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Solar Optimisation Upgrades in the Victorian Commercial and Industrial Sector

PREPARED FOR:
Department of Environment, Land, Water & Planning, Victoria

About the authors

The Institute for Sustainable Futures (ISF) is an interdisciplinary research and consulting organisation at the University of Technology Sydney. ISF has been setting global benchmarks since 1997 in helping governments, organisations, businesses and communities achieve change towards sustainable futures. We utilise a unique combination of skills and perspectives to offer long term sustainable solutions that protect and enhance the environment, human wellbeing and social equity.

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Citation

Please cite as: J.Wyndham, C.Briggs, D.Alexander, K.Maras, T.Morris and C.Dunstan (2019), *Solar Optimisation Upgrades in the Victorian Commercial and Industrial Sector.*

Acknowledgements

We would like to thank Verena Pichler, Emma Jacobs and Ben Rothstein (DELWP) for their engaged involvement and input in the course of the study. The study also benefitted from the insight of a range of demand management specialists currently growing the sector.

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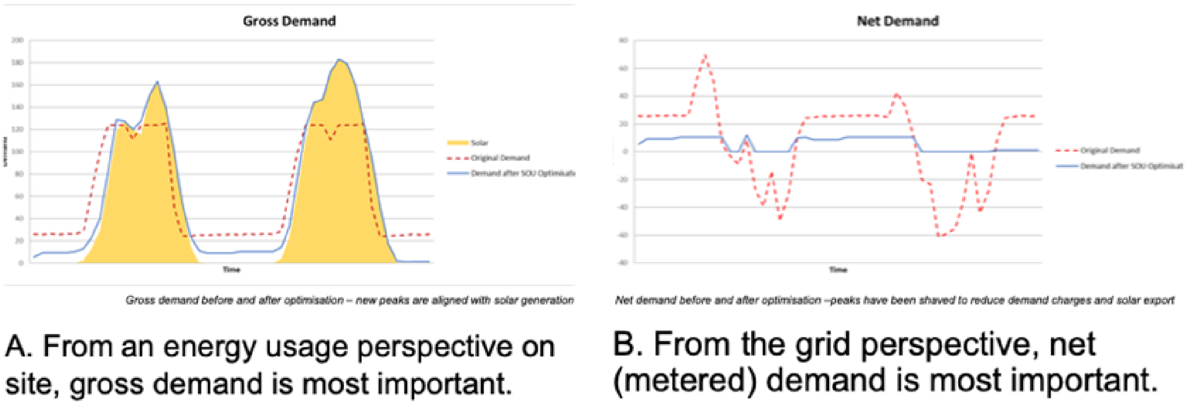
Summary

This is the first evaluation of the potential for ‘Solar Optimisation Upgrades’ (SOUs) to reduce grid electricity demand across the Victorian Commercial and Industrial (C&I) sector. SOUs refer to the use of demand management and energy storage to increase on-site utilisation of solar photovoltaics (PV) in order to:

- maximise self-consumption and avoid higher cost grid energy;
- reduce business energy bills by reducing network demand charges that typically account for a large proportion of C&I electricity bills;
- reduce network costs, including reduced infrastructure investment by lowering both demand and export peaks; and
- maximise renewables integration and output, with minimal curtailment, to reduce greenhouse emissions.



Load flexibility from the user (a) and grid (b) perspectives. The original energy usage curve is shifted onsite to match the solar generation curve to minimise export to the grid, reducing the business’ bills, which also creates a flatter, more manageable load for the electricity grid to manage. A win-win situation!

The Institute for Sustainable Futures (ISF) was commissioned by the Victorian Department of Environment, Land, Water and Planning (the Department) to support an evaluation of the inclusion of SOUs into the Victorian Energy Upgrade (VEU) program. The purpose of the study was to provide the Department with technical and cost data on SOUs and to support the development of a Regulatory Impact Statement on the development of 2021 to 2025 targets for the VEU program.

Six types of SOUs were examined:

1. Upgrades of building or energy management systems (BMS/EMS) to optimise:
   a) Heating, Ventilation and Air-Conditioning (HVAC)
   b) refrigeration, or
   c) cold-water storage;
2. Capacity upgrades to:
   a) refrigeration, and
   b) cold-water storage capacity; and
3. Battery storage.

Method

ISF examined the load shifting potential for each SOU within six C&I sub-sectors:

- retail, offices and hotels for the commercial sector;
- a comparison of 24/7 operations and weekday/6-day operations for the industrial sector; and
- a specific focus on the food value-chain, which encompassed both commercial and industrial scale operations.

Two different PV sizing strategies were tested: a fitted system which limits ‘solar spill’ to 5 per cent; and an oversized system with solar spill of 20 per cent. Technology learning rates were included for forward estimates on SOU costs.

Two uptake scenarios were estimated based on the relationship with payback periods.

1. The first “mainstreamed” scenario is based on the uptake curve used by the VEU program for PV.
2. A second “BAU” scenario was developed (following industry feedback) where SOU uptake is slower than for PV to reflect the less developed market for SOUs.

The gap between these two scenarios represents the opportunity for policy-makers if they can develop the market for SOUs to the point where they are considered equivalent to the purchase of the PV system itself.

The modelling assumptions, including SOU system sizing, are presented in section 2.3.

Results

The findings for potential reduction in grid electricity consumption and payback periods for SOUs are outlined below. The results from solar PV systems above and below 100kW are separated given the different incentives for generation under 100kW (Small Technology Certificates) and over 100kW (Large Generation Certificates). These should be considered as indicative results as there are significant limitations on the availability of data, which are outlined in the following section.

Potential reduction in grid electricity consumption

The study found significant potential for SOUs to reduce grid electricity consumption. The headline results are summarised in Table 1 for systems under and over 100kW under the different scenarios and timeframes.

For 2021, the scenarios range from 1.4 gigawatt-hours (GWh) to 7.7 GWh. For 2025, the scenarios range from 6.9 GWh to 16.4 GWh.

Table 1. Grid electricity savings (MWh/year) from SOUs

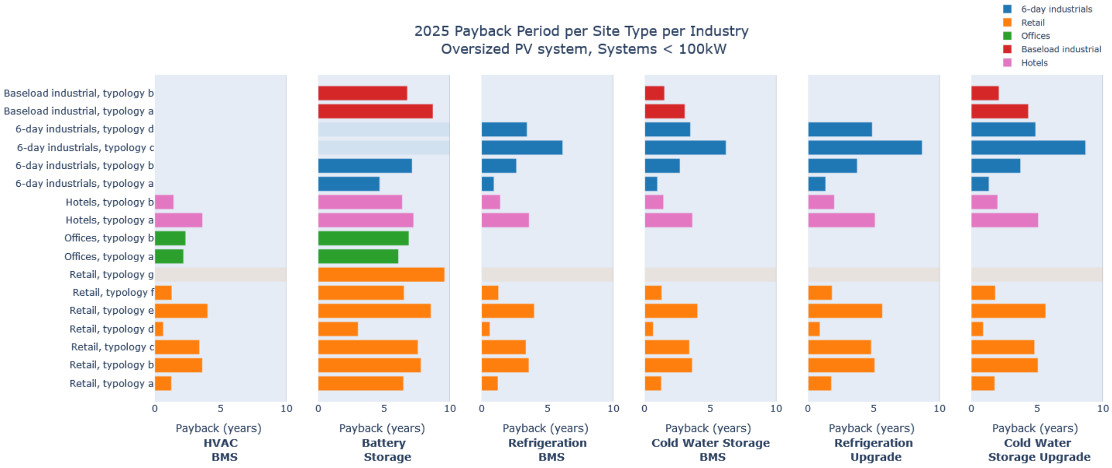
		2021			2025		
	Uptake Scenario	***Fitted***	***Oversized***	***Total***	***Fitted***	***Oversized***	***Total***
PV Systems < 100 kW	SOU Mainstreamed	7165.1	1335.1	8500.1	7993.9	5774.3	13768.2
	BAU	1853.5	426.0	2279.5	3511.0	2884.5	7903.0
PV Systems > 100 kW	SOU Mainstreamed	496	407	1,031	1,136	1,471	2,607
	BAU	2031	966	2,997	3,375	3,085	6,460
Total	SOU Mainstreamed	7661.1	1742.1	9531.1	9129.9	7245.3	16375.2
	BAU	3884.5	1392	5276.5	6886	5969.5	14363

Prospective payback periods for SOUs[1]

The results for the payback periods on SOUs across different sectors and sites which underpin the uptake scenarios are represented below. Battery storage had the least potential for all solar sizing with long paybacks across all scenarios.

For solar PV systems <100kW, the key findings are:

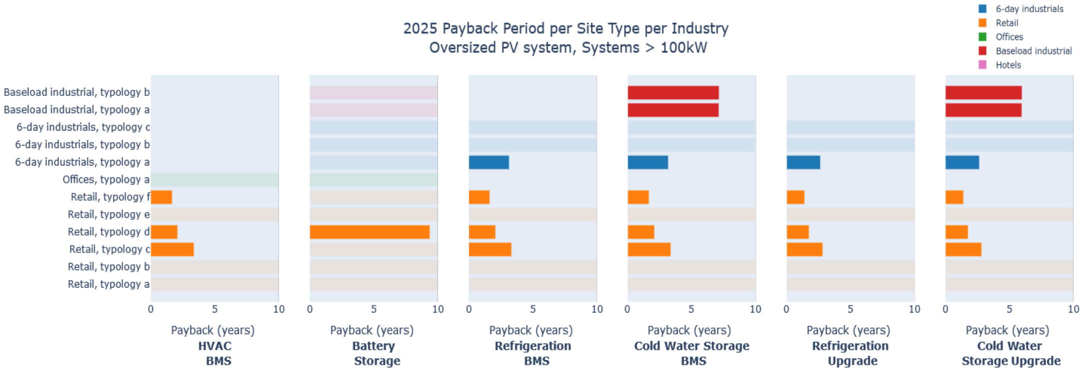
- For many of the cases, the payback periods are less than 3-years. In particular, BMS upgrades for refrigeration, HVAC and cold-water storage;
- There are also quick (<5 years) payback results for refrigeration and cold water storage upgrades; and
- Based on their load profile, offices are best suited to HVAC optimisation.



2025 SOUs , Oversized solar systems <100kW

For solar PV systems >100kW, the key findings are:

- Only cold water and refrigeration upgrades in 6-day industrials and retail have paybacks for less than 5 years for fitted systems in 2020;
- For over-sized PV systems, paybacks for BMS upgrades for HVAC and cold water storage fall to under 6-years several 2020 cases; and
- By 2025, these best performing options have paybacks of around 3-years or lower and a significant number of other SOUs have paybacks under 5-years.



2025 PV uptake rate scenario, oversized solar systems >100kW

[1] Note that payback periods for SOUs are not inclusive of payback periods for solar PV systems.

Limitations

These results should be viewed as a preliminary estimate and there are some important limitations that should be noted:

- Firstly, whilst there is excellent data on the number of solar PV installations by system size for the state of Victoria, there is little data on the distribution of solar PV installations across C&I sectors. This analysis was therefore limited to an assumption of uniformity across and within sectors;
- Secondly, some SOU options were not included, which may understate the market potential. The team extensively reviewed the literature and targeted those SOUs that were most prospective, scoping out options that were either: likely to engage with traditional industrial demand response schemes or would be unlikely to install a large enough solar PV system to soak up “spill” (e.g. data centres). The two key SOUs that are recommended for future investigation are HVAC in schools and water pumping in agriculture;
- Thirdly, gas consumption was not included which would also be reduced by SOUs, such as gas hot water systems, and improve the financial returns and environmental impact;
- Fourthly, wholesale and energy market services revenue were not included in the financial analysis: in the period to 2025, the number of wholesale market customers and ‘value-stacking’ to respond to price signals or provide network services is likely to increase and improve the business case for SOUs.

The report includes recommendations to address the limitations of the study and complementary measures for implementing the program and building a market for SOUs.

