Electrification Opportunities in Victoria's Commercial Sector

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Executive Summary

This Report finds that:

- On average over the period from 2001 – 2017, there has been net fuel switching from gas to electricity in the commercial sector in Victoria.
    - Gas accounted for 39.3% of commercial energy consumption in 2001 and 36.4% in 2017.
- The rate of switching is volatile from year to year, but in trend terms has been falling over time.
    - In 2002, about 500 TJ switched from gas to electricity
    - However, this figure has been falling by about 55 TJ per year, on average
    - Since 2012, *net* fuel switching in the sector has tended to be from electricity to gas.
- While there are many opportunities for electrification in the sector, the financial returns (generally measured as simple payback on investment) for those documented are highly variable by opportunity and building type. Indeed, the potentials and economics are likely to vary from enterprise to enterprise.
    - In some cases – such as switching from gas to electric radiant heaters, induction cooktops, electric or heat pump dryers – there may be no additional, or even a lower, capital cost for an electric option; in other cases – such as ground- or water-to-air heat pumps replacing gas supplemental heating, there would be a significant premium.
    - Paybacks on investments range from negative (reduced capital cost) to over 100 years in the worst case.
- VEU support levels modelled tend to reduce investment payback periods by 1 – 3 years. For marginal cases (which may be payback periods in the 5 – 10 year range), such support for the investment case could be significant and may well induce switching that would not otherwise occur.
- On a plausible uptake scenario, we could see additional annual gas savings reaching 14.5 PJ by 2030, offset by additional (renewable) electricity consumption of 7.8 PJ, with a net reduction in energy consumption of 6.8 PJ and avoided greenhouse gas emissions of 750,000 t CO_2-e.
    - This scenario assumes value support equivalent to $10/t CO_2-e.

Overall, we conclude that there is significant potential to reduce greenhouse gas emissions in the commercial sector in Victoria by encouraging electrification, using renewable electricity, via the Victorian Energy Upgrades program. However, the expected attractiveness and therefore uptake of opportunities is likely to be highly variable by building type and enterprise. VEU is a voluntary program, so those organisations mostly likely to be benefit from electrification can 'self-select' – provided they are aware of the opportunity of support.

The risk of free-riding (providing support for investments that are likely to have proceeded without the support) exists in some cases, where the investment paybacks are already short. We would suggest that no VEU support is provided for such activities. However, we note that the 'background' or BAU rate of fuel switching to electricity in Victoria's commercial sector appears to have slowed on average over time. Also, many electrification opportunities identified have paybacks of 5 years or more, and these are unlikely to proceed on those terms. Since modelled (and modest) levels of VEU support can, in some cases, reduced paybacks by 1 – 3 years, then such support could well be material and effective in inducing additional electrification.

This project has involved developing a spreadsheet model that will enable DELWP to test varying levels of VEU support, for up to 21 different electrification opportunity types, for 8 building types, and 2 scenarios (total cost or incremental cost). Opportunities to deepen the research and/or enhance the model could include:

- Modelling expected uptake of specific opportunities by sector or enterprise, as a function of investment paybacks and other factors
- Ideally, conducting industry consultations or other forms of research to identify critical variables, including required paybacks, current and planned switching behaviours, impediments and potential accelerators, to more accurately model 'dose/response' relationships.
- Also, gas end-use by business/sub-sector is not well-documented, and detailing this – including the extent of variability by enterprise type or sector – could also form part of any follow-up research effort.

1. Background

1.1 Purpose

This study examines the potential for electrification of non-electrical energy use in the commercial sector in Victoria. The purpose is to determine whether it would be advantageous to support this activity under the Victorian Energy Upgrades program.

1.2 Context

Energy markets are undergoing rapid change in Australia, as indeed they are in many countries around the world. The changes are being driven by a mix of factors including:

- Significant reductions in the levelised cost of electricity generated from large-scale wind farms and from solar photovoltaic (PV) panels, to the point where generation from these renewable sources is no more expensive, and in some cases less expensive, than conventional sources and prices generally available for contract in the National Energy Market
- PV panels have additional value for customers when installed 'behind the meter' on buildings, as the value of this generation is equivalent to the avoided cost of electricity imports
- Low feed-in tariffs, relative to the cost of imported electricity, create an incentive for those with PV systems to use the electricity themselves rather than export it, and/or to store it for later use[1]
- Market prices for both electricity and gas in Australia have increased by around 200% over since 2000, increasing the demand for alternative supply sources and for energy efficiency
- There are growing concerns regarding the use, and in particular the development of new, fossil fuel resources due to climate change
- Investment risks in fossil fuel development have also been increased by policy uncertainty at the national level
- The use of electricity from renewable sources offers a 'fast track' for companies or organisations wishing to reduce their greenhouse gas emissions, and innovations such as renewable electricity power purchase agreements (PPAs) are making this easier and cheaper for customers to choose
- At the end-use level, the efficiency of many electrical technologies continues to out-pace that of gas technologies, through continuing advances in the co-efficients of performance of heat-pump based technologies (for space heating and cooling, hot water), in particular.

The effect of these factors has included rapid take-up of solar generation systems first in the residential sector and, more recently, in the commercial and even industrial sectors. Also, they create a context in which it is increasingly likely that customers may have a greater tendency to at least consider electrical solutions over gas-based solutions.

For context, it should be recalled that electricity is already the dominant energy source in the sector, accounting for just under 64% of energy consumption in commercial and services sector in Victoria

[1] Although, despite falling battery storage costs, this remains an uneconomic choice for many consumers.

in FY2017.[2] Second, it should be noted that the delivered cost of energy remains *considerably* lower for gas than for electricity – noting that prices paid for both energy sources vary significantly from customer to customer – but probably around one quarter of the cost. Based on analysis of data presented in the *Independent Review into the Electricity and Gas Retail Markets in Victoria* (2017), typical business customer costs for electricity may be around $101/GJ but only $26/GJ for gas. This price differential reflects the fact that electricity is a derived or secondary energy source, while gas is a primary energy source. It also reflects the commercial sector's higher willingness to pay for electricity, as it is able to deliver some services (IT, lighting, etc) that gas cannot. However, the price differential means that customers do have a financial incentive to use gas in end-uses or applications where that is feasible, such as space heating and hot water.

One incentive to consider (complete) fuel switching is the opportunity to avoid two sets of connection costs and fixed charges, but this consideration is not likely to be large enough for commercial customers to outweigh the effects of the price gas-electricity price differential.

Expectations regarding *future* costs are also very important for customer decision-making about fuel choice. The rapid changes in the energy market make this more difficult than usual to evaluate. On the one hand, the falling cost of renewable electricity generation will place downward pressure on electricity prices over time. However, there are also short-term price risks associated with the possible retirement of large coal-fired generation units at the end of their economic lives. There will also be a need to increase energy storage capacity, as part of the transition to a low carbon economy, and there will be costs associated with building this capacity. Figure 1 below indicates that in Victoria at least, and over the last 20 years, the retail prices of electricity and gas moved broadly in line with each other (to varying degrees, as shown), meaning that the relative cost of the two energy sources will not have changed greatly. Given that gas and electricity compete with each other, and also that gas can be used to generate electricity, there is an argument that broadly the same cost relativities between the two sources could persist for some time into future.[3] Therefore it seems likely that expectations about future relative costs of electricity and gas will not be a major factor weighing on fuel choice decisions in the near future.

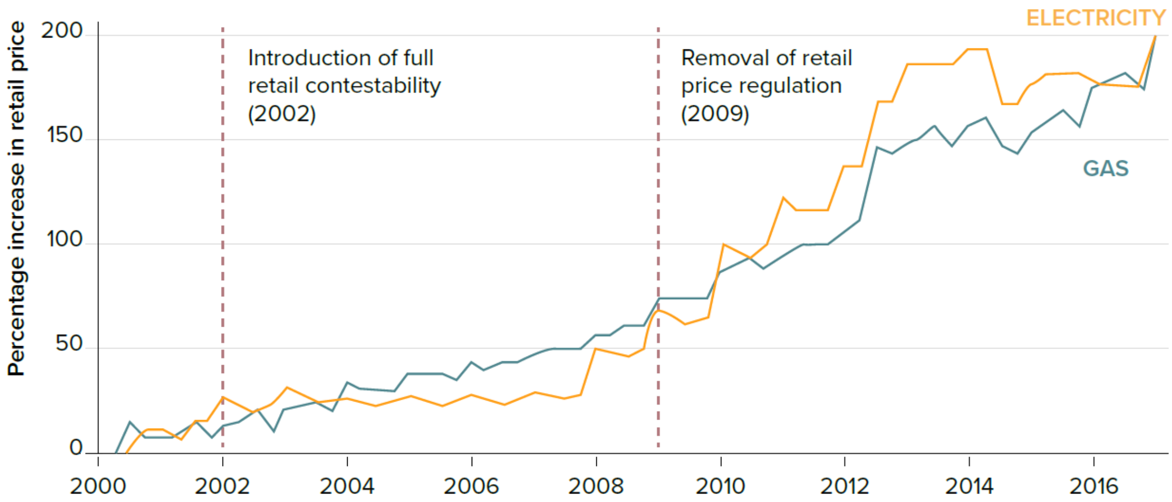

Figure 1: Victorian Electricity and Gas Price Index, 2000 - 2017

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2 *Australian Energy Statistics*, 2018, Table F.

