15	86.49	3,157.40	15.45%	21.07%	14.73%	1.36%	37.57%	7.07%	2.74%	100.00%
NSW & ACT	Summer	Weekday	1:00:00 AM	3,114.92	470.32	661.86	458.23	42.31	1,175.04	221.99	85.17	3,114.92	15.10%	21.25%	14.71%	1.36%	37.72%	7.13%	2.73%	100.00%
NSW & ACT	Summer	Weekday	2:00:00 AM	3,100.17	468.34	655.73	456.63	42.36	1,168.68	222.07	86.36	3,100.17	15.11%	21.15%	14.73%	1.37%	37.70%	7.16%	2.79%	100.00%
NSW & ACT	Summer	Weekday	3:00:00 AM	3,154.48	476.47	677.96	463.87	43.32	1,181.97	221.84	89.05	3,154.48	15.10%	21.49%	14.71%	1.37%	37.47%	7.03%	2.82%	100.00%
NSW & ACT	Summer	Weekday	4:00:00 AM	3,338.67	502.62	742.90	490.01	45.96	1,234.02	228.57	94.59	3,338.67	15.05%	22.25%	14.68%	1.38%	36.96%	6.85%	2.83%	100.00%
NSW & ACT	Summer	Weekday	5:00:00 AM	3,651.46	693.26	790.68	501.15	50.40	1,300.64	216.66	98.67	3,651.46	18.99%	21.65%	13.72%	1.38%	35.62%	5.93%	2.70%	100.00%
NSW & ACT	Summer	Weekday	6:00:00 AM	4,108.29	847.71	858.43	554.10	58.55	1,440.53	245.64	103.34	4,108.29	20.63%	20.89%	13.49%	1.43%	35.06%	5.98%	2.52%	100.00%
NSW & ACT	Summer	Weekday	7:00:00 AM	4,510.17	935.20	988.95	577.92	64.36	1,569.01	253.62	121.11	4,510.17	20.74%	21.93%	12.81%	1.43%	34.79%	5.62%	2.69%	100.00%
NSW & ACT	Summer	Weekday	8:00:00 AM	4,751.37	919.24	1,033.05	564.62	67.13	1,759.71	286.62	121.00	4,751.37	19.35%	21.74%	11.88%	1.41%	37.04%	6.03%	2.55%	100.00%
NSW & ACT	Summer	Weekday	9:00:00 AM	4,891.75	942.59	1,067.41	577.03	67.86	1,825.07	292.72	119.07	4,891.75	19.27%	21.82%	11.80%	1.39%	37.31%	5.98%	2.43%	100.00%
NSW & ACT	Summer	Weekday	10:00:00 AM	4,978.71	971.48	1,083.96	582.36	68.10	1,856.69	295.76	120.35	4,978.71	19.51%	21.77%	11.70%	1.37%	37.29%	5.94%	2.42%	100.00%
NSW & ACT	Summer	Weekday	11:00:00 AM	5,011.70	992.07	1,084.90	582.02	68.31	1,868.76	294.92	120.72	5,011.70	19.80%	21.65%	11.61%	1.36%	37.29%	5.88%	2.41%	100.00%
NSW & ACT	Summer	Weekday	12:00:00 PM	5,032.57	1,005.71	1,088.09	586.05	68.81	1,866.95	295.67	121.28	5,032.57	19.98%	21.62%	11.65%	1.37%	37.10%	5.88%	2.41%	100.00%
NSW & ACT	Summer	Weekday	1:00:00 PM	5,020.19	1,022.42	1,079.55	580.59	68.14	1,856.09	292.71	120.69	5,020.19	20.37%	21.50%	11.57%	1.36%	36.97%	5.83%	2.40%	100.00%
NSW & ACT	Summer	Weekday	2:00:00 PM	4,937.98	1,006.38	1,056.25	574.20	67.05	1,826.87	288.51	118.72	4,937.98	20.38%	21.39%	11.63%	1.36%	37.00%	5.84%	2.40%	100.00%