Glossary

Abbreviation	Description
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
ARENA	Australian Renewable Energy Agency
BAU	Business As Usual
BMS	Building Management System
C&I	Commercial & Industrial
Department	Victorian Department of Energy, Land, Water and Planning
EMS	Energy Management System
GW/GWh	Gigawatt / Gigawatt Hours
HVAC	Heating, Ventilation and Air-Conditioning
ISF	Institute for Sustainable Futures
kW/kWh	Kilowatt / Kilowatt Hours
LGC	Large Generation Certificate
MW/MWh	Megawatt /Megawatt Hours
NREL	National Renewable Energy Laboratory
O&M	Operations & Maintenance
PV	Solar Photovoltaics
REALM	Renewable Energy and Load Management
SOU	Solar Optimisation Upgrade
SRES	Small-scale Renewable Energy Scheme
VEU	Victorian Energy Upgrade Program

Contents

1 Introduction

1.1 The opportunity for solar optimisation upgrades

The emergence of lower-cost demand management and energy storage technologies is creating opportunities for commercial and industrial (C&I) businesses on-site to reduce grid electricity demand by optimising the use of on-site solar photovoltaics (PV). There are two fundamental ways C&I business can undertake these 'solar optimisation upgrades' (SOUs):

1. Load management to shift the timing of energy demand to consume more output from solar power in daylight hours; and
2. Energy storage to retain surplus output from solar panels for use to power loads at other times. In addition to battery storage, many C&I businesses have other energy storage options including thermal storage (cold and hot water tanks can be used as stores of energy by using solar power to drive the temperature up or down ahead of cooling or heating needs) and material processing or stockpiling.

In a pre-feasibility study for the Australian Renewable Energy Agency (ARENA), the Institute for Sustainable Futures (ISF) identified two ways in which SOUs can reduce grid electricity demand:

1. Optimising the use of existing on-site solar installations by reducing the volume of surplus electricity that is exported to the grid or 'spilt' (i.e. curtailed by grid export limits or not used by the site); and
2. Increasing the capacity of solar energy that can be installed cost-effectively on-site by expanding the loads that can be powered by solar energy.

Demand-side flexibility for SOUs will be critical as more C&I businesses install solar PV on-site. For instance, in Victoria, there is already almost 1,500 megawatts (MW) of installed solar PV – of which approximately 275 MW is in the C&I sector – and 2018 was a record-setting year for new installations. However, distribution networks service providers (DNSPs) are already applying export limits in order to manage the impacts of increased distributed energy resources (DERs) on the thermal, voltage and frequency limits of the low voltage network. Demand-side flexibility is essential to both maximise the value of solar PV to C&I businesses and facilitate its seamless integration with the electricity network and market.

However, load flexibility is not commonly leveraged by Australian consumers, including C&I businesses. There is agreement amongst a wide range of Australia's energy market institutions that there is significant untapped potential for low-cost load flexibility to improve the efficiency, security and reliability of our energy system (see ARENA/AEMO 2018; AEMC 2018; Commonwealth of Australia 2017). As the Australian Energy Market Commission (AEMC) has observed, there is a 'lack of transparency' about the size, cost and availability of demand-side flexibility.

1.2 Scope of this study

ISF was commissioned by the Victorian Department of Environment, Land, Water and Planning (the Department) to support an evaluation of the inclusion of SOUs into the Victorian Energy Upgrade (VEU) program. The purpose of the study was to provide the Department with technical and cost data on SOUs and to support the development of a Regulatory Impact Statement on the development of 2021 and 2025 targets for the VEU program to be released for public consultation. Further detail on the VEU program is provided in Appendix One.

The scope of the study included an evaluation of the technical capacity and cost-effectiveness of six types of SOUs to shift load away from higher demand or higher price times.

Table 2. Solar Optimisation Upgrades (SOUs)

Solar Optimisation Upgrade		Description
1	BMS/EMS for HVAC optimisation (pre-cooling)	Use of automated pre-cooling or tuning of heating, ventilation and air conditioning (HVAC) systems to reduce consumption
2	BMS/EMS for refrigeration optimisation	Use of thermal inertia in refrigeration systems to store excess generation from solar PV
3	Capacity upgrade for refrigeration	
4	BMS/EMS for cold water storage	Use of cold water storage system to store excess generation from solar PV
5	Capacity upgrade for cold water storage	
6	Battery storage	Use of battery to store excess generation from solar PV to use outside daylight hours

ISF was commissioned by the Department to evaluate the scope for use of SOUs in six C&I sub-sectors (Table).

Table 3. C&I, Sectoral Coverage

Sub-sector		Examples
Commercial		
1	Retail	Stand-alone shop, shopping centres, entertainment
2	Offices	Public buildings, commercial offices
3	Hotels	Hotels, motels, hostels, resorts
Industrial		
4	Weekday/6-day operation	Warehouse, small-scale manufacturing
5	24/7 operation	Heavy manufacturing, hospitals
Value chain (commercial & industrial)		
6	Food value chain	Supermarket, food processing, cold-storage facility

Some of the SOUs are more or less common in these sectors and have therefore been assumed to be available or unavailable:

Table 4. Availability of SOUs by C&I Sector

	HVAC OPTIMISATION	REFRIGERATION	COLD WATER STORAGE	BATTERY
Commercial				
Retail	Y	Y	Y	Y
Offices	Y	N	N	Y
Hotels	Y	Y	Y	Y
Industrial				
Weekday / 6-day	N*	Y	Y	Y
24/7 operation	N*	N*	Y	Y
Value chain (commercial and industrial)				
Food value chain	Y	Y	Y	Y

* HVAC optimisation was excluded for weekday and 24/7 industrial operations since the scale of the load is expected to be significantly lower compared to the other potential loads. Note industrial-scale refrigeration for 24/7 cold stores is captured under the food value chain (not the generic 24/7 industrial operations category).

For each SOU, ISF provided technical specifications, cost estimates and grid electricity savings estimates for 2021-2025. This report summarises the methodology, key results and implications of the study.

2 Methodology

The overarching project design and key phases are outlined in Figure 1 below.

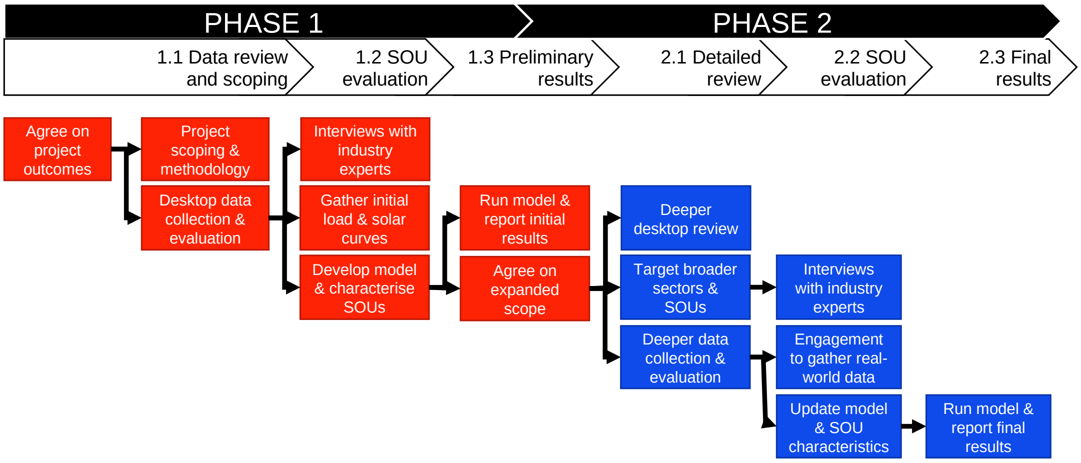


Figure 1. Phases of the Solar Optimisation Upgrades study

2.1 Modelling approach

The basic approach in the modelling is summarised in Figure 2.

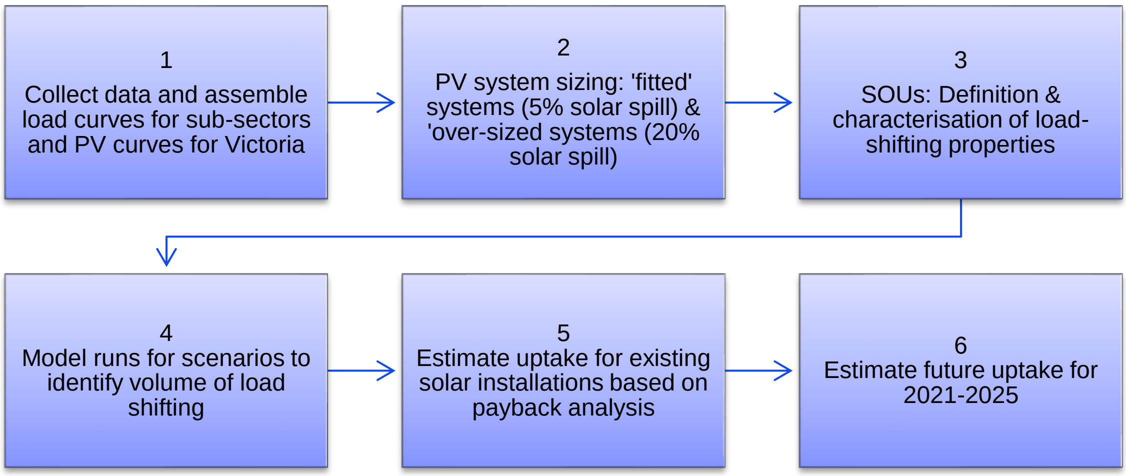


Figure 2. Solar Optimisation Upgrades, Modelling Approach

Load curves from a range of C&I sectors and PV output curves, ISF developed an Excel – VBA time-series model to analyse SOU potential, that considers the following parameters at the site level:

- hourly total load profile;
- hourly solar PV generation, usage rate, and export;

- time-of-use electricity tariffs;
- grid demand charges; and
- characteristics of SOUs.

SOUs are modelled to achieve the greatest possible utilisation of solar PV such that export to the grid is minimised and net demand peaks are reduced. To do this, the model uses load shifting, which simply changes the time-of-use of electricity consumption within a given set of constraints. The model uses two classes of load shifting (storage and pre-cool), each of which requires a unique optimisation algorithm to account for characteristics of operation.

2.1.1 Solar utilisation and peak shaving strategy

Both the storage and precool algorithm classes attempt to maximise solar utilisation and minimise demand peaks. These strategies were employed for the following reasons:

- maximising self-consumption to avoid the higher costs of grid energy;
- saving money by reducing network demand charges that typically account for a large proportion of C&I electricity bills;
- there are grid benefits to lowering both demand and export peaks, such as reduced infrastructure investment; and
- maximising renewables integration, with minimal curtailment, to reduce CO2 emissions.

Here it is important to distinguish between gross demand (the total demand on site) and net demand (gross demand minus solar generation). From an energy usage perspective on site, gross demand should be considered. From the perspective of the grid, net demand is most important as it represents the demand and export that are metered at the site – those to which tariffs are applied. Therefore, peak shaving is applied to reduce peaks in *net demand* – which may in fact increase peaks in the gross demand curve. However, under the solar optimisation paradigm, these gross demand peaks coincide with solar PV generation to maximise self-consumption of solar PV generation.

Figure and Figure show an illustrative example of gross and net demand for the same 48 hours period with a near ideal case of peak shaving using the battery storage algorithm. We can see in the case of gross demand that the optimisation has increased demand during solar hours to ensure total self-consumption of solar PV generation, while reducing demand outside these hours through battery discharge. The net demand shows that the demand and export peaks have been successfully shaved leaving a net profile that is flatter and fits in a narrower range.