3 Barring policy developments such as carbon pricing.

Overall, and as discussed in more detail below, the financial case for fuel switching from gas to electricity today is variable from customer to customer and from end-use to end-use. In the marginal cases, therefore, financial assistance from VEU could be a determining factor.

1.3 Scope and Limitations

This study examines a set of specific electrification opportunities, as documented by Arup Pty Ltd. There may well be other electrification opportunities that are not examined here.

Second, data about the end-use of gas in the commercial sector, and how that varies by building type, is limited. The circumstances of individual gas users, and the hurdles they may face in considering electrification, will be highly variable. This, together with a variable business case for fuel switching, means that is difficult predict the likely rate of switching with the data available to this study.

To deepen the analysis, the most feasible methodology may be to undertake direct research with gas users in the sector, through surveys and/or interviews, to determine their propensity to switch, required or threshold rates of return on investment, and barriers or other factors that may affect the timing switching decisions.

2. Floor Area and Energy Consumption

2.1 Overview

The quantitative analysis of electrification opportunities in the commercial sector in Victoria contains four main steps:

1. Characterise the commercial sector in terms of floor area by building type, covering the period 2017 to 2030
2. Model the expected electricity and gas consumption of existing (pre-2018) buildings by class over the 2017 – 2030 period under 'business as usual' assumptions
3. Identify electrification opportunities and associated capital costs, changed energy use patterns (primarily, reduced gas and increased electricity consumption), changed energy costs, and investment paybacks
4. Model the state-wide energy consumption changes and emissions savings associated with expected uptake of the opportunity set, assuming renewable electricity is substituted for gas.

Further details of steps 1 – 3 are provided below, while the step 4 results are presented in Chapter 3.

2.2 Floor Area

Our analysis of commercial building floor area in Victoria began with a review of the *Next Wave Refresh*, 2018. This study provides an in-depth analysis of certain commercial building types in Victoria, covering a sub-total of around 40.8 million sqm of floor area in 2017. However, this does not cover all non-residential buildings in Victoria.

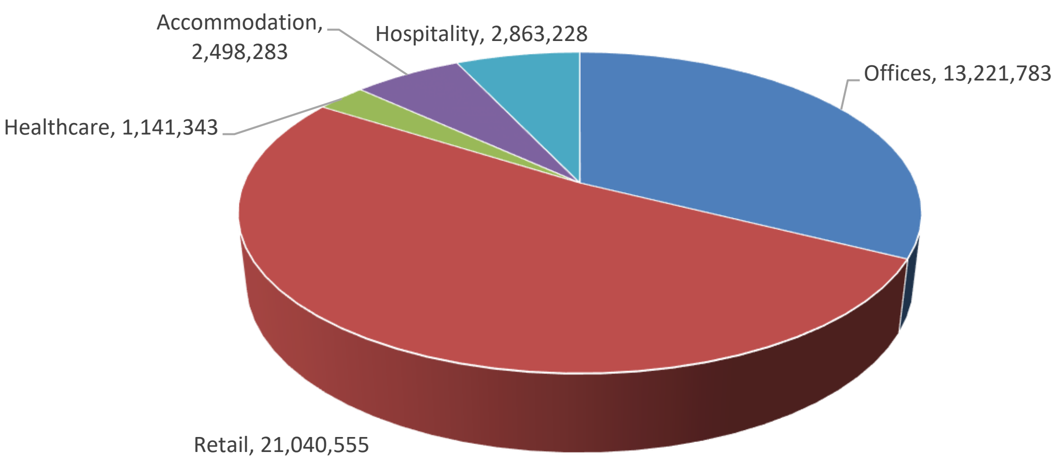


Figure 2: Next Wave Refresh Floor Area Observations, 2017 (sqm)

For this study, we aim to encompass the whole of the non-residential built environment. For this reason, we adopted a stock model derived from past projects, including the 2012 Commercial Building Baseline Study[4], and the Code Calculator study[5], as updated. This model shows a total of some 72.3 million sqm of non-residential floor area in Victoria in 2017, divided (by NCC Class) as shown in

Figure 3. We note that there is considerable uncertainty regarding the total non-residential floor area in all jurisdictions. The Australian Government is understood to be planning an update to the Commercial Baseline Study in FY2020.

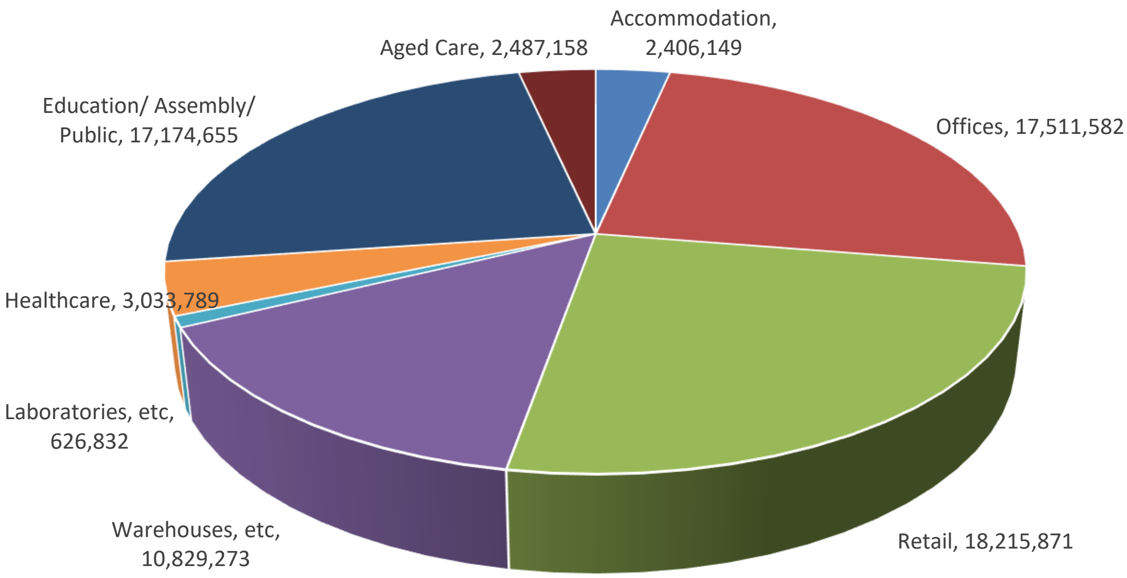


Figure 3: SPR Floor Area Estimates, Non-Residential Buildings by NCC Class, Victoria, 2017, sqm

Floor area projections to 2030 reflect past assumptions from the Code Calculator project referenced above – see Figure 4. In line with assumptions from the Commercial Building Baseline Study, we assume that 1% of the stock is either demolished and rebuilt or undergoes a major refurbishment to new Code standards annually. Removing the 'new' (built to Code) floor area, Figure 5 shows that the pre-2018 commercial building floor area, that is more likely to participate in electrification investments, falls from around 72 million sqm in 2017 to around 41 million sqm in 2030. New, or post-2018, buildings could also participate, but unless the financial drivers for switching are large, it is less likely that equipment will be replaced prior to the end of its economic life.

[4] COAG NSEE, *Baseline Energy Consumption and Greenhouse Gas Emissions of Non-Residential Buildings in Australia*, 2012.

[5] SPR, *Emissions and Energy Savings from Potential Changes to National Construction Code Energy Performance Requirements – the Code Calculator*, June 2017.