NSW & ACT	Summer	Weekday	3:00:00 PM	4,818.40	997.03	1,025.02	562.52	65.59	1,776.87	275.95	115.42	4,818.40	20.69%	21.27%	11.67%	1.36%	36.88%	5.73%	2.40%	100.00%
NSW & ACT	Summer	Weekday	4:00:00 PM	4,588.80	978.33	957.23	533.50	64.77	1,683.27	260.54	111.15	4,588.80	21.32%	20.86%	11.63%	1.41%	36.68%	5.68%	2.42%	100.00%
NSW & ACT	Summer	Weekday	5:00:00 PM	4,209.66	885.49	879.87	494.80	59.64	1,541.13	241.62	107.11	4,209.66	21.03%	20.90%	11.75%	1.42%	36.61%	5.74%	2.54%	100.00%
NSW & ACT	Summer	Weekday	6:00:00 PM	3,992.23	815.17	819.81	494.46	58.35	1,452.44	246.11	105.89	3,992.23	20.42%	20.54%	12.39%	1.46%	36.38%	6.16%	2.65%	100.00%
NSW & ACT	Summer	Weekday	7:00:00 PM	3,942.82	819.84	828.03	498.10	57.93	1,409.05	219.39	110.48	3,942.82	20.79%	21.00%	12.63%	1.47%	35.74%	5.56%	2.80%	100.00%
NSW & ACT	Summer	Weekday	8:00:00 PM	3,772.47	810.65	755.85	484.44	55.39	1,347.82	209.86	108.46	3,772.47	21.49%	20.04%	12.84%	1.47%	35.73%	5.56%	2.88%	100.00%
NSW & ACT	Summer	Weekday	9:00:00 PM	3,563.58	788.85	694.43	470.51	52.50	1,258.13	196.17	103.00	3,563.58	22.14%	19.49%	13.20%	1.47%	35.31%	5.50%	2.89%	100.00%
NSW & ACT	Summer	Weekday	10:00:00 PM	3,402.58	710.42	687.09	460.32	49.69	1,210.88	188.72	95.47	3,402.58	20.88%	20.19%	13.53%	1.46%	35.59%	5.55%	2.81%	100.00%
NSW & ACT	Summer	Weekday	11:00:00 PM	3,273.99	657.19	673.36	446.62	47.26	1,172.55	190.04	86.97	3,273.99	20.07%	20.57%	13.64%	1.44%	35.81%	5.80%	2.66%	100.00%
NSW & ACT	Winter	Weekday	12:00:00 AM	3,103.86	405.42	698.78	511.53	35.02	1,120.43	211.62	121.05	3,103.86	13.06%	22.51%	16.48%	1.13%	36.10%	6.82%	3.90%	100.00%
NSW & ACT	Winter	Weekday	1:00:00 AM	3,054.16	394.63	693.54	502.60	34.22	1,101.99	208.43	118.74	3,054.16	12.92%	22.71%	16.46%	1.12%	36.08%	6.82%	3.89%	100.00%
NSW & ACT	Winter	Weekday	2:00:00 AM	3,017.14	385.90	689.08	497.19	33.51	1,086.41	206.49	118.56	3,017.14	12.79%	22.84%	16.48%	1.11%	36.01%	6.84%	3.93%	100.00%
NSW & ACT	Winter	Weekday	3:00:00 AM	3,024.67	393.72	697.78	497.16	33.68	1,078.60	203.59	120.14	3,024.67	13.02%	23.07%	16.44%	1.11%	35.66%	6.73%	3.97%	100.00%
NSW & ACT	Winter	Weekday	4:00:00 AM	3,102.34	403.91	727.57	513.33	34.69	1,095.00	204.74	123.10	3,102.34	13.02%	23.45%	16.55%	1.12%	35.30%	6.60%	3.97%	100.00%
NSW & ACT	Winter	Weekday	5:00:00 AM	3,345.11	438.38	796.30	557.09	37.89	1,167.48	219.80	128.16	3,345.11	13.11%	23.80%	16.65%	1.13%	34.90%	6.57%	3.83%	100.00%