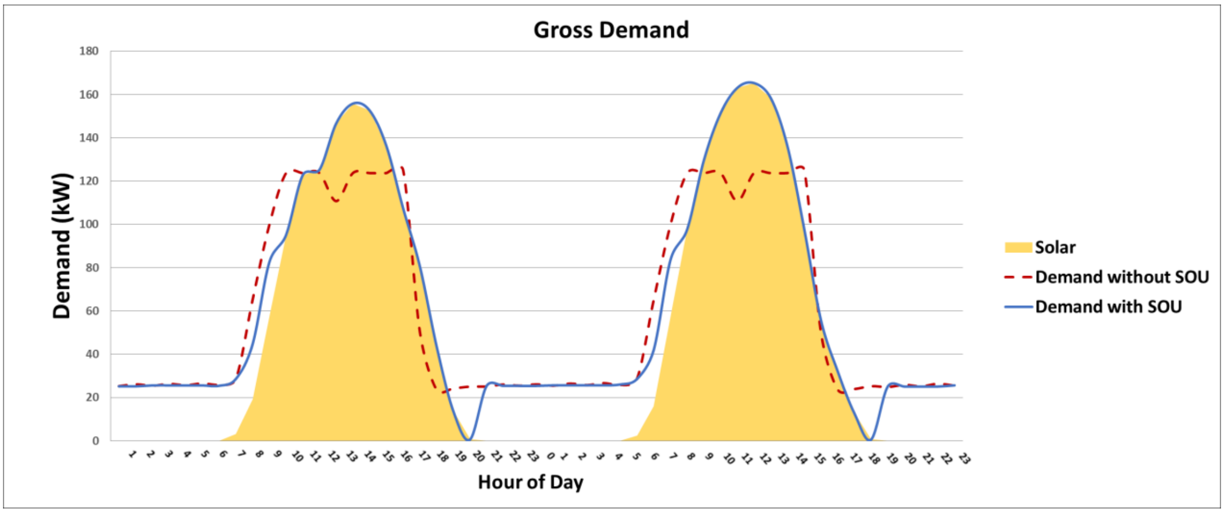


Figure 3 Illustrative example: Gross demand before and after battery storage peak shaving optimisation – new peaks are aligned with solar generation

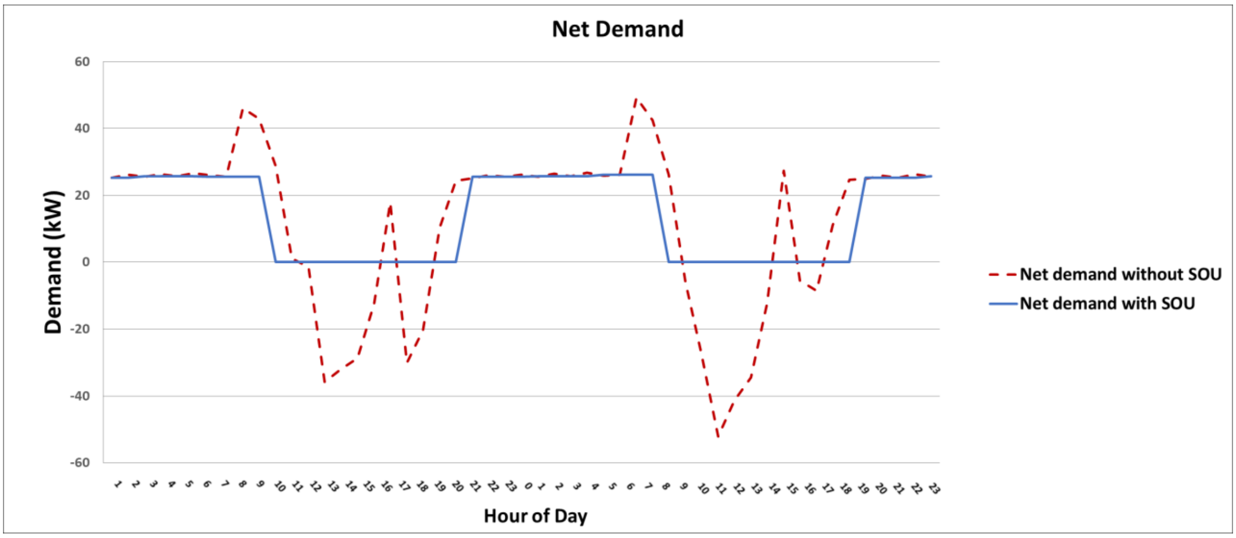


Figure 4 Illustrative example: Net demand before and after battery storage peak shaving optimisation –peaks have been shaved to reduce demand charges and solar export

The scatter plots in Figure show a year's worth of hourly net demand data for the example above – before and after optimisation. The intensity of colour represents the distribution of hourly demand over the year. That is, at a given hour of the day, demand values with greater colour intensity represent a higher frequency of that demand value at that hour for all days over the year. The scatter plots show that while demand peaks were successfully shaved, and the frequency of solar export was reduced, there are still times when solar is being underutilised. In this case, weekend days with little demand were responsible for this underutilisation.

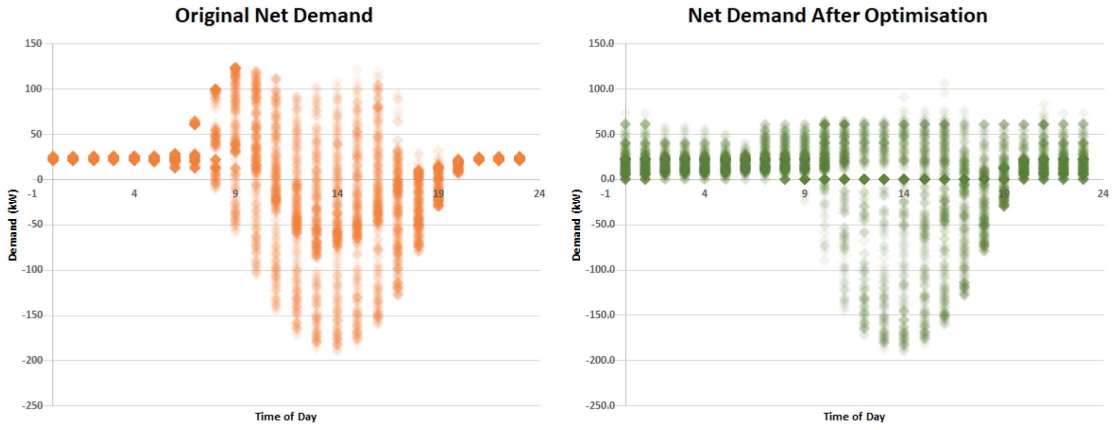


Figure 5 Frequency of demand at day hour during a full year

2.1.2 Solar Optimisation Algorithms

While both classes of load shifting in the model target peak shaving and solar utilisation, differences in their characteristics mean that different optimisation algorithms were required. The assumption in all cases is that load and solar insolation forecasting is relatively accurate up to 3 days ahead.

Battery Storage

The battery storage algorithm considers the following characteristics when attempting to achieve an optimal outcome:

- Storage capacity (kWh)
- Charge/discharge rates (kW)
- State of charge (% of storage capacity)
- Quantum of demand peaks in forecast

The principal challenge with battery storage optimisation and a peak shaving strategy is balancing the available energy at a given time with the opportunity to peak shave in the near future. A strategy which allows the battery to discharge too soon may result in a lack of available energy to address a given peak. Since demand charges take the greatest peak in a period, it is more cost effective to shave all peaks to the same level, rather than shave some peaks and not others. An optimisation that does not achieve uniform peak shaving is therefore unsuccessful in fulfilling its purpose

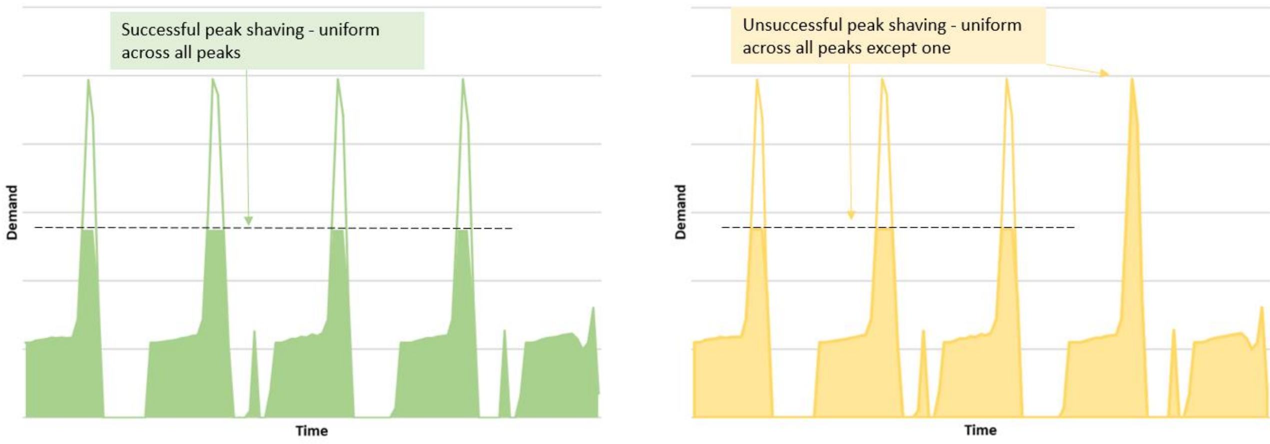


Figure 6 Successful and unsuccessful peak shaving

Therefore, the model uses demand and solar PV forecasts at each hour to determine a discharge limit, which prevents the battery from discharging too much too soon, while maximising peak shaving across all peaks within the forecast period.

Sizing batteries to achieve an optimum financial return is complex and relies on a detailed assessment of site specific characteristics. This work assesses the potential benefits of batteries across numerous site types with varying characteristics; the development of an algorithm that could provide comprehensive, high performance optimisation across all site types is out of scope. Battery sizing in the model therefore applies a simplifying heuristic algorithm. The heuristic algorithm first considers the storage capacity required for perfect daily peak shaving and then reduces this capacity by a factor of 6 to avoid the economic consequences of oversizing. This figure is an empirically derived factor that was shown through trial and error to consistently reduce payback across a range of site types. The charge and discharge power capacities are subsequently derived as the battery energy capacity divided by 2.7. This ratio is based on typical commercial battery ratios of power capacity versus energy capacity.

Battery charging is designed to prioritise utilisation of solar, and secondarily to charge if time-of-use tariffs are less than the levelised cost of storage. The discharge limit is used as a charge limit to avoid the battery causing a peak that is higher than the uniform peak shaving limit.

Pre-cool

The pre-cool algorithm focusses on shifting load where there is the opportunity to pre-emptively overcool such that future cooling is not required due to thermal lag. This is applied to both refrigeration and HVAC.

The pre-cool algorithm considers the following characteristics when attempting to achieve an optimal outcome:

- Thermal efficiency – loss of coolth as a function of shift time
- Precool capacity – cooling load as a proportion of demand
- Acceptable overcooling limits (implicitly assumed via empirical data)
- Time of shiftable peaks relative to solar PV generation (shift time)
- Site specific shift capacity, derived from subload data where possible, or assumed as percentage of total site load

The principal constraint in the pre-cool algorithm is thermal efficiency. This efficiency is an exponential decay function of shift time which represents the rate of loss of coolth (i.e. gain of warmth) on site according to Newton's law of cooling. The decay function was designed around a simplified, empirically derived model, since detailed thermal modelling is out of scope. The exponential nature of the decay function means that efficiency losses are significantly affected by shift time. Therefore, the model prioritises the minimisation of shift time when attempting to utilise solar PV generation by increasing cooling during the latest possible solar hour before a peak.

Figure shows a successful precool event where an afternoon peak has been shifted into the solar generation period resulting in a net zero demand. Note that due to efficiency losses, the total energy used on site is greater than the original demand, but more solar PV energy and less grid energy is used. Also note that the solar PV generation closest to the peak has been preferenced to minimise efficiency losses.