Figure 4: Expected Stock Growth by Building Class, 2017 – 2030

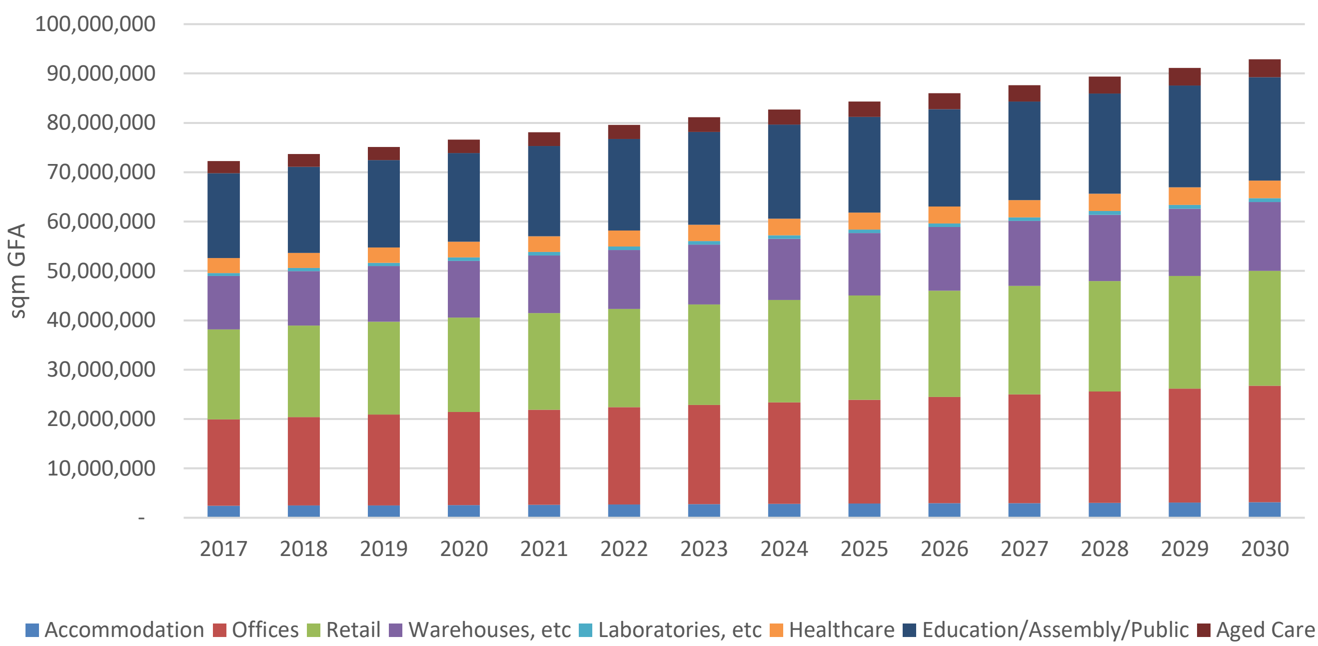
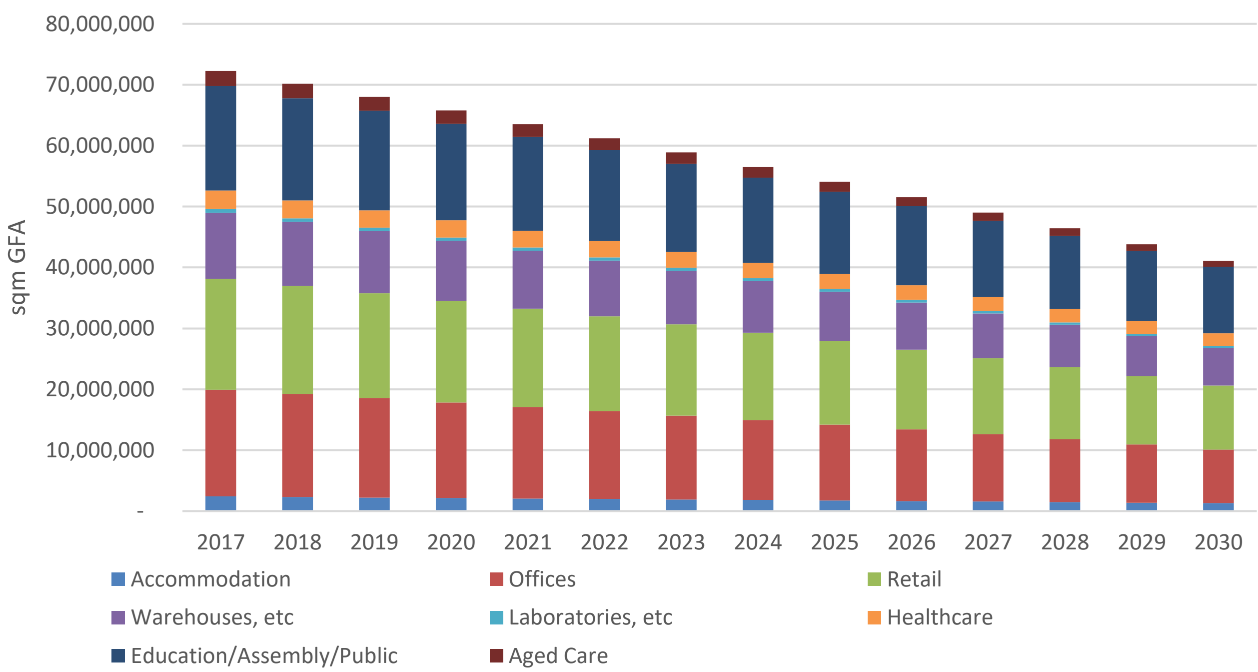


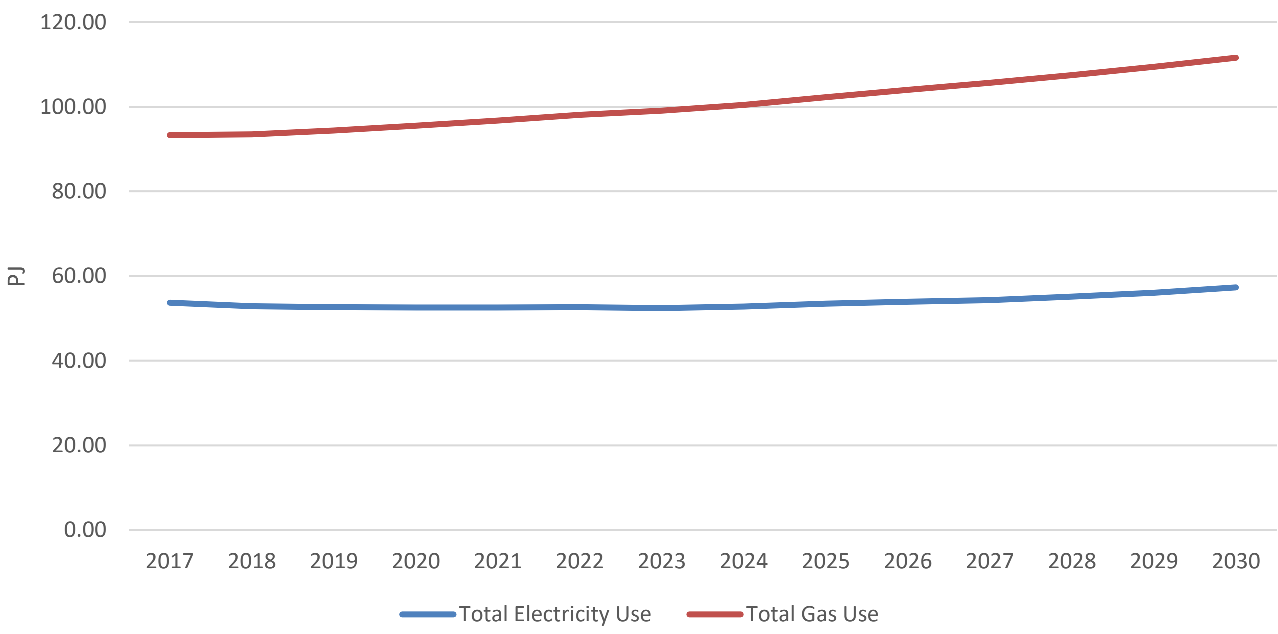
Figure 5: Pre-2018 Stock by Building Class



2.3 Energy Use

To quantify opportunities for electrification in the commercial sector, we want to isolate the historical quantity of gas consumption, in particular, in existing buildings, and project this forward to 2030. Historical (FY2017) energy consumption is drawn from *Australian Energy Statistics* (AES), 2018, Table F, commercial and services sectors, noting that we exclude very minor quantities of LPG and diesel from the analysis. For projections, we utilise forecasts prepared by SPR for the Australian Energy Markets Operator (AEMO). These projections represent a 'business as usual' scenario (AEMO's 'neutral' scenario), and they include the estimated effects of major national and Victorian state policies on energy consumption. The projected gas use represents an unusually high (relative to other states) and also rising share of total energy use in this sector, rising from 42.4% in 2017 to 48.6% in 2030. The high share is attributable to Victoria's cooler climate, extensive gas distribution network and relatively low gas prices, at least historically, while the rising share over time is primarily attributable to the efficiency of electrical end-uses increasingly significantly faster than for gas end-uses.