NSW & ACT	Winter	Weekday	6:00:00 AM	3,798.80	614.03	895.00	600.60	45.31	1,279.90	228.40	135.56	3,798.80	16.16%	23.56%	15.81%	1.19%	33.69%	6.01%	3.57%	100.00%
NSW & ACT	Winter	Weekday	7:00:00 AM	4,206.87	668.71	1,072.34	633.41	51.29	1,387.19	230.79	163.13	4,206.87	15.90%	25.49%	15.06%	1.22%	32.97%	5.49%	3.88%	100.00%
NSW & ACT	Winter	Weekday	8:00:00 AM	4,530.03	660.54	1,145.63	633.85	55.23	1,597.99	268.07	168.71	4,530.03	14.58%	25.29%	13.99%	1.22%	35.28%	5.92%	3.72%	100.00%
NSW & ACT	Winter	Weekday	9:00:00 AM	4,627.29	672.97	1,141.51	646.78	55.35	1,661.68	282.35	166.65	4,627.29	14.54%	24.67%	13.98%	1.20%	35.91%	6.10%	3.60%	100.00%
NSW & ACT	Winter	Weekday	10:00:00 AM	4,606.50	676.49	1,116.87	640.07	54.76	1,667.01	287.16	164.13	4,606.50	14.69%	24.25%	13.89%	1.19%	36.19%	6.23%	3.56%	100.00%
NSW & ACT	Winter	Weekday	11:00:00 AM	4,566.39	671.09	1,103.70	632.35	54.28	1,657.26	285.48	162.23	4,566.39	14.70%	24.17%	13.85%	1.19%	36.29%	6.25%	3.55%	100.00%
NSW & ACT	Winter	Weekday	12:00:00 PM	4,509.04	666.99	1,085.21	625.41	53.77	1,637.61	279.32	160.73	4,509.04	14.79%	24.07%	13.87%	1.19%	36.32%	6.19%	3.56%	100.00%
NSW & ACT	Winter	Weekday	1:00:00 PM	4,475.23	666.62	1,069.70	620.21	53.21	1,629.70	276.35	159.44	4,475.23	14.90%	23.90%	13.86%	1.19%	36.42%	6.18%	3.56%	100.00%
NSW & ACT	Winter	Weekday	2:00:00 PM	4,413.96	653.50	1,045.40	615.88	52.26	1,614.54	275.11	157.25	4,413.96	14.81%	23.68%	13.95%	1.18%	36.58%	6.23%	3.56%	100.00%
NSW & ACT	Winter	Weekday	3:00:00 PM	4,333.12	631.46	1,024.31	608.07	51.61	1,591.25	271.48	154.94	4,333.12	14.57%	23.64%	14.03%	1.19%	36.72%	6.27%	3.58%	100.00%
NSW & ACT	Winter	Weekday	4:00:00 PM	4,258.30	632.89	996.74	601.93	52.30	1,556.47	264.67	153.29	4,258.30	14.86%	23.41%	14.14%	1.23%	36.55%	6.22%	3.60%	100.00%
NSW & ACT	Winter	Weekday	5:00:00 PM	4,246.22	633.14	995.35	604.55	53.46	1,539.37	261.02	159.32	4,246.22	14.91%	23.44%	14.24%	1.26%	36.25%	6.15%	3.75%	100.00%
NSW & ACT	Winter	Weekday	6:00:00 PM	4,034.43	606.01	931.44	581.78	52.80	1,453.81	254.27	154.32	4,034.43	15.02%	23.09%	14.42%	1.31%	36.04%	6.30%	3.83%	100.00%
NSW & ACT	Winter	Weekday	7:00:00 PM	3,860.55	594.53	913.09	576.43	50.86	1,351.17	219.80	154.69	3,860.55	15.40%	23.65%	14.93%	1.32%	35.00%	5.69%	4.01%	100.00%