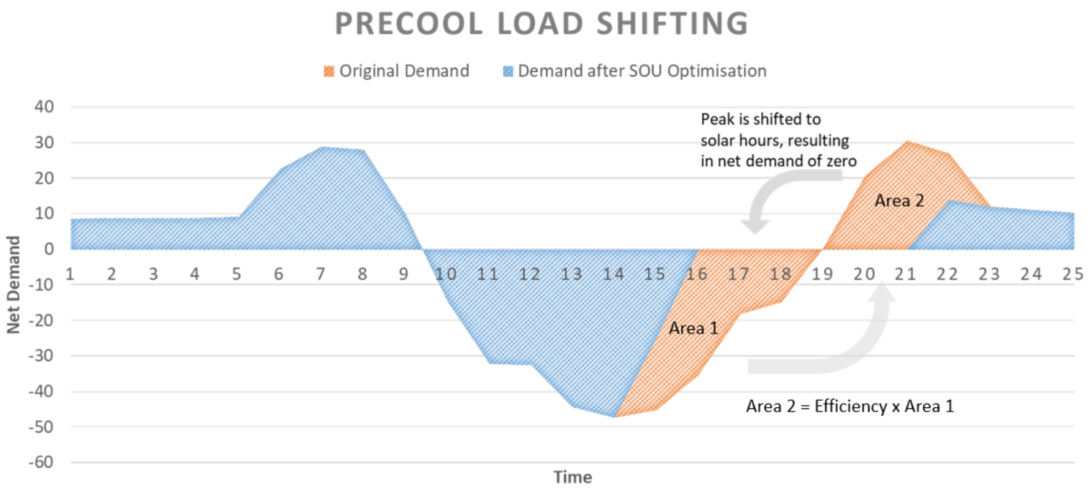


Figure 7 Result of a successful precool optimisation event

Note that morning peaks cannot be shaved with a solar targeted precool strategy such as this. However, an early morning pre-cool strategy which takes advantage of off-peak tariffs may be cost effective if efficiency losses do not negate the cost benefits of peak shaving.

2.1.3 Estimating the Uptake of SOUs

The number of SOU installations that are taken up are influenced by two factors – the 'addressable market' of sites and the uptake by these sites of SOUs which is linked to the payback rate.

Addressable Market – Number of SOU sites

The "addressable market" is an estimation of the number of C&I sites in Victoria that could potentially install an individual SOU and reflects an upper bound on the SOU uptake. This upper bound is quantified by the number of PV systems in Victoria on C&I sites – sourced from the Australian PV Institute whose underlying data draws on the Clean Energy Regulator data (January 2019).

The number of systems is allocated into the six different C&I sub-sectors based on a classification of ANZSIC industry categories. For example, manufacturing is classified as baseload industrial, public administration and safety is classified as 'office' etc. Subsequently, the proportion of sites for each of the six sub-sectors is then determined by ABS data on the overall number of business sites within each of the ANZSIC industry categories.

Table 5. ANZSIC Industry Categories and Business Numbers

ANZSIC	Count of Businesses	Count with Multiple Premises	Sector Category
Accommodation and Food Services	30	11	Retail
Administrative and Support Services	38	9	Offices
Agriculture, Forestry and Fishing	62	4	Agriculture
Arts and Recreation Services	24	19	Offices
Construction	38	31	not applicable
Education and Training	40	1	Offices
Electricity, Gas, Water and Waste Services	148	21	not applicable
Financial and Insurance Services	5	18	Offices
Health care and Social Assistance	96	23	Offices
Information Media and Telecommunications	16	19	Offices
Manufacturing	293	40	Baseload industrial
Mining	17	6	not applicable
Other Services	3	5	not applicable
Professional, Scientific and Technical Services	31	8	Offices
Public Administration and Safety	8	5	Offices
Rental, Hiring and Real Estate Services	79	34	Offices
Retail Trade	40	48	Retail
Transport, Postal and Warehousing	125	23	6-day industrials
Hotels, etc	851	0	Hotels
Wholesale Trade	70	16	6-day industrials

Translating financial evaluation to SOU uptake: the BAU and PV Uptake Rate Case

DELWP provided uptake curves for PV used for their large solar payback modelling. The uptake curves estimate the additional capacity of PV (MW/y) as payback durations of PV system years decreases. Each sub-sector has a unique uptake curve. Uptake is capped at 90% to account for the proportion of customers who are inflexible to the financial case of SOUs.

The model assumes that that the uptake for SOUs will be lower than those of solar PV at any given payback level. Solar PV is now a well-understood technology whereas there is limited awareness, understanding or models for businesses to create easy benchmarks to price demand management projects. Industry experts that were interviewed in the project noted that businesses will invest with higher payback rates for solar PV than energy efficiency and demand management projects. Therefore, a lower uptake rate has been assumed at each level of payback for SOUs relative to PV.

Consequently, there are two estimates derived from the payback analysis of SOUs:

- 'SOU mainstreamed' uptake rate scenario: uptakes for SOUs based on the PV uptake curves as a marker for the uptake which could be achieved if SOUs were mainstreamed in the way of rooftop solar.
- Current market estimate (or 'BAU'): discounted uptake for SOUs relative to the PV uptake curves based on industry advice;

Consequently, the gap between the two curves represents the opportunity for policy-makers if they are able to facilitate the growth of SOUs from the much lower market uptake that is currently likely to an uptake comparable to PV – to make SOUs a natural complement to PV.

Future Uptake to 2025

The current and future potential of SOU uptake has been estimated by changing the main assumptions in the underlying model. There are several key factors:

- Industry experts have advised some sites install PV systems sized beyond their existing peak demand to act as a hedge for future energy costs. Under our model, the proportion of business that install over-sized systems increases as SOUs improves the returns.
- The cost of BMS or EMS upgrades are projected to reduce as the market becomes more mature and competitive which is reflected in lower capital expenditure and operating costs (yearly subscription fee).
- Battery capital costs are also forecast to reduce significantly.

The main drivers of the current and projected uptakes are given in the Table 4.

Table 6 Forward scenario assumptions

	2020	2025
Capital Expenditure, SOU ($)	5000	2500
Operating Cost (yearly subscription), SOU ($)	0	0
Proportion Oversized PV Systems (%)	10%	30%
Battery capital cost ($/kWh)	1000	700

2.2 Data sources

Demand-side data for the C&I sector in Australia is extremely limited, particularly when seeking detailed sub-metered load data. While the Australian Government is funding the National Energy Analytics Research (NEAR) Program[2], this is currently focused on the residential sector. Many businesses with BMS or EMS in place have this data available, however are unwilling to make this public due to commercial and/or resource constraints. The second phase of this project focused on developing a targeted repository for C&I demand-side data that could be a precursor for a more comprehensive database in the future.

ISF gathered data for the modelling of SOUs from four major sources:

- The Department provided a range of data sources, which included a program model (VEU model) used to analyse eligible energy efficiency upgrades in the C&I sector and a solar PV uptake model (produced by Green Energy Markets).

[2] https://www.csiro.au/en/Research/EF/Areas/Electricity-grids-and-systems/Economic-modelling/Energy-Use-Data-Model

ISF used Departmental data sources as far as possible to align with the two existing VEU program models.

- Publicly available online sources (e.g. load curves published by the US National Renewable Energy Laboratory (NREL));
- Cost data collected from industry for the ARENA-funded Renewable Energy and Load Management (REALM) project;
- Energy consumption data from industry experts and Victorian C&I customers, both from historical BMS outputs and current sub-metered usage for target flexible loads; and
- Interviews with industry experts and Victorian C&I customers to test and verify assumptions.

Detail behind the data sources used in this study is outlined in Table 5.

Table 7 Data Sources

Data Item	Source	Notes
Load curves	Load curves were collected from three different sources: • EnergyPlus™,NREL , funded by the US Department of Energy's Building Technologies Office (supermarket, small hotel, strip mall, stand-alone retail, warehouse); • A specialist company provided four I-identified load curves for Victorian C&I businesses (manufacturing factory, office and regional hospital); • A specialist company provided a I-identified load curve for a Victorian abbatoir; • Two load curves from a previous ISF project were used (cold storage, supermarket); • Overall load curves were provided by six Victorian businesses over 12 months of operation. Three of these businesses were able to provide sub-metered data for target flexible loads.	Desktop data availability was best for the retail sector. Detailed sub-metered loads were obtained for HVAC in hotels and refrigeration in the food sector.
Prices	Price assumptions were drawn from the following sources: • Feed-in tariffs were also derived from the Green Energy Markets model used by DWELP; • Time of use electricity tariffs for C&I businesses (VEU model); and • Network demand charges (Ausnet 2019 schedule, Australian Energy Regulator).	No revenue from the provision of energy market and network services was included.
Costs	Cost assumptions were drawn from the following sources: • BMS/ EMS upgrades (expert interviews, academic literature + costings from ISF projects); • Battery storage (Lazards); • Cold storage tank upgrade (market interviews, ISF REALM project); and • Refrigeration upgrade (market interviews, industry fact sheets, academic literature, ISF REALM project).	
Solar PV uptake	The Department provided estimates of total numbers of PV installations per system size category for the state of Victoria for 2019 to 2025. The distribution of system installations was not mapped across industry or within industry, therefore system size based weighted averages were assumed across all industries.	
Learning rates	There is limited data on which to make assumptions on learning rates. Our approach was informed by assessment that it is an early-stage market where costs reflect bespoke projects for larger consumers. As the sector and technology matures, significant cost reductions are likely. Cost reductions or learning rates were assumed for BMS/EMS upgrades and battery capital costs.	No assumption of learning rates were included for cold storage tank or refrigeration upgrades.

2.3 Modelling assumptions

Given the limited timeframe of the study and the lack of publicly available demand-side data, a number of assumptions were made in the modelling of SOUs. These included:

- **The use of representative load curves**: model load curves were used for each C&I sector based on available data from NREL and two Victorian technology providers and two specific businesses in the hotel and retail sectors. Where there were multiple load curves, results were averaged across the sector (e.g. retail). It was assumed that the load curves used are reflective of other C&I customers in the same sector. For the typology of sites used in the modelling, see Appendix
- **Two solar PV system sizings were modelled**: a 'fitted' or business-as-usual (BAU) system (5% solar spill of output relative to load); and an 'over-sized' system (20% solar spill of output relative to load). This decision was based on interviews with industry experts who suggested that most solar installers and businesses will size solar PV to minimise export but some businesses install larger systems as a hedge against future prices. In generating an overall estimate of grid electricity demand savings, it was assumed that fitted systems comprise 90 per cent of systems in 2020 and decline over time to 70 per cent of systems by 2025.
- **SOU Capacity:** The SOU capacity is a representation of how much of a particular subload can be shifted. Due to the number of site typologies under analysis, and the limited data available, modelling required simplifying assumptions about SOU capacity. For site typologies where data about subloads was unavailable, the SOU capacity was set as a percentage of peak load, based on advice from industry expert interviews:
  - HVAC BMS: 30%
  - Refrigeration BMS: 25%
  - Cold water storage BMS: 50%
  - Refrigeration Upgrade: 40%
  - Cold water storage upgrade: 45%

  This approach would be an overestimate for shifting at non-peak times, but this is inconsequential for the model which follows a peak shaving strategy only. For typologies where good subload data was available the model replaced these values. Batteries were sized according to a heuristic as described in section 2.1.1.
- **A BMS and/or EMS upgrade is required**: one of the observations from ISF's REALM for Business study for ARENA was that even leading businesses with modern systems can require an upgrade of their BMS or the installation of more sophisticated EMS software to leverage demand flexibility. Interviews with industry experts also indicated the quality of existing BMS is highly variable across sites.

For each SOU it was assumed that on-site demand control technologies would need to be upgraded. Cost estimates provided by industry experts were highly variable as they commented on a large range of site sizesSOUs are not well implemented, creating a negative experience for the customer, or if there are regular personnel changes and loss of corporate knowledge. For the purposes of our study, this means the range of outcomes is less certain and it may be difficult to develop appropriate deemed methods and factors.