Figure 6: Total Electricity and Gas Consumption, Commercial & Services Sectors, Victoria



Source: SPR drawing on Australian Energy Statistics, 2018, Table F, and in-house projections

We then estimate the share of this electricity and gas use that is attributable to new and existing (pre-2018) buildings by NCC Class, in order to isolate the expected gas consumption of the existing commercial building stock over this period. This requires that we take a view on the extent to which fuel switching might be expected to occur under 'business as usual', or no new policy, assumptions. As a starting point, we examine the historical trends revealed in AES. Figure 7 shows that, overall, there has been a modest shift towards electricity over this period, with electricity's share rising from 60.7% in FY2001 to 67.1% by FY2007, before falling again to 63.6% by FY2017. Over the period, then, there are two key effects: first, on average there has been modest electrification, equal to about 110 TJ per year, or 0.3% increase in electricity consumption annually. However, the *rate* of fuel switching to electricity declined, on average, over the period. This second effect is more clearly seen in Figure 8. This shows annual fuel switching from gas to electricity, with a positive number meaning a net switch to electricity and a negative number meaning a net switch to gas. In trend terms, it indicates that in FY2002 there was around 500 TJ of energy switching from gas to electricity annually, but this had fallen to around zero by FY2012. Clearly the trend is volatile from year to year, but the overall slowing in the rate of electrification is apparent.

Figure 7: Historical Fuel Mix, Commercial and Services, Victoria

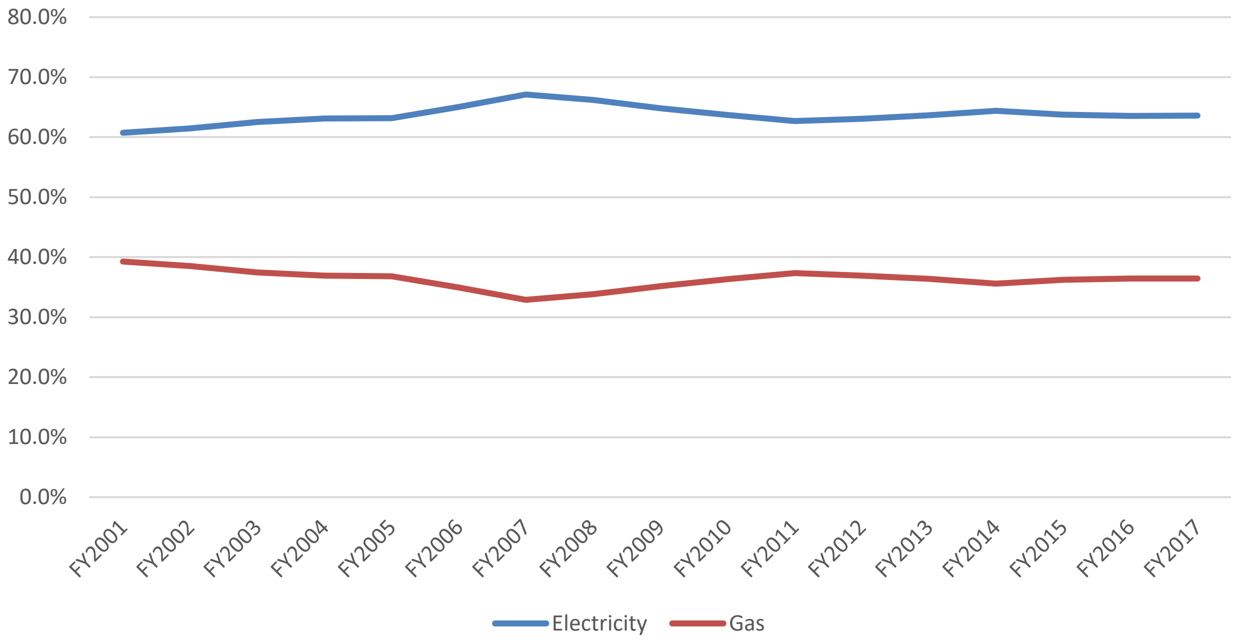
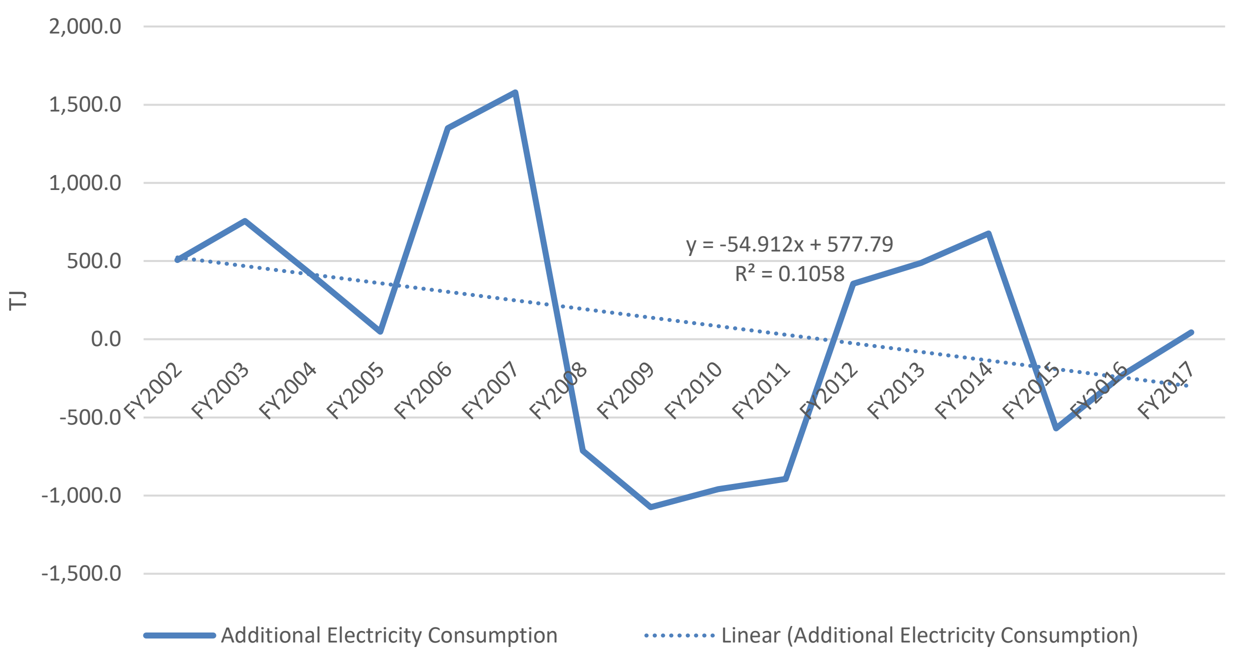
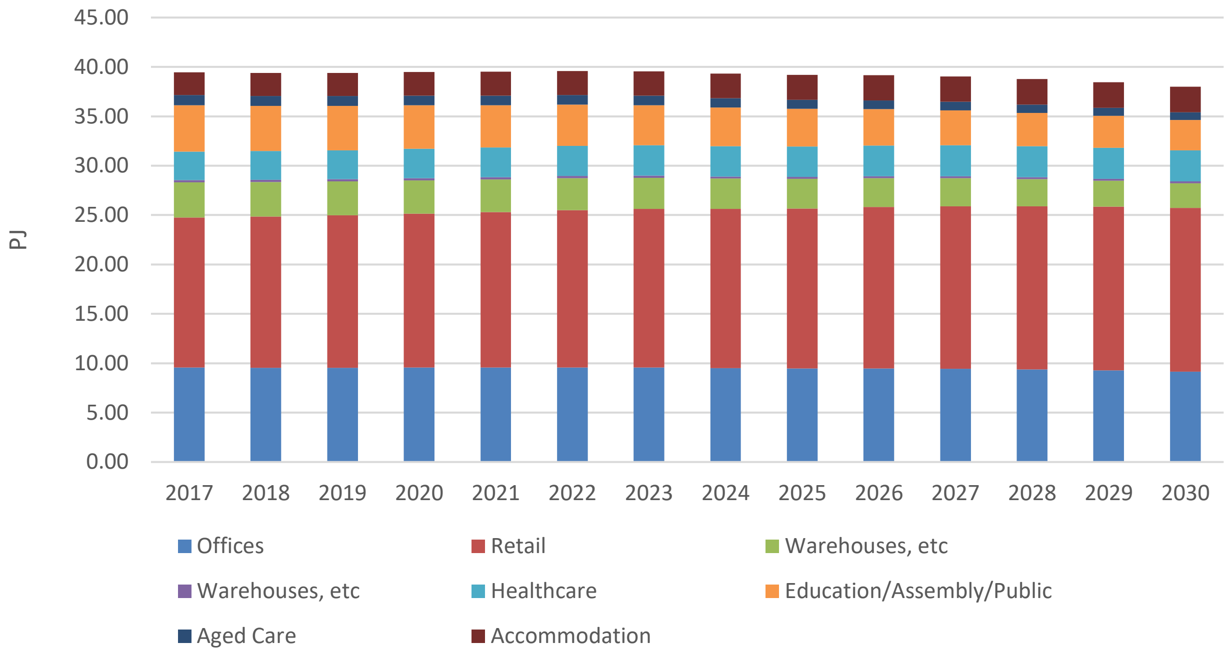