NSW & ACT	Winter	Weekday	8:00:00 PM	3,733.98	633.49	829.08	577.90	51.48	1,286.32	194.25	161.46	3,733.98	16.97%	22.20%	15.48%	1.38%	34.45%	5.20%	4.32%	100.00%
NSW & ACT	Winter	Weekday	9:00:00 PM	3,564.71	605.38	760.37	558.00	46.26	1,241.79	207.91	144.99	3,564.71	16.98%	21.33%	15.65%	1.30%	34.84%	5.83%	4.07%	100.00%
NSW & ACT	Winter	Weekday	10:00:00 PM	3,395.03	509.93	748.30	540.02	42.10	1,210.06	209.67	134.95	3,395.03	15.02%	22.04%	15.91%	1.24%	35.64%	6.18%	3.97%	100.00%
NSW & ACT	Winter	Weekday	11:00:00 PM	3,246.19	419.41	729.76	533.33	37.59	1,176.23	226.64	123.23	3,246.19	12.92%	22.48%	16.43%	1.16%	36.23%	6.98%	3.80%	100.00%
NSW & ACT	Shoulder	Weekday	12:00:00 AM	3,101.54	513.18	656.39	491.29	36.45	1,093.17	198.55	112.50	3,101.54	16.55%	21.16%	15.84%	1.18%	35.25%	6.40%	3.63%	100.00%
NSW & ACT	Shoulder	Weekday	1:00:00 AM	3,053.74	460.63	655.17	485.74	35.60	1,098.24	207.58	110.77	3,053.74	15.08%	21.45%	15.91%	1.17%	35.96%	6.80%	3.63%	100.00%
NSW & ACT	Shoulder	Weekday	2:00:00 AM	3,029.39	454.98	650.44	480.73	34.99	1,088.82	208.23	111.20	3,029.39	15.02%	21.47%	15.87%	1.16%	35.94%	6.87%	3.67%	100.00%
NSW & ACT	Shoulder	Weekday	3:00:00 AM	3,057.49	460.53	671.61	484.11	35.57	1,087.49	204.74	113.45	3,057.49	15.06%	21.97%	15.83%	1.16%	35.57%	6.70%	3.71%	100.00%
NSW & ACT	Shoulder	Weekday	4:00:00 AM	3,189.76	475.19	703.01	505.01	37.24	1,134.91	216.37	118.03	3,189.76	14.90%	22.04%	15.83%	1.17%	35.58%	6.78%	3.70%	100.00%
NSW & ACT	Shoulder	Weekday	5:00:00 AM	3,464.70	557.37	769.94	539.91	40.63	1,201.30	231.66	123.90	3,464.70	16.09%	22.22%	15.58%	1.17%	34.67%	6.69%	3.58%	100.00%
NSW & ACT	Shoulder	Weekday	6:00:00 AM	3,837.26	709.96	833.20	579.29	46.88	1,301.28	238.99	127.65	3,837.26	18.50%	21.71%	15.10%	1.22%	33.91%	6.23%	3.33%	100.00%
NSW & ACT	Shoulder	Weekday	7:00:00 AM	4,202.05	780.65	966.61	599.57	52.09	1,413.10	241.88	148.16	4,202.05	18.58%	23.00%	14.27%	1.24%	33.63%	5.76%	3.53%	100.00%
NSW & ACT	Shoulder	Weekday	8:00:00 AM	4,465.36	781.24	1,008.50	588.12	56.38	1,604.98	276.03	150.11	4,465.36	17.50%	22.58%	13.17%	1.26%	35.94%	6.18%	3.36%	100.00%
NSW & ACT	Shoulder	Weekday	9:00:00 AM	4,600.50	806.80	1,027.85	603.77	56.45	1,670.66	285.22	149.75	4,600.50	17.54%	22.34%	13.12%	1.23%	36.31%	6.20%	3.26%	100.00%
NSW & ACT	Shoulder	Weekday	10:00:00 AM	4,673.21	824.77	1,042.56	609.56	56.60	1,699.63	289.16	150.92	4,673.21	17.65%	22.31%	13.04%	1.21%	36.37%	6.19%	3.23%	100.00%