1. **The financial analysis does not fully incorporate the value-stack available for accessing load flexibility**

This study solely focused on load flexibility to better match solar generation, using a pre-cool algorithm that is calculated from potential "solar spill". This, in and of itself, does not account for load deferral opportunities for solar optimisation e.g. deferring or 'ramping down' refrigeration loads until the insolation resource is higher.

There are also a range of potential additional revenue and value sources for demand management and response that are not included in the analysis. These include:

- *Wholesale market costs/revenue*: C&I businesses can reduce wholesale purchases costs through demand flexibility where they have exposure to spot prices or earn revenue by bidding in demand response during high-price events.
- *Network services*: C&I businesses could reduce the capital expenditure and/or operational expenditure of network businesses by reducing peak demand (deferring or avoiding augmentation), lowering replacement expenditure (e.g. reducing load on targeted lines with aging assets) or supporting frequency or voltage management. The Demand Management Incentive Scheme has been established to enable networks to use demand management where they are cheaper to traditional solutions but their use is still uncommon at this stage.
- *Ancillary services*: there are six markets for Frequency Control and Ancillary Services in which C&I businesses with large volumes of demand response capacity may be able to earn revenue.
- *Emergency and reliability services*: AEMO has contracted for emergency demand response under the Reliability and Emergency Reserve Trader (RERT) scheme for the past two summers in Victoria.

There is a growing range of energy management platforms that optimise load management in response to different price signals from these various revenue sources. In practice, 'value-stacking' and access to these revenue sources is generally uncommon now but it is likely they will become more accessible over the duration of this study to 2025 – improving the business case.

If SOUs are included in the VEU, C&I businesses may need to choose between accessing revenue through the program (by flexing demand to soak excess solar generation) or participating in other demand management schemes or commercial aggregator offers to address high peak demand. One potential outcome of demand management targeted on peak demand times is that the overall grid electricity consumption increases which is not compatible with the aims of the VEU.

2. The demand management services market is not transparent – and therefore capital and operation & maintenance (O&M) costs are uncertain

Although cost estimates were gathered from interviews with both technology provides and customers using these solutions, the demand management services market is at an early stage. Therefore, the market is not transparent and the final commercial costs for future deployments are uncertain.

The payback estimates for the SOUs are particularly sensitive to ongoing O&M costs. This is a key reason why SOU options with solar systems <100 kW deliver a more attractive business case than larger systems.

3 Results

The results from the study, accounting for the number of SOU installations and grid electricity savings, are presented for:

- overall grid electricity savings for the C&I sector;
- electricity savings for each of the major sub-sectors; and
- electricity savings for each of the SOUs.

The key points to note are:

- Paybacks are generally but not always better for over-sized systems;
- There are more opportunities for solar PV systems <100 kW, which is driven by lower transaction and O&M costs;
- The most prospective SOUs for solar systems <100kW appear to be BMS upgrades for refrigeration and HVAC, noting that this is not the case in some retail sub-sector sites where load is well-matched to solar;
- For solar PV systems >100kW:
    - Only a handful of options have paybacks for less than 5 years for fitted systems in 2020 (cold water and refrigeration upgrades which increase storage capacity in 6-day industrials and retail);
    - For over-sized PV systems, paybacks for BMS upgrades for HVAC and cold water storage to undertake pre-cooling fall to under 6-years several 2020 cases – other options have longer paybacks.
    - These are the best performing options in the forward years and fall to paybacks of around 3-years or lower by 2025. A significant number of the SOUs have paybacks of less than 5-years by 2025.
- The most prospective SOUs for solar systems >100kW appear to be (in order):
    - cold water storage capacity upgrades;
    - refrigeration capacity upgrades; and
    - BMS/EMS upgrades with existing cold storage tanks, HVAC and refrigeration system.
- The sectors with the highest uptake of SOUs were retail and weekday/6-day industrial operations;
- Battery storage at present day cost has long paybacks under all scenarios, except one retail case which delivered a payback of around 8 years. This exception was due to a particularly peaky load curve that was conducive to successful peak shaving. However, if prices fall aggressively – which may well occur given the level of investment occurring – then better paybacks would result across the board as shown in our 2025 scenarios; and
- Behaviour change is a critical factor shaping uptake that mediates payback rates – and therefore cannot be clearly seen in the results e.g. Buildings Alive has shown the benefits of HVAC pre-cooling for offices in reality, while refrigeration businesses can be hesitant to engage with load flexibility (particularly outside of frozen operations).

3.1 Payback Periods

A payback period represents the amount of time it takes for the cummulative return on an investment to equal the total cost of the system. The payback periods derived from the model for each site typology are represented in the figures below. Note that the results do not include VEEC revenue. Scenarios with payback periods of greater than 10 years yield an uptake rate of zero. As such they are made semi-transparent in the figures. The quicker the payback periods, the better the outcome.

Note results from solar PV systems above and below 100 kW are separated given the different incentives for generation under 100 kW (Small Technology Certificates) and over 100 kW (Large Generation Certificates).