Figure 8: Historical Fuel Switching, Gas to Electricity, Commercial & Services, Victoria



For our 'business as usual' projection of electricity and gas use in the sector, we assume that the starting point matches the average over the historical period (0.3% per year), but that this rate falls slowly (by 0.01 percentage points per year) over the period to 2030. The resulting projection of gas consumption in existing (pre-2018) commercial buildings in Victoria is shown in Figure 9. This shows a small decline in gas consumption to around 38 PJ in 2030. As is discussed further below, this BAU assumption of ongoing, if slowing, electrification is uncertain. Figure 8 could be read as indicating the reverse could be as likely. However, this conclusion would be based on past trends only, while factors discussed in Section 1.2 above are more consistent with ongoing but modest rates of electrification under BAU conditions.

Figure 9: Business as Usual Projection of Gas Consumption, Commercial and Services, Victoria



2.4 Electrification Opportunities

Arup Pty Ltd was retained as a specialist subconsultant to provide technical and costing inputs on 21 specific electrification options that may be suitable – in appropriate applications – in the commercial sector in Victoria. These are summarised in Table 1. The opportunities documented will not represent all the opportunities that may be available, but rather they attempt to cover the major end-uses of gas (and other fossil fuels) in commercial buildings in Victoria, and feasible electrical alternatives.

The opportunities cover the following end-use categories:

1. Space heating
2. Domestic hot water
3. Space cooling
4. Cooking
5. Clothes drying
6. Swimming pool
7. Backup generation
8. Fire Pump.

Table 1: Electrification Opportunities, Commercial Sector

No.	Opportunity	Description
1.1	Split system heat pumps - Air to Air	Small scale DX refrigeration system taking heat from outside air.
1.2	Split system heat pumps - Ground to Air	Medium scale DX refrigeration system taking heat from the ground.
1.3	Split system heat pumps - Water to Air	Medium scale DX refrigeration system taking heat from the water (typically groundwater)
1.4	Variable refrigerant flow (VRF) heat pumps - Air to Air	Small scale DX refrigeration system with variable refrigerant flow for part load conditions, taking heat from outside air.
1.5	Variable refrigerant flow (VRF) heat pumps - Ground to Air	Medium scale DX refrigeration system with variable refrigerant flow for part load conditions, taking heat from the ground.
1.6	Variable refrigerant flow (VRF) heat pumps - Water to Air	Medium scale DX refrigeration system with variable refrigerant flow for part load conditions, taking heat from the water (typically groundwater)
1.7	Electric radiant heaters	Heater giving most of it energy through radiation
1.8	Heat pump - Air to Water	Large scale DX refrigeration system taking heat from outside air.
1.9	Heat pump - Ground to Water	Large scale DX refrigeration system taking heat from the ground.
1.10	Heat pump - Water to Water	Large scale DX refrigeration system taking heat from the water (typically groundwater)
2.1	Heat pump water heater (HPWH)	Hot water tank with integrated heat pump taking the heat from the room air.
2.2	Solar water heater (SWH)	Solar heat collection system for domestic hot water.
3	Solar absorption chiller	Chiller powered by heat instead of a compressor.
4.1	Induction cooktops	Cooktop using a magnetic field for heating
4.2	Electric cooktops	Cooktop using an electric resistance to generate heat
5.1	Electric dryer	Creates hot air to dry clothes using electric resistance
5.2	Heat pump dryer	Dryer with integrated refrigeration circuit
6.1	Pool heat pump heater	DX refrigeration system taking heat from air to heat the pool water
6.2	Solar pool heater	Solar heat collection system for heating pool water
7	Battery backup	Electrochemical storage system
8	Electric fire pump	Fire pump driven by an electric motor

While the end-use of gas and other fossil fuels varies by commercial building type, generally space heating is almost always the dominant use, followed by hot water, and/or end-uses specific to different enterprise or organisation types (cooking in retail, hotels, institution and healthcare; dryers and pools in hotels, etc). It is important to note that many commercial buildings use no gas at all. While the Commercial Building Baseline Study data is now dated (2011 or earlier), we note that of the 3,800 data records for offices, only 873 or 22% used gas. For retail buildings, the figure is as low as 2% and for hospitals/healthcare, as high as 53%.6 Detailed information on gas end-use within commercial buildings is rare, with the Commercial Building Baseline Study being relied upon in this study for want for more recent and relevant data.

Within the opportunity set documented, the first 10 above relate to space heating, in line with this being the key end-use of gas in most cases. Fire pumps and back-up generators were listed as non-fossil fuel (generally diesel) end-uses that could, in principle, be electrified. However, many fire pumps will run from diesel in order to minimise risks of electricity power interruptions during fires. This problem could be overcome with significant battery storage of electricity within buildings – and this could, again in principle, also replace backup diesel generators. However, in the latter case in particular, batteries may need to be large in capacity and therefore expensive, and such investments are unlikely to be made solely on the grounds of electrifying fire pump or back-up generation fossil fuel use. Annual fuel use for these purposes is likely be very low, on average, in any case, and would not merit significant expenditure in a retrofit situation. In new buildings, where the opportunity to avoided diesel fire pump or backup generator costs exists, the situation may be different. Also, the business case for commercial-scale batteries is complex and will primarily driven by electricity tariff structures rather than minor fuel switching opportunities. Therefore these potential opportunities are not further analysed.

For the other end-uses, Arup or SPR has characterised, for each building type and opportunity:

- What percentage of gas end-use could potentially be electrified with this opportunity (eg, replacing a supplemental gas space heater with an electric heater would only replace the share of gas use that is for supplemental heating – which we cap at 20% (estimate), whereas replacing a gas boiler could replace 100% of space heating gas use)
- Which end-use is targeted
- Which building types are expected to be most and least suited
- Could it apply to retrofit applications, new buildings or both?
- The energy efficiency of the base case and of the electrific alternative (expressed dimensionless units equivalent to useful energy out/energy in – eg, a gas space heater may have an energy efficiency of 0.85 (or 85% useful energy (heat) out for energy (gas) in), while a heat pump may have an energy efficiency of 35 (or 350% useful energy (heat/coolth) out for energy (electricity) in
- Annual energy consumption costs for the gas end-use and electrical alternative, both measured in $/kWh (see price assumptions below)
- The installed capital cost in both cases ($/kW of capacity or per-unit, depending upon the end-use).

The model then calculates a number of KPIs including:

[6] COAG NSEE (2012) Data tables.

- the cost difference (undiscounted) after 10 years, being the simple addition of 10 years of energy cost changes and the difference in the capital cost
- the simple payback in years (how many years of energy operating cost savings would it take to offset the additional cost (if any) of the electrical alternative[7]
- Simply payback in years with VEU support (see below)
- Avoided carbon emissions
- Changes in peak electrical demand.

The model examines the attractiveness of the electrification options under two scenarios or assumptions: first, in a new building application or a retrofit application at the end of the equipment's life, where only the *incremental* or *additional* cost of the electrical alternative is relevant; and second, where electrification may be considered in other cases (before the end of the economic life of the equipment in question, then the relevant consideration is the *total* cost.

For any given electrification opportunity, the investment paybacks can vary significantly by building type. This is due to differences in the average size of buildings, the implications of this for the total installed capacity (eg, of space heating), the differing space heating and cooling loads, differing hot water and cooking and other energy requirements. As a result, the model is tailored to examine the paybacks and other KPIs in a unique manner for each building class. To do this, the model draws on a set of assumptions regarding these key factors, as shown in Table 2. These values were largely compiled by Arup drawing on a wide range of sources, as noted in the table, and standard engineering assumptions (eg, with respect to specific energy loads). For some building classes, assumptions had to be made where references were not readily available.

It should be noted, therefore, that the estimates of electrification potentials relate to 'typical' or 'average' buildings and that these values will in fact vary for individual cases and buildings: they are intended to provide general guidance only. In addition, it was necessary to make assumptions about the typical number of more specific items (gas cooktops, dryers, etc) per average building, and these are shown in Table 3. Note that these assumptions are not critical as costs and savings characteristics are defined 'per unit' and can be multiplied by any number as required to estimate saving for different-sized establishments.