NSW & ACT	Shoulder	Weekday	11:00:00 AM	4,709.50	837.51	1,050.26	613.68	56.91	1,709.40	289.77	151.97	4,709.50	17.78%	22.30%	13.03%	1.21%	36.30%	6.15%	3.23%	100.00%
NSW & ACT	Shoulder	Weekday	12:00:00 PM	4,720.93	844.54	1,052.64	613.57	57.40	1,712.10	288.18	152.50	4,720.93	17.89%	22.30%	13.00%	1.22%	36.27%	6.10%	3.23%	100.00%
NSW & ACT	Shoulder	Weekday	1:00:00 PM	4,725.29	857.22	1,045.86	611.22	57.46	1,714.83	286.32	152.38	4,725.29	18.14%	22.13%	12.94%	1.22%	36.29%	6.06%	3.22%	100.00%
NSW & ACT	Shoulder	Weekday	2:00:00 PM	4,664.33	847.84	1,020.92	607.63	56.53	1,697.19	283.85	150.37	4,664.33	18.18%	21.89%	13.03%	1.21%	36.39%	6.09%	3.22%	100.00%
NSW & ACT	Shoulder	Weekday	3:00:00 PM	4,560.53	829.55	992.87	600.46	55.39	1,657.71	276.27	148.28	4,560.53	18.19%	21.77%	13.17%	1.21%	36.35%	6.06%	3.25%	100.00%
NSW & ACT	Shoulder	Weekday	4:00:00 PM	4,399.84	804.82	950.45	585.44	55.52	1,592.31	265.98	145.32	4,399.84	18.29%	21.60%	13.31%	1.26%	36.19%	6.05%	3.30%	100.00%
NSW & ACT	Shoulder	Weekday	5:00:00 PM	4,171.96	761.41	904.39	559.85	53.79	1,491.74	255.16	145.63	4,171.96	18.25%	21.68%	13.42%	1.29%	35.76%	6.12%	3.49%	100.00%
NSW & ACT	Shoulder	Weekday	6:00:00 PM	4,009.60	734.60	845.92	550.90	53.91	1,429.30	252.35	142.62	4,009.60	18.32%	21.10%	13.74%	1.34%	35.65%	6.29%	3.56%	100.00%
NSW & ACT	Shoulder	Weekday	7:00:00 PM	3,871.53	708.66	842.52	558.07	52.46	1,340.70	225.36	143.76	3,871.53	18.30%	21.76%	14.41%	1.36%	34.63%	5.82%	3.71%	100.00%
NSW & ACT	Shoulder	Weekday	8:00:00 PM	3,706.13	726.82	768.22	554.82	51.39	1,254.64	198.51	151.72	3,706.13	19.61%	20.73%	14.97%	1.39%	33.85%	5.36%	4.09%	100.00%
NSW & ACT	Shoulder	Weekday	9:00:00 PM	3,521.36	699.04	730.60	530.40	47.51	1,182.02	196.65	135.14	3,521.36	19.85%	20.75%	15.06%	1.35%	33.57%	5.58%	3.84%	100.00%
NSW & ACT	Shoulder	Weekday	10:00:00 PM	3,355.35	630.34	717.61	506.69	43.90	1,138.18	193.26	125.36	3,355.35	18.79%	21.39%	15.10%	1.31%	33.92%	5.76%	3.74%	100.00%
NSW & ACT	Shoulder	Weekday	11:00:00 PM	3,224.35	582.25	692.03	492.36	39.50	1,110.55	193.09	114.56	3,224.35	18.06%	21.46%	15.27%	1.23%	34.44%	5.99%	3.55%	100.00%

Appendix A.II Graphs

A summer weekday and winter weekday graph sample for the central estimates for NSW & ACT is as follows. Note that graphs are provided for each season (summer, shoulder & winter) and each weekday type (weekday & weekend)