Systems below 100kW

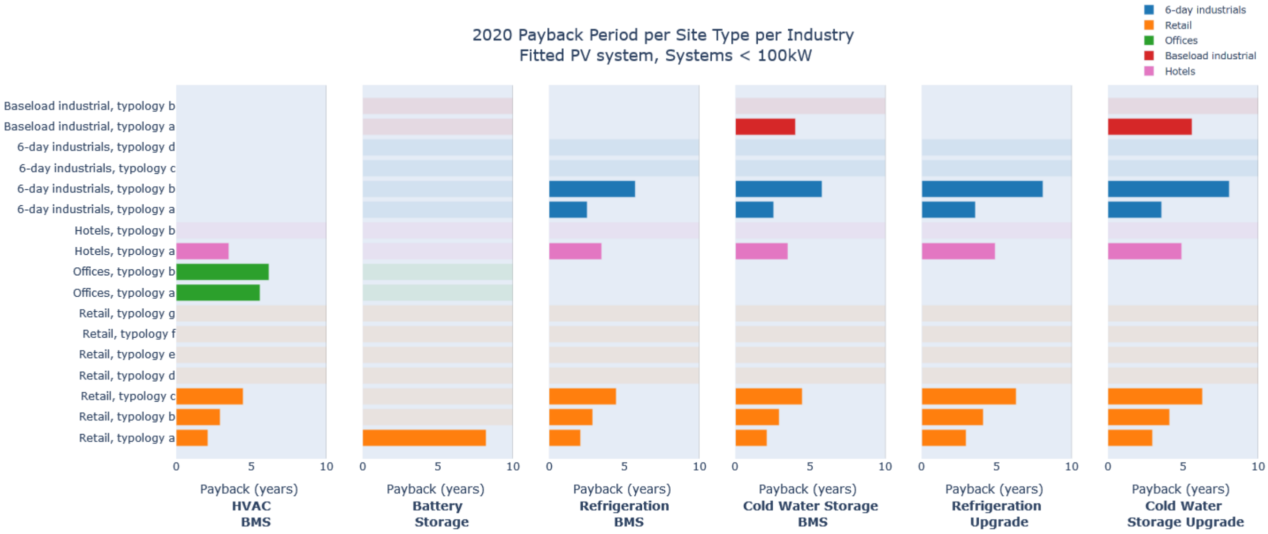


Figure 2 2020 PV uptake rate scenario, fitted solar systems <100kW

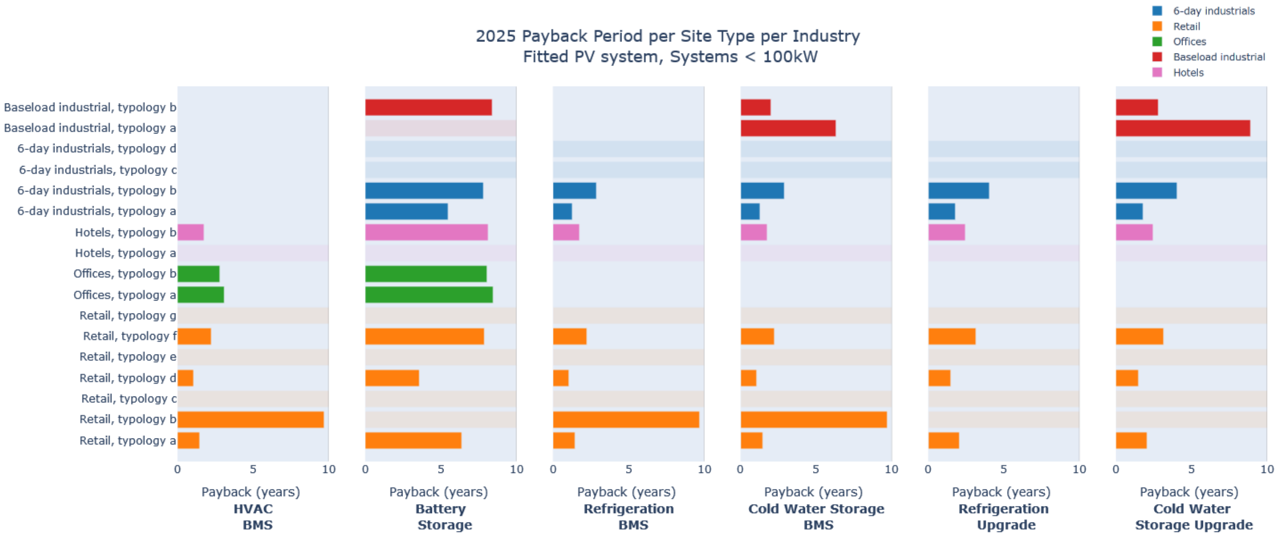


Figure 3 2025 PV uptake rate scenario, fitted solar systems <100kW

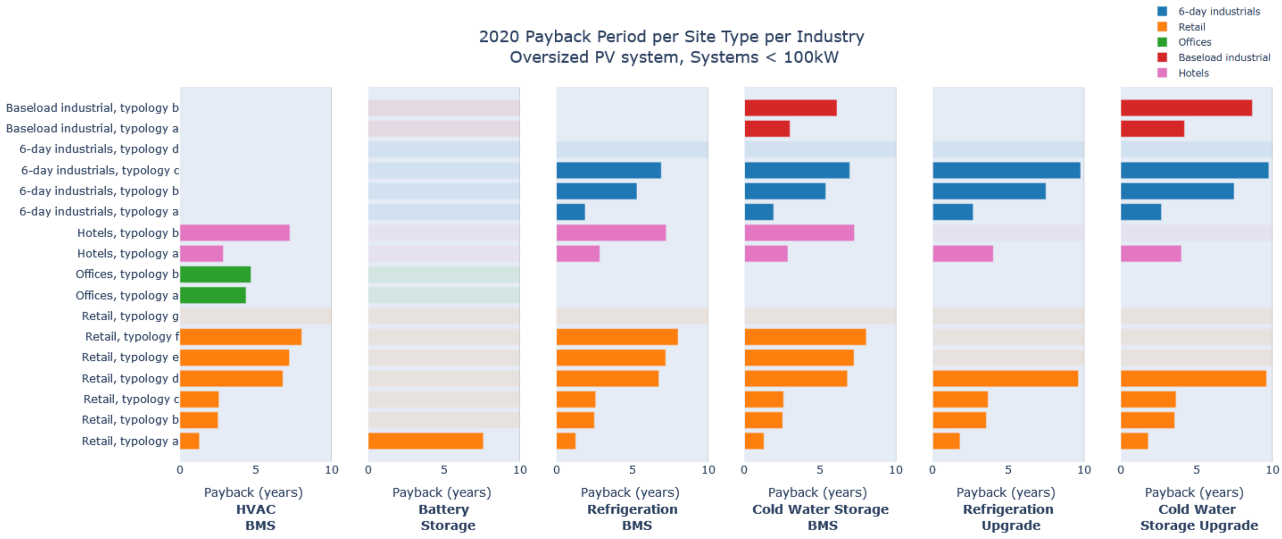


Figure 4 2020 PV uptake rate scenario, oversized solar systems <100kW

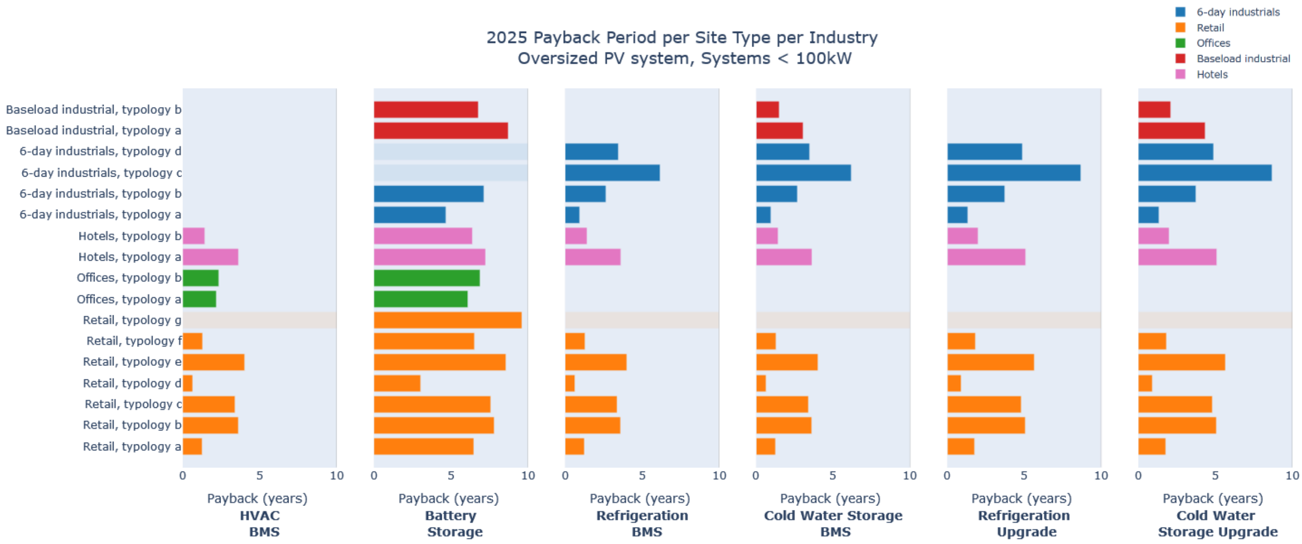


Figure 5 2025 PV uptake rate scenario, oversized solar systems <100kW

Systems above 100kW

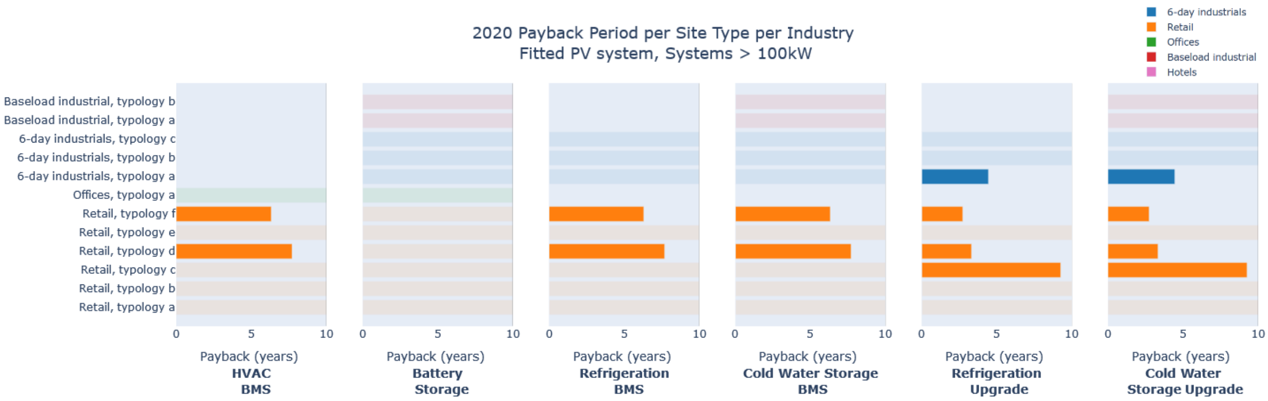


Figure 6 2020 PV uptake rate scenario, fitted solar systems >100kW

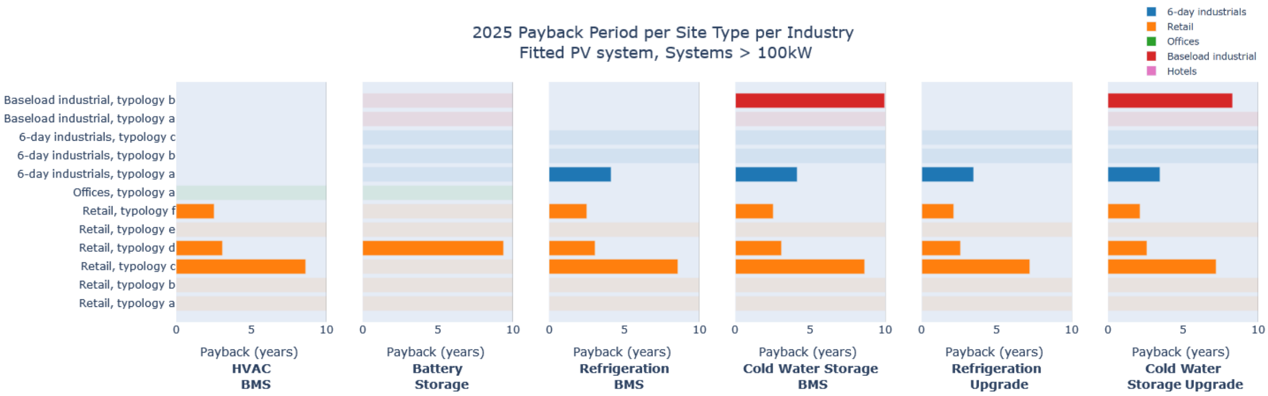


Figure 7 2025 PV uptake rate scenario, fitted solar systems > 100kW

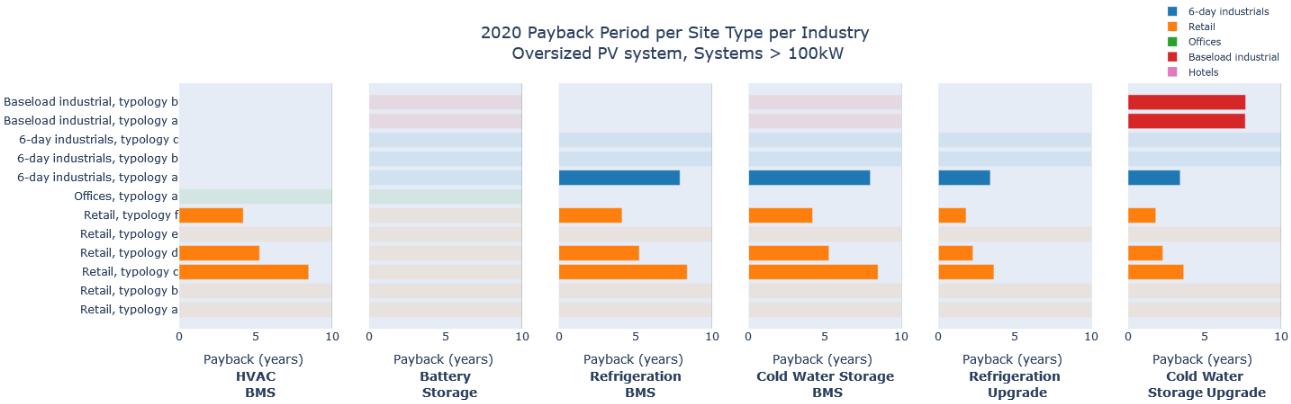


Figure 8 2020 PV uptake rate scenario, oversized solar systems >100kW

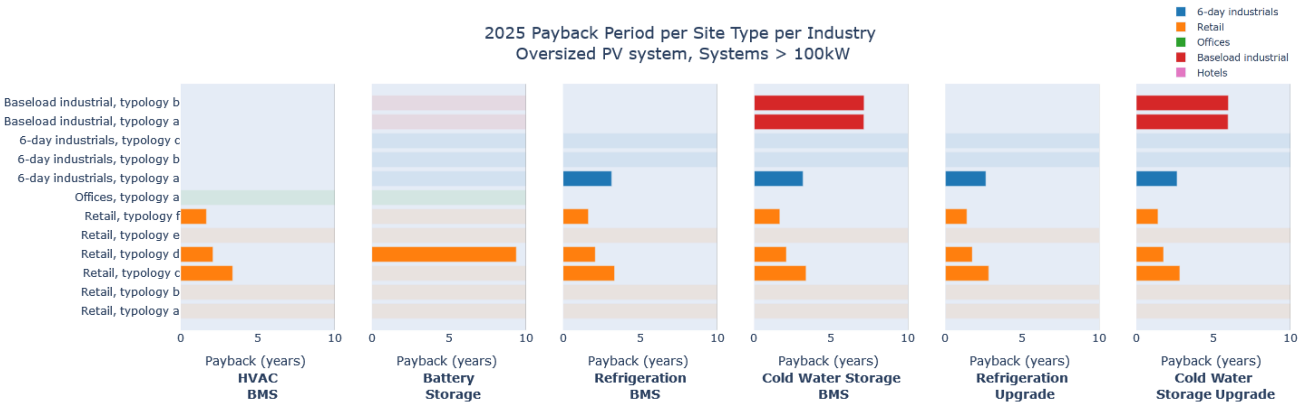


Figure 9 2025 PV uptake rate scenario, oversized solar systems >100kW

3.2 Overall grid electricity savings

The aggregate results for the potential for SOU packages with PV systems <100kW to reduce grid electricity consumption are presented in Table 6:

Table 7. Aggregate Grid Electricity Savings from SOUs in the C&I Sector; systems <100kW

		2020			2025		
Uptake Scenario	Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
PV Uptake Rate	Number of Installations per Year	1066.0	169.0	2073.9	1269.4	901.3	2170.7
	Grid Energy Savings (MWh/yr)	7165.1	1335.1	8500.1	7993.9	5774.3	13768.2
BAU	Number of Installations per Year	267.3	45.2	544.6	520.0	377.9	1632.5
	Grid Energy Savings (MWh/yr)	1853.5	426.0	2279.5	3511.0	2884.5	7903.0

Table 6 also illustrates the split in installations and grid electricity savings with fitted and over-sized PV systems and by uptake rate scenario. The payback rates are better for over-sized systems but as most systems are fitted to minimise grid exports or curtailed output these account for most of the savings in 2020. Over time, however, the capacity to use SOUs to utilise a higher proportion of output is projected to significantly increase the installation of larger systems.

Table 8 Aggregate Grid Electricity Savings from SOUs in the C&I Sector; systems > 100kW

Scenario	Element	2021			2025		
		Fitted	Over-sized	Total	Fitted	Over-sized	Total
BAU	Number of Installations	21	11	38	49	49	89
	Grid electricity savings	496	407	1,031	1,136	1,471	2,607
PV Uptake case	Number of installations	86	27	113	144	86	230
	Grid electricity savings	2031	966	2,997	3,375	3,085	6,460

3.3 Electricity savings for the major C&I sub-sectors

The results for each of the sub-sector analysed are presented beneath.