For some calculations, it is necessary to estimate this average economic life of equipment, and these assumptions – drawn from a wide range of sources – are shown in Table 4. We note that commercial equipment is often rated in terms of hours of commercial use, rather than years, to reflect the fact that the *intensity* of use of different equipment types (eg, hours per year) will vary greatly from establishment to establishment.

[7] As discussed further below, it is not always the case that the electric option has a higher cost or lower running costs – that varies from opportunity to opportunity. Note that paybacks can only be calculated when there is a higher cost associated with electrification (otherwise the payback is, in effect, a negative number of years).

Table 2: Building-Level Assumptions

Building type	Building gross floor area	Space heating load	Spec. space heating load	Space heating energy (UE)	Spec. space heating energy (UE)	Space cooling load	Spec. space cooling load	Space cooling energy (UE)	Spec. space cooling energy (UE)	DHW heating load	DHW heating energy	DHW cooking energy
[-]	[m^2_{GFA}]	[kW]	[W/m^2_{GFA}]	[MWh/a]	[kWh/m^2_{GFA}]	[kW]	[W/m^2_{GFA}]	[MWh/a]	[kWh/m^2_{GFA}]	[kW]	[MWh/a]	[MWh/a]
NCC 3 - Hotels	**16,621**	**1,163**	70	**2,556**	**154**	**2,078**	125	**2,076**	**125**	152	**444**	**228**
NCC 5 - Offices (base building)	**25,749**	**1,416**	55	**2,651**	**103**	**3,476**	135	**1,996**	**78**	158	**461**	**0**
NCC 9a - Hospitals	**82,625**	**8,262**	100	**6,256**	**76**	**12,394**	150	**12,394**	150	729	**2129**	**0**
NCC 9b - School	**5,512**	**276**	50	**440**	**80**	**0**	0	**0**	**0**	1	**1**	**0**
NCC 6 - Retail	**50,516**	**5,557**	110	**7,577**	150	**7,577**	150	**6,315**	125	34	100	50
NCC 7 - Warehouses	**5,000**	**461**	55	**400**	80	**500**	100	**350**	70	0	0	0
NCC 8 - Laboratories	**1,000**	**92**	50	**103**	103	**135**	135	**78**	78	34	100	0
NCC 9c - Aged care	**20,000**	**1,842**	55	**2,400**	120	**2,700**	135	**1,560**	78	158	461	100
Notes and Sources	*Based on averages from Baseline Study*	*Calculation based on specific load and GFA*	*Australian Constructi on Handbook page 624*	*Calculation based on specific energy consumpti on and GFA*	*-gas use * % of gas for heating + electricity use * % of elec for heating -energy * COP to derive useful energy*	*Calculation based on specific load and GFA*	*Australian Constructi on Handbook page 581*	*Calculation based on specific energy consumpti on and GFA*	*- electricity use * percentage of elec for heating -energy * COP to get the useful energy*	*-annual load factor of 33% or 8h/ day https://www.sciencedirect.com/science/article/pii/S0301421518307249*	*-gas use * percentage of gas for DHW -energy * COP to get the useful energy*	*-gas use * percentage of gas for cooking -energy * COP to get the useful energy*

Source: Arup Pty Ltd, drawing a range of sources as noted.

Table 3: Typical Number of Opportunities/Average Building - Assumptions

	Gas Space Heater (unducted, supplemental)	Gas radiant heaters	Gas Boiler HHW	Gas Boiler DHW	Gas-fired absorption	Gas kitchen cooktops	Gas dryer	Swimming pool gas heater	Backup diesel generator	Fire pumps
Accommodation	0.2	0.1	0.5	0.5	0.01	20	20	0.3	0.8	1
Offices	0.1	0.1	0.1	0.5	0.1	2	0.01	0.05	0.8	1
Retail	0.1	0.1	0.1	0.5	0.1	20	0.01	0.05	0.8	1
Warehouses, etc	0.2	0.1	0.1	0.5	0.01	0	0	0	0.8	1
Laboratories, etc	0.1	0.1	0.1	0.5	0.01	0	0	0	0.8	1
Healthcare	0.1	0.1	1	0.5	0.01	50	50	0.1	0.8	1
Education/Assembly/Public	0.5	0.1	0.1	0.5	0.01	5	0.01	0.2	0.8	1
Aged Care	0.5	0.1	0.2	0.5	0.01	20	10	0.1	0.8	1

Table 4: Average Economic Life Assumptions

Equipment	Economic Life	Equipment	Economic Life
Split system heat pumps - Air to Air	15	Heat pump water heater (HPWH)	13
Split system heat pumps - Ground to Air	20	Solar water heater (SWH)	15
Split system heat pumps - Water to Air	20	Solar absorption chiller	10
Variable refrigerant flow (VRF) heat pumps - Air to Air	20	Induction cooktops	5
Variable refrigerant flow (VRF) heat pumps - Ground to Air	15	Electric cooktops	10
Variable refrigerant flow (VRF) heat pumps - Water to Air	15	Electric dryer	10
Electric radiant heaters	15	Heat pump dryer	10
Heat pump - Air to Water	15	Heat pump heater	10
Heat pump - Ground to Water	20	Solar pool heater	15
Heat pump - Water to Water	15	Battery Backup	10
		Fire pump	15

Various sources

2.4.1 Energy Cost and Emissions Intensity Assumptions

For the purpose of payback and avoided emissions calculations, it is necessary to employ assumptions about prices and emissions intensity values for fuels. The following assumptions, as set out in Table 5. We assume that renewable electricity (eg, sourced via a power purchase agreement) has an emissions intensity of zero.

Table 5: Price and Emissions Intensity Assumptions by Fuel

Fuel combusted	Energy costs	Energy content	Emission factor CO2	Emission factor CH4	Emission factor NO2	Emission factor CO2eq	Emission factor CO2eq
	[$/kWh]		[kg CO2-e/GJ]	[kg CO2-e/GJ]	[kg CO2-e/GJ]	[kg CO2-e/GJ]	[kg CO2-e/kWh]
Natural gas	0.11		51.4	0.1	0.0	51.5	0.19
LPG							
Diesel	0.15		69.9	0.1	0.2	70.2	0.25
Grid-Electricity VIC	0.28						1.16

Source: Arup Pty Ltd drawing on inhouse research and National Greenhouse Accounts Factors Workbook, July 2018

2.4.2 VEU Supports and Payback Periods

For the purposes of making payback calculations with/without VEU support, we made the following assumptions that affect the value of support per MWh switched. These are set up in the model as user-defined variables, to enable DEWLP to model the impact of differing levels of support, emissions factors or deeming periods. With the assumptions shown below, for example, a capital subsidy would have a value of $84 per deemed MWh switched, assuming switching is to emissions-free renewable electricity (10 x 0.7 x 12). This value is then 'grossed up' to a capital value, for a given switching investment, as a function of the savings yield (kWh/kW) and the average capacity installed (kW) for each equipment and building type (see Table 2).

Table 6: VEU Assumptions

Parameter	Units	Value
Value of VEU support	$/t CO2-e	$10
Emissions factors	t CO2-e/MWh	0.7
Deeming period	years	12

Noting that each building type is unique (see Table 2), the resulting investment paybacks for the opportunity set are highly variable by building type, and also sensitive to assumptions. An indicative table of results, for hotels, is shown in Appendix 1, Table 9. This table is for incremental rather total costs. In this case, 9 out of 19 opportunities show a positive undiscounted financial saving after 10 years, while many show negative savings. In 5 cases the electrical alternative has the same or lower capital cost as the gas equivalent, meaning that paybacks cannot be calculated. Those opportunities with positive savings after 10 years also show simple paybacks of 7 years or less, without VEU support, while VEU support as per Table 6 generally reduces paybacks by 2 years or more, depending upon the opportunity. However, for opportunities that are far from economic – see, for example, opportunity 1.2 in Table 9 – VEU support reduces the simple payback from 23.5 years to 22.4 years, which is not a material impact. Opportunities where the above level of VEU support would appear to make a material difference include for split system heat pumps and variable refrigerant flow heat pumps to replace supplemental gas space heating; replacement of gas boilers with different heat pump options; solar absorption chillers for space cooling; and heat pump pool heaters.

Table 10 in Appendix 1 shows similar data as for Table 9 but in this case the paybacks are calculated on the basis of the *total* cost of the electrification opportunity rather than only the incremental cost. This results set is appropriate when electrification is proposed to occur prior to the end of the economic life of existing gas equipment. Predictably, the investment payback periods are longer in all cases on this basis than on the basis of incremental costs only. Opportunity 1.1 (replacing gas supplemental space heating with a split system heat pump), for example, shows simple paybacks of 10.6 years without VEU support and 9.1 years with VEU support, on a total cost basis, as compared to 6.8 years and 5.3 years respectively on an incremental costs basis.