Systems below 100kW

Table 9 Grid Electricity Savings from SOUs by Major C&I Sub-Sector – BAU case

Energy Savings Per Year (MWh/yr)	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	262.2	61.5	323.7	572.0	386.6	958.6
Retail	276.9	69.3	346.2	477.1	375.8	852.9
Offices	173.9	49.1	223.0	405.8	443.5	1811.5
Baseload industrial	141.9	52.3	194.1	636.3	744.0	1380.3
Hotels	513.4	84.9	598.3	862.8	759.3	1622.1
Total	1368.3	317.0	1685.3	2954.0	2709.3	6625.5

Table 2 Number of Installations by Major C&I Sub-Sector – BAU case

Number of System Installs	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	27.6	5.2	32.8	64.9	40.2	105.1
Retail	36.4	6.1	42.4	64.6	41.7	106.3
Offices	44.0	9.8	53.8	102.7	89.2	211.4
Baseload industrial	20.7	5.7	26.4	102.8	95.7	198.5
Hotels	94.9	13.7	108.7	159.5	132.3	291.8
Total	223.6	40.5	264.1	494.5	399.1	913.2

Table 11 Grid Electricity Savings from SOUs by Major C&I Sub-Sector – PV uptake rate case

Energy Savings Per Year (MWh/yr)	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	1317.9	229.1	1547.0	1618.2	1041.0	2659.1
Retail	849.1	163.7	1012.8	841.3	646.0	1487.3
Offices	939.1	199.1	1138.2	1656.1	1267.6	2923.7
Baseload industrial	1367.3	317.3	1684.6	1951.4	1527.9	3479.4
Hotels	1848.6	313.9	2162.5	1915.6	1395.4	3311.1
Total	6322.0	1223.1	7545.1	7982.6	5877.9	13860.5

Table 12 Number of Installations by Major C&I Sub-Sector – PV uptake rate case

Number of System Installs	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	152.4	23.5	175.9	201.5	137.3	338.8
Retail	116.3	17.6	133.9	120.8	89.1	209.9
Offices	237.7	39.6	277.3	431.3	259.7	691.0
Baseload industrial	198.3	40.6	238.9	342.2	227.2	569.4
Hotels	341.8	52.8	394.6	361.5	283.7	645.2
Total	1046.4	174.2	1220.6	1457.4	997.0	2454.3

Systems above 100kW

Table 13 Grid Electricity Savings from SOUs by Major C&I Sub-Sector – BAU case

Energy Savings Per Year (MWh/yr)	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	18	11	29	39	48	87
Retail	79	58	137	219	246	465
Offices	215	117	332	290	374	665
Baseload industrial	48	48	96	129	200	329
Hotels	74	59	132	193	247	440
Total	191	114	305	264	356	621

Table 14 Number of Installations by Major C&I Sub-Sector – BAU case

Number of System Installs	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	1	0	2	2	2	4
Retail	3	2	5	9	7	16
Offices	9	3	12	12	10	23
Baseload industrial	2	1	3	6	5	11
Hotels	3	2	5	8	7	15
Total	8	3	11	11	10	21

Table 15 Grid Electricity Savings from SOUs by Major C&I Sub-Sector – PV uptake rate case

Energy Savings Per Year (MWh/yr)	2021			2025		
	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	734	271	1,004	1,275	803	2,078
Baseload industrial	50	63	113	156	278	435
Offices	-	-	-	-	-	-
Retail	1,248	632	1,880	1,944	2,004	3,948
Grand Total	2,031	966	2,997	3,375	3,085	6,460

Table 16 Number of Installations by Major C&I Sub-Sector – PV uptake rate case

Number of Systems #	2021			2025		
	Fitted	Oversized	Total	Fitted	Oversized	Total
6-day industrials	29	8	38	51	25	76
Baseload industrial	2	2	4	7	8	16
Offices	-	-	-	-	-	-
Retail	55	17	71	85	53	138
Grand Total	86	27	113	144	86	230

3.4 Electricity savings for each SOU package

The aggregated results by sector and then by SOU are given in the tables below.

Systems below 100kW

Table 17. Grid Electricity Savings from SOU Packages under the BAU Case

Energy Savings Per Year (MWh/yr)	2020			2025		
SOU	Fitted	Oversized	Total	Fitted	Oversized	Total
HVAC BMS	452.4	98.4	550.8	756.3	631.8	1388.0
Battery Storage	0.0	0.0	0.0	60.4	72.8	133.3
Refrigeration BMS	432.5	99.7	532.2	764.3	562.6	1521.3
Cold Water Storage BMS	447.6	98.8	546.3	838.1	665.7	1503.8
Refrigeration Upgrade	274.3	64.1	338.4	479.2	447.3	926.4
Cold Water Storage Upgrade	246.8	65.0	311.8	612.8	504.3	2430.2
Total	1853.5	426.0	2279.5	3511.0	2884.5	6395.5

Table 18. Number of intallations of SOUs under the BAU Case

Number of System Installs	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
HVAC BMS	74.3	12.3	86.7	130.3	94.2	224.5
Battery Storage	0.0	0.0	0.0	9.2	14.8	24.0
Refrigeration BMS	59.2	10.2	69.5	106.5	72.0	248.4
Cold Water Storage BMS	62.6	10.2	72.9	118.0	84.4	202.4
Refrigeration Upgrade	37.2	6.1	43.3	65.1	51.9	116.9
Cold Water Storage Upgrade	33.9	6.3	272.3	91.0	60.7	816.2
Total	267.3	45.2	544.6	520.0	377.9	897.9

Table 19. Grid Electricity Savings from SOU Packages under the PV uptake case

Energy Savings Per Year (MWh/yr)	2020			2025		
SOU	Fitted	Oversized	Total	Fitted	Oversized	Total
HVAC BMS	1500.9	280.5	1781.4	1542.6	1123.7	2666.4
Battery Storage	36.3	5.0	41.3	462.8	393.2	856.0
Refrigeration BMS	1494.8	276.9	1771.7	1459.4	1035.0	2494.4
Cold Water Storage BMS	1692.8	312.7	2005.5	1651.6	1184.8	2836.3
Refrigeration Upgrade	1196.8	217.5	1414.3	1363.7	950.4	2314.1
Cold Water Storage Upgrade	1243.6	242.4	1486.0	1513.8	1087.1	2601.0
Total	7165.1	1335.1	8500.1	7993.9	5774.3	13768.2

Table 20. Number of intallations of SOUs under the PV uptake rate case

Number of System Installs	2020			2025		
Sector	Fitted	Oversized	Total	Fitted	Oversized	Total
HVAC BMS	268.9	43.1	311.9	296.4	195.5	491.9
Battery Storage	5.1	0.6	5.6	89.5	73.9	163.4
Refrigeration BMS	212.1	35.4	247.5	210.0	160.6	370.6
Cold Water Storage BMS	244.3	40.6	284.9	255.3	182.1	437.4
Refrigeration Upgrade	163.8	23.0	186.9	196.1	134.5	330.7
Cold Water Storage Upgrade	171.7	26.3	1036.9	222.0	154.6	376.6
Total	1066.0	169.0	2073.9	1269.4	901.3	2170.7

Systems above 100kW

Table 21 Grid Electricity Savings from SOU Packages under the BAU Case

Savings Mwh/y	2021			2025		
	Fitted	Oversized	Total	Fitted	Oversized	Total
Battery Storage	18	11	29	39	48	87
Cold Water Storage BMS	79	58	137	219	246	465
Cold Water Storage Upgrade	215	117	332	290	374	665
HVAC BMS	48	48	96	129	200	329
Refrigeration BMS	74	59	132	193	247	440
Refrigeration Upgrade	191	114	305	264	356	621
Grand Total	624	407	1,031	1,136	1,471	2,607

Table 22 Number of intallations of SOUs under the BAU Case

Number of Systems #	2021			2025		
	Fitted	Oversized	Total	Fitted	Oversized	Total
Battery Storage	1	0	2	2	2	4
Cold Water Storage BMS	3	2	5	9	7	16
Cold Water Storage Upgrade	9	3	12	12	10	23
HVAC BMS	2	1	3	6	5	11
Refrigeration BMS	3	2	5	8	7	15
Refrigeration Upgrade	8	3	11	11	10	21
Grand Total	27	11	38	49	40	89

Table 23 Grid Electricity Savings from SOU Packages under the PV uptake case

Savings Mwh/y	2021			2025		
	Fitted	Oversized	Total	Fitted	Oversized	Total
Battery Storage	23	14	38	67	65	132
Cold Water Storage BMS	276	185	462	743	660	1,403
Cold Water Storage Upgrade	659	266	925	809	799	1,608
HVAC BMS	188	110	298	362	377	738
Refrigeration BMS	260	166	426	664	562	1,226
Refrigeration Upgrade	625	224	849	731	622	1,353
Grand Total	2,031	966	2,997	3,375	3,085	6,460

Table 24 Number of intallations of SOUs under the PV uptake rate case

Number of Systems #	2021			2025		
	Fitted	Oversized	Total	Fitted	Oversized	Total
Battery Storage	1	1	2	4	3	7
Cold Water Storage BMS	12	5	17	31	18	50
Cold Water Storage Upgrade	28	7	35	34	22	57
HVAC BMS	8	3	11	16	10	25
Refrigeration BMS	11	5	16	28	15	43
Refrigeration Upgrade	26	6	32	31	17	48
Grand Total	86	27	113	144	86	230

4 Conclusions

If SOUs are incorporated into the VEU program, it will be the first market-based instrument to incorporate demand management in Australia. Other programs internationally are often driven by utilities (e.g. several electricity and gas utilities offering commercial demand response program in New York[3], or Tampa Electric's Load Management Program in West Central Florida).[4] From this perspective, the Victorian Government could play a leadership role in mainstreaming demand management that complements its current support for solar PV.

Inclusion of SOUs in the VEU program is highly prospective to incentivise solar PV uptake by C&I businesses in a way that facilitates the integration of variable and distributed renewable energy generation into electricity networks. However, further work is required to effectively validate this approach, including:

- Fully characterising the Victorian C&I sectors that could engage with the program, both in terms of potential solar PV uptake and available load flexibility; and
- Mapping the distribution of solar PV system capacities against sector sites characterised by demand profile shapes and magnitudes
- An investigation of complementary policy and/or program measures that will enable end users and demand management providers to best deliver the VEU program outcomes and support the integration of more variable renewable energy generation in the grid.

These conclusions are outlined in more detail below.

1. Victoria should support the development of SOUs and a demand management services market

The key finding is that there are cost-effective opportunities for SOUs to increase the value of on-site solar PV for C&I businesses in a way that facilitates better integration of DERs into electricity networks and markets. However, the opportunity is not well-understood by businesses and the market for service providers is not well-developed. Research for this project underlined findings of the REALM for Business project undertaken for ARENA where participant companies noted:

> *"We are at an early stage with knowledge of opportunities. We see it with our own engineers. They do audits and see energy efficiency opportunities but not load shifting because they don't understand the value. There is a whole lot of training and upskilling needed to identify opportunities and translate into new jobs and also the businesses you're pitching to - they won't sign onto anything they can't understand at least a basic level." (Schneider Electric)*

> *"There are lots of other priorities and limited resources to direct. It is less complex to get an energy efficiency project over the line that is well-understood than a demand management project. There are other more familiar options." (NBN)*

Similar observations were made by industry experts in interviews for this study that:

[3] , Institute for Sustainable Futures (2018), *Appendix B: Renewable Energy and Load Management (REALM) for Industry Report* - https://arena.gov.au/assets/2018/10/REALM-Industry-Report_public_FINAL.pdf
[4] https://www.tampaelectric.com/business/saveenergy/loadmanagement/

1. Businesses apply higher financial benchmarks or hurdle rates to demand management projects than solar PV on its own because it is not as well-understood and considered riskier.

   "There is likely to be resistence and internal politics to overcome about wanting complete autonomy for energy use"

2. There is a lack of industry tools that can make it easy for solar installers to incorporate SOUs.

   "Success is highest where case studies can be provided, particularly when these case studies are competitors…It is difficult to quantify the costs of flexibility solutions since it relates to more than the monitoring provided."

   "Demand management is a very broad church. Relevant assets will have significantly varied capabilities, constraints and costs."

Consequently, the VEU program can promote the development of a market for demand management that extends beyond the value of the VEECs. Inclusion in the VEU program would:

- Increase the profile, awareness and legitimacy of SOUs; and
- Accelerate the development of a demand management market, including the service providers and tools, by creating greater demand for SOUs.

A wholesale demand response mechanism is scheduled to come into operation in 2022 within the National Electricity Market. Accelerating the development of a demand management services market will position Victorian businesses to take advantage of opportunities when the wholesale demand response mechanism commences.

2. Complementary measures should be investigated in parallel to help address non-financial barriers

Inclusion of SOUs into the VEU program will allow demand management providers to include VEEC revenue in the business cases they provide to businesses and normalise as part of their offering. However, the VEU program alone cannot facilitate the full potential of load management. Two major non-financial barriers that the VEU program should consider during implementation are:

- *Information and experience gaps*: customers, energy auditors and solar installers do not currently have the tools and skills to identify and price opportunities for SOUs. More certainty will develop over time once projects are proven on the ground.
- *Scheme transaction costs and time-lags*: inclusion of SOUs in the VEU program will need to develop a robust method for measuring and verifying savings. As industry experts have observed, demand management is viewed as a riskier option than efficiency upgrades or just installing solar PV so there may not be many participants willing to invest in the measurement and verification initially. There are some precedents such as the ARENA/AEMO demand response trial which included the use of baselines for the payment of incentives. However, establishing these methods through industry consultation and then the application by businesses could be time-consuming, resource-intensive and slow. It may be in time that some SOUs can be transferred to the Common Upgrade Stream as they are better understood; for example, HVAC

optimisation and pre-cooling in the office sector could become more standardised as an offering in a sector with less diversity than industrials.

Two policy options that the Department could consider to address these non-financial barriers are:

1. Supporting the uptake of energy management technology; and
2. Incentivising load management to improve grid reliability.

Supporting behaviour change through energy management technology

There is an immediate opportunity to unlock value and minimise network impacts of on-site solar PV simply by upgrading a BMS and/or EMS to leverage existing sources of flexibility and storage. However, there are information and skill gaps that need to be addressed. Whilst undertaking the work to include SOUs in the VEU program, the Department could consider measures to accelerate uptake and address some of these barriers. Some examples of initiatives to consider include:

- Developing training offerings on demand management for solar installers and energy auditors;
- Establishing a grant or subsidy for BMS/EMS upgrades in concert with the installation of solar PV and/or for businesses with PV already installed. Eligibility should be limited to accredited installers or service providers with a demand management offering (which would also encourage upskilling ahead of inclusion in VEU program); and/or
- Data collection on the real-world performance of SOUs that is shared through an education and awareness program.

These could act as a bridge for demand management measures that would be eligible as SOUs, and increase the likelihood of the expanded VEU program achieving its expected outcomes.

A program or policy to incentivise load management for reliability

Reliability of supply is a critical challenge for enabling the transition towards renewables. Load management offers an impactful and easily accessible solution. However, SOUs will only tap into a portion of the reliability benefits that load management offers. Incentives for SOUs will not necessarily ease network constraints as there will be a diversity of responses; if they are not located in the right areas, deployed at the right times or aggregated to a meaningful volume they will not materially improve reliability or reduce network and market costs associated with peak demand events.

Therefore, the Department could consider measures to target the reliability value of SOUs. For example:

- Incentivising or contracting for demand reduction on Critical Peak Demand days or similar grid-scale events across Victoria, expanding on existing programs e.g. AusNet Services' existing Critical Peak Demand Tariff program[5]. This could be implemented over ~4 years to accelerate commercial activity towards the establishment of the Wholesale Demand Response Mechanism; and/or

[5] https://www.ausnetservices.com.au/Business/Electricity/Demand-Management/Critical-Peak-Demand-Tariff

- Trialling innovative pricing and incentives, value stacking and streamlined regulation, in collaboration with distributors, to kick-start SOUs in a way that also promotes energy system security and grid reliability. Pricing trials, which complement and/or leverage existing tariff arrangements that support load shifting, would address the three key barriers identified by the ARENA-funded REALM pre-feasibility study in 2018:
    - Electricity supply agreements and tariffs need to be remodelled to provide genuine, focussed incentives for consumers that unlock value for energy markets and networks;
    - Business and market capacity needs to be developed. Pilot projects are required to demonstrate the value and practicality of decentralised renewable energy and load management systems for businesses and energy networks, retailers and aggregators. These are required to develop business and market capacity and relationships and to commercialise demand-side technologies;
    - Energy market reform must open up the energy market revenue streams for load flexibility, which is likely to be delivered to participating businesses much more cheaply than supply-side options flexible capacity

3. Further analysis is required to more accurately estimate the opportunity for more SOU technology options for a wider range of C&I sectors

The estimates provided in this study can only be indicative due to limitations in energy consumption data for the Australian C&I sector, and sectoral data for both sub-sector business counts and their solar PV uptake. Further work is needed to produce a more accurate estimate and an understanding of the most prospective opportunities for SOUs by:

- *Undertaking an in-depth analysis of load flexibility for the Victorian C&I sector:* the current study is based on a small sample of load curves from each of the sectors. Australian demand-side data is opaque therefore a robust data-collection methodology is needed to gather more primary data inputs to validate this study's findings. The second phase of this project has established a solid base for future study by: demonstrating a method for inputting real-world load and sub-load data to deliver sectoral output; and framework that could house a comprehensive C&I energy consumption database. A state-wide survey would be the ideal approach, likely requiring a year of engagement, data gathering and analysis. This would allow other prospective opportunites, such as HVAC in schools and water pumping in agriculture, to be fully explored.
- *Develop projections for current and future C&I solar PV uptake distributions for systems 15-100 kW:* there is currently no public data available on either the complete set of Victorian C&I customers to the sub-sector level or the uptake of solar PV at these businesses. This work could be undertaken in tandem with the previous recommendation to further analyse load flexibility for the C&I sector.
- *Extending the analysis to include impacts on gas consumption*: the study was limited to electricity which understates the potential impact of SOUs, especially during winter in Victoria e.g. engagement with hotel managers exposed an opportunity for gas water heating.

- *Extending the analysis to include value-stacking and other sources of revenue*: SOUs are not systems that exist in isolation, rather they are a specific application of fuctionality from a broader set of system capability. For example, installation of a BMS may deliver SOU capability, but may also enable access to the demand response market through its demand management capabilities. Capital expenditure on systems that support SOUs therefore has the potential to deliver several streams of stacked value simultaneously. ISF has identified 5 potential value streams that may complement the value of SOUs if capital expenditure is leveraged approapriately:
  - wholesale arbitrage
  - ancillary services (e.g. network voltage and frequency support)
  - capitalisation on new and existing tariff structures (e.g. time-of-use, demand charges, dynamic pricing)
  - demand response

  Figure 10 shows a high level methodology for extending this analysis to include value-stacking.

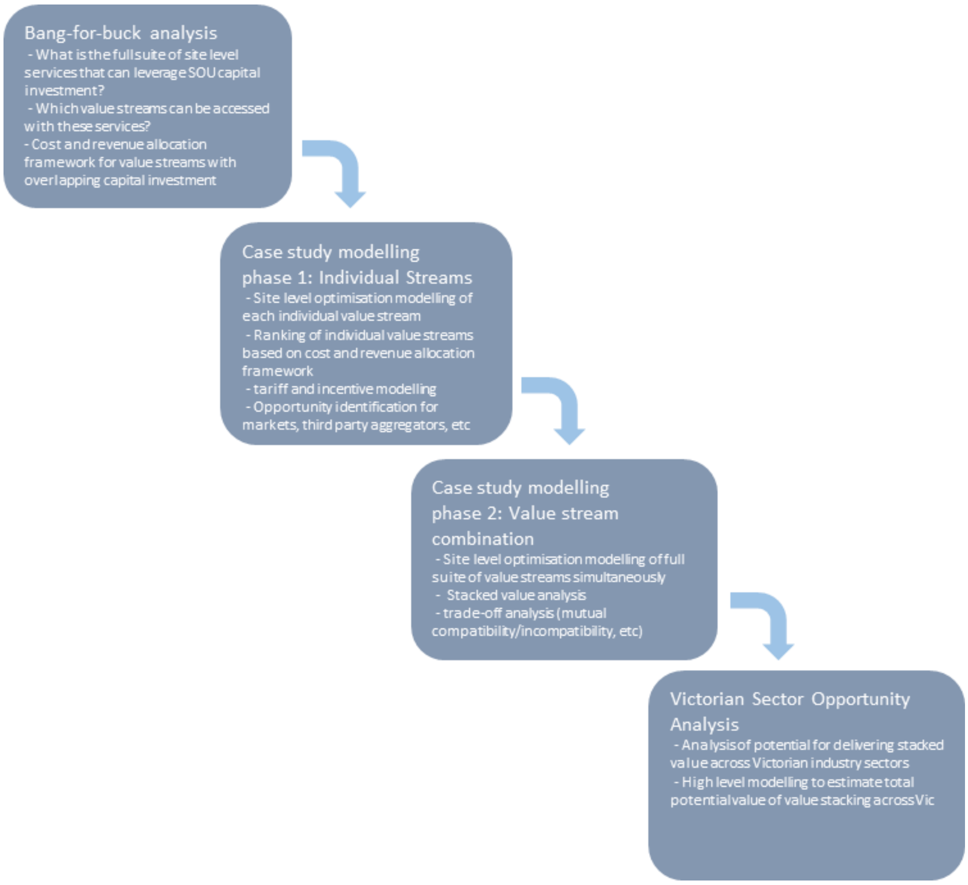


Figure 10. Potential steps in extending analysis to consider value-stacking of additional revenue streams

Appendix 1: Background on the VEU program

The Victorian Energy Upgrades (VEU) program is a market-based scheme which provides incentives for activities which reduce greenhouse gas emissions. One Victorian Energy Efficiency Certificate (VEEC) is equal to one tonne of greenhouse gas emissions avoided.

The VEU program was established to create incentives for energy efficiency activities. Under the Victorian Energy Efficiency Target Act 2007, the objectives of the program are the efficient use of electricity and gas, reduction of emissions, and driving innovation and investment in industries that supply goods and services which deliver energy reductions.

On-site renewable energy and demand management can have a comparable impact to energy efficiency by reducing grid electricity and gas demand consistent with the Act under which the VEU program was established. The Department currently provides incentives for solar panels. Consequently, the Department is considering the expansion of the VEU program to include demand management.

Under the VEU program, the Department incentivises upgrades in two ways:

- For common upgrades, by determining how this type of upgrade would reduce emissions on average – that amount of emissions is then deemed to be attributed to such an upgrade; or
- For program-based activities, organisations measure and verify the use of energy before and after an upgrade (and thereby the reduction in energy achieved).

This report has been produced to support the development of a Regulatory Impact Statement on the development of 2021 and 2025 targets for the VEU program to be released for public consultation.

Appendix 2: Site Type Descriptors used for Modelling

Site Typology	Descriptor	Load Curve Origin	Sector
6-day industrials, Typology a	Factory Floor	Synthetic	6-day industrials
6-day industrials, Typology b	Warehouse	Synthetic	6-day industrials
6-day industrials, Typology c	Cold Storage	Real	6-day industrials
6-day industrials, Typology d	Cold Storage	Real	6-day industrials
Baseload industrial, Typology a	Small Hospital	Synthetic	Baseload industrial
Baseload industrial, Typology b	Abbatoir	Real	Baseload industrial
Hotels, Typology a	Hotel	Real	Hotels
Hotels, Typology b	Hotel	Real	Hotels
Offices, Typology a	Office	Synthetic	Offices
Offices, Typology b	Office	Synthetic	Offices
Retail, Typology a	Retail Store	Synthetic	Retail
Retail, Typology b	Retail Store	Synthetic	Retail
Retail, Typology c	Supermarket	Synthetic	Retail
Retail, Typology d	Hotel	Synthetic	Retail
Retail, Typology e	Strip Mall	Synthetic	Retail
Retail, Typology f	Supermarket	Real	Retail
Retail, Typology g	Retail Store	Real	Retail

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A full bibliography can be provided on request