The overall picture that emerges from the opportunity and payback analysis is that financial attractiveness of options, at least on the assumptions made, is highly variable. In some cases, electrification opportunities have no incremental capital costs or even lower costs than gas equivalents. For these, VEU support should not be needed for electrification to occur in the normal course of events, at least at the end of the economic life of the equipment in question. In other cases, the paybacks are too long with or without VEU support for the support to make a material impact on an electrification decision. In the middle is a subset of opportunities – which do vary by building type – where paybacks are no more than 7 years without VEU support and reduced by 2 years for more with it. In such cases, VEU support could have a material impact in inducing switching behaviours.

The model provided to DELWP enables users to select and vary support levels, key assumptions such as deeming periods and emissions factors, preferred opportunities for each end-use type (space heating, space cooling, etc) and to examine results by building type and by incremental or total cost scenario. This functionality will enable DELWP to identify the most attractive combinations of support and switching opportunity for each commercial sector. As described in Chapter 3, the model also can be used to estimate total energy impacts (reduced gas consumption and increased electricity consumption) statewide, by selecting preferred electrification opportunities and expected project uptake (additional to BAU).

3. State-wide Energy and Emissions Impacts

3.1 Opportunity Uptake

Within the scope of this project, we do not attempt to model uptake of specific electrification opportunities with or with VEU support. While this functionality could be added on, it would require – ideally – data to be collected for specific sectors regarding:

- required or minimum-acceptable payback periods
- propensity to consider fuel switching before or only at the end of the economic life of equipment
- co-benefits or else constraints that apply in particular cases or locations (eg, potential electrical network or switchboard upgrade costs)
- other factors that may weigh on switching decisions – building tenure and/or leasing arrangements, actual energy costs faced (cf those modelled here), building operational hours, available down-time for upgrade works, etc.

For the time being, the model enables the user to select, for each building type or sector:

1. which of the opportunities (for each end-use) should be modelled – this decision would generally be based on those with the shortest payback periods, but DELWP may wish to model the impact of particular opportunities even if they do not offer the shortest paybacks;
2. how many projects of each type are expected annually – this would be likely to vary as a function of the degree of VEU support modelled, which in turn will change the payback periods for each opportunity and sector. Second, the relevance of each opportunity for the different sectors must be borne in mind. For example, few offices will have swimming pools attached, so electrification of pool heating for this building type is assumed to be zero.

3.1.1 Indicative Results

SPR has pre-populated the model with assumptions about preferred electrification options and project numbers, but these can be over-ridden by users. Nevertheless, the assumptions provide indicative results in terms of plausible volumes of electrification by commercial building class. One such scenario is summarised in Table 7, including avoided gas consumption (in PJ) by end-use, and increased electricity consumption, by building class. By 2030, this scenario would see a reduction of gas consumption of around 14.5 PJ, offset by increased (renewable) electricity consumption of 7.8 PJ.

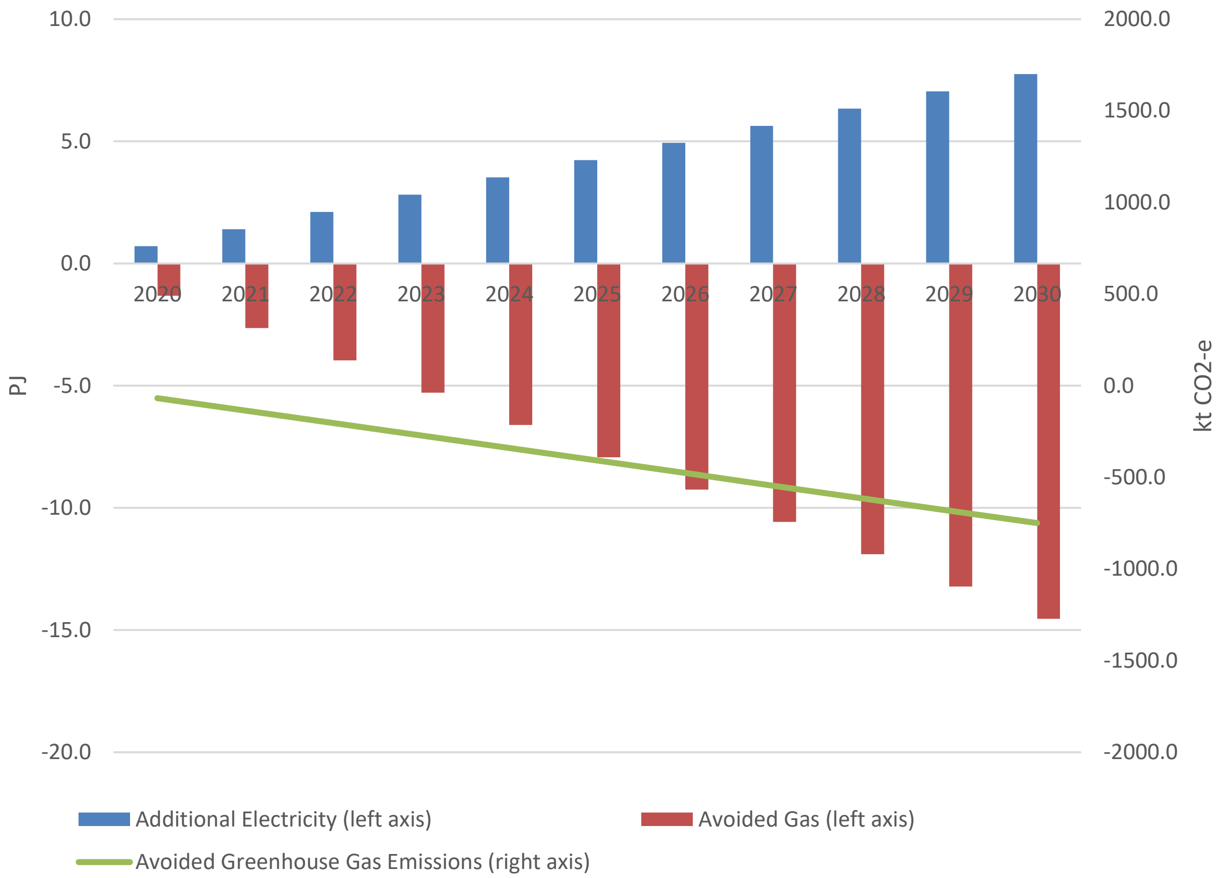
Table 7: Indicative State-Wide Energy Consumption Impacts

Building Class/ End-Use	Best opportunity	No. of projects per year	19-20	20-21	21-22	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30
NCC 3 - Hotels	Avoided Gas Consumption												
Space heating	1.8	5	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5
Domestic hot water	2.1	5	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4
Cooking	4.1	5	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.6	-0.6	-0.7
Clothes drying	5.2	5	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4
Swimming pool	6.2	5	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5
Totals			-0.2	-0.4	-0.7	-0.9	-1.1	-1.3	-1.6	-1.8	-2.0	-2.2	-2.5
NCC 3 - Hotels	Additional Electricity Consumption		0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.2
NCC 5 - Offices (base building)	Avoided Gas Consumption												
Space heating	1.8	10	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-0.9
Domestic hot water	2.1	10	-0.1	-0.1	-0.2	-0.3	-0.4	-0.4	-0.5	-0.6	-0.7	-0.7	-0.8
Cooking			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clothes drying			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swimming pool			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals			-0.2	-0.3	-0.5	-0.6	-0.8	-1.0	-1.1	-1.3	-1.4	-1.6	-1.8
NCC 5 - Offices (base building)	Additional Electricity Consumption		0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7
NCC 6 - Retail	Avoided Gas Consumption												
Space heating	1.8	5	-0.1	-0.2	-0.4	-0.5	-0.6	-0.7	-0.9	-1.0	-1.1	-1.2	-1.3
Domestic hot water	2.1	5	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-1.0	-1.1	-1.2
Cooking	4.1	5	-0.2	-0.4	-0.6	-0.8	-0.9	-1.1	-1.3	-1.5	-1.7	-1.9	-2.1
Clothes drying			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swimming pool			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals			-0.4	-0.8	-1.3	-1.7	-2.1	-2.5	-2.9	-3.3	-3.8	-4.2	-4.6
NCC 6 - Retail	Additional Electricity Consumption		0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.7
NCC 7 - Warehouses	Avoided Gas Consumption												
Space heating	1.1	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Domestic hot water			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clothes drying			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swimming pool			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 7 - Warehouses	Additional Electricity Consumption		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 8 - Laboratories	Avoided Gas Consumption												
Space heating	1.8	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Building Class/ End-Use	Best opportunity	No. of projects per year	19-20	20-21	21-22	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30
Domestic hot water	2.1	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cooking			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clothes drying			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swimming pool			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 8 - Laboratories	Additional Electricity Consumption		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 9a - Hospitals	Avoided Gas Consumption												
Space heating	1.8	3	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.7
Domestic hot water	2.1	3	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6
Cooking	4.1	3	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.8	-0.9	-1.0
Clothes drying	5.2	3	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5
Swimming pool			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals			-0.3	-0.5	-0.8	-1.0	-1.3	-1.5	-1.8	-2.0	-2.3	-2.6	-2.8
NCC 9a - Hospitals	Additional Electricity Consumption		0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7
NCC 9b - School	Avoided Gas Consumption												
Space heating	1.8	10	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
Domestic hot water	2.1	10	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Cooking	4.1	10	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
Clothes drying			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swimming pool	6.2	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
Totals			-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6
NCC 9b - School	Additional Electricity Consumption		0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
NCC 9c - Aged care	Avoided Gas Consumption												
Space heating	1.8	5	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.4
Domestic hot water	2.1	5	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4
Cooking	4.1	5	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6	-0.7
Clothes drying	5.2	5	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3
Swimming pool	6.2	5	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5
Totals			-0.2	-0.4	-0.6	-0.8	-1.0	-1.3	-1.5	-1.7	-1.9	-2.1	-2.3
NCC 9c - Aged care	Additional Electricity Consumption		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1
Total avoided gas	PJ		**-1.3**	**-2.6**	**-4.0**	**-5.3**	**-6.6**	**-7.9**	**-9.3**	**-10.6**	**-11.9**	**-13.2**	**-14.5**
Total additional electricity	PJ		**0.7**	**1.4**	**2.1**	**2.8**	**3.5**	**4.2**	**4.9**	**5.6**	**6.3**	**7.0**	**7.8**
Net energy saving	PJ		**0.6**	**1.2**	**1.9**	**2.5**	**3.1**	**3.7**	**4.3**	**4.9**	**5.6**	**6.2**	**6.8**

The changed energy consumption patterns, and net energy savings, and associated emissions savings, in this scenario are shown in Figure 10. In total, this scenario would avoid 750,000 t CO2-e annually by 2030. These energy and emissions changes are additional to those expected under BAU conditions. As noted, savings could be larger or smaller depending upon the degree of support offered by VEU, and also on actual, as distinct from expected, market-driven or BAU incentives for electrification over this period.

Figure 10: Commercial Sector Electrification Scenario, Victoria



Key energy and emissions impacts for this scenario are summarised in Table 8.

Table 8: Summary Energy and Emissions Impact, Commercial Sector Electrification Scenario, Victoria

Avoided Gas Consumption	Units	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NCC 3 - Hotels	PJ	-0.2	-0.4	-0.7	-0.9	-1.1	-1.3	-1.6	-1.8	-2.0	-2.2	-2.5
NCC 5 - Offices (base building)	PJ	-0.2	-0.3	-0.5	-0.6	-0.8	-1.0	-1.1	-1.3	-1.4	-1.6	-1.8
NCC 6 - Retail	PJ	-0.4	-0.8	-1.3	-1.7	-2.1	-2.5	-2.9	-3.3	-3.8	-4.2	-4.6
NCC 7 - Warehouses	PJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 8 - Laboratories	PJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 9a - Healthcare	PJ	-0.3	-0.5	-0.8	-1.0	-1.3	-1.5	-1.8	-2.0	-2.3	-2.6	-2.8
NCC 9b - Education/Assembly/ Public	PJ	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.5	-0.5	-0.6
NCC 9c - Aged care	PJ	-0.2	-0.4	-0.6	-0.8	-1.0	-1.3	-1.5	-1.7	-1.9	-2.1	-2.3
Total	PJ	**-1.3**	**-2.6**	**-4.0**	**-5.3**	**-6.6**	**-7.9**	**-9.3**	**-10.6**	**-11.9**	**-13.2**	**-14.5**
Additional Electricity Consumption	**Units**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
NCC 3 - Hotels	PJ	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.2
NCC 5 - Offices (base building)	PJ	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7
NCC 6 - Retail	PJ	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.2	2.5	2.7
NCC 7 - Warehouses	PJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 8 - Laboratories	PJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NCC 9a - Healthcare	PJ	0.2	0.3	0.5	0.6	0.8	0.9	1.1	1.2	1.4	1.5	1.7
NCC 9b - Education/Assembly/Public	PJ	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
NCC 9c - Aged care	PJ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1
Total	PJ	**0.7**	**1.4**	**2.1**	**2.8**	**3.5**	**4.2**	**4.9**	**5.6**	**6.3**	**7.0**	**7.8**
Avoided Greenhouse Emissions (assuming renewable electricity)	**Units**											
NCC 3 - Hotels	kt CO2-e	-11.5	-23.0	-34.5	-46.0	-57.5	-69.0	-80.6	-92.1	-103.6	-115.1	-126.6
NCC 5 - Offices (base building)	kt CO2-e	-8.2	-16.4	-24.6	-32.8	-41.0	-49.2	-57.4	-65.6	-73.8	-82.0	-90.2
NCC 6 - Retail	kt CO2-e	-21.5	-43.0	-64.4	-85.9	-107.4	-128.9	-150.4	-171.8	-193.3	-214.8	-236.3
NCC 7 - Warehouses	kt CO2-e	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5	-0.6	-0.7	-0.7
NCC 8 - Laboratories	kt CO2-e	-0.2	-0.3	-0.5	-0.6	-0.8	-1.0	-1.1	-1.3	-1.4	-1.6	-1.8
NCC 9a - Healthcare	kt CO2-e	-13.2	-26.3	-39.5	-52.6	-65.8	-78.9	-92.1	-105.2	-118.4	-131.5	-144.7
NCC 9b - Education/Assembly/Public	kt CO2-e	-2.8	-5.5	-8.3	-11.0	-13.8	-16.6	-19.3	-22.1	-24.8	-27.6	-30.3
NCC 9c - Aged care	kt CO2-e	-10.8	-21.6	-32.4	-43.2	-54.0	-64.8	-75.6	-86.5	-97.3	-108.1	-118.9
Total	kt CO2-e	**-68.1**	**-136.3**	**-204.4**	**-272.5**	**-340.7**	**-408.8**	**-476.9**	**-545.0**	**-613.2**	**-681.3**	**-749.4**

4. Summary and Conclusions

4.1 Summary

Key findings include:

- On average over the period from 2001 – 2017, there has been net fuel switching from gas to electricity in the commercial sector in Victoria. Gas accounted for 39.3% of commercial energy consumption in 2001 and 36.4% in 2017.
- The rate of switching is volatile from year to year, but in trend terms has been falling over time. In 2002, about 500 TJ switched from gas to electricity and, on average, this figure has been falling by about 55 TJ per year. Since 2012, net fuel switching in the sector has tended to be from electricity to gas.
- While there are many opportunities for electrification in the sector, the financial returns (generally measured as simple payback on investment) for those documented are highly variable by opportunity and building type. Indeed, the potentials and economics are likely to vary from enterprise to enterprise.
- In some cases – such as switching from gas to electric radiant heaters, induction cooktops, electric or heat pump dryers – there may be no additional, or even a lower, capital cost for an electric option; in other cases – such as ground- or water-to-air heat pumps replacing gas supplemental heating, there would be a significant premium. Paybacks on investments range from negative (reduced capital cost) to over 100 years in the worst case.
- VEU support levels modelled tend to reduce investment payback periods by 1 – 3 years. For marginal cases (which may be payback periods in the 5 – 10 year range), such support for the investment case could be significant and may well induce switching that would not otherwise occur.
- On a plausible scenario, for example, we could see annual gas savings reaching 14.5 PJ by 2030, offset by additional (renewable) electricity consumption of 7.8 PJ, with a net reduction in energy consumption of 6.8 PJ and avoided greenhouse gas emissions of 750,000 t CO_2-e.

4.2 Conclusions

This report has established that there is significant potential to reduce greenhouse gas emissions in the commercial sector in Victoria by encouraging electrification, using renewable electricity, via the Victorian Energy Upgrades program. However, the expected attractiveness and therefore uptake of opportunities is likely to be highly variable by building type and enterprise. VEU is a voluntary program, so those organisations mostly likely to be benefit from electrification can 'self-select' – provided they are aware of the opportunity of support.

The risk of free-riding (providing support for investments that are likely to have proceeded without the support) exists in some cases, where the investment paybacks are already short. We would suggest that no VEU support is provided for such activities. However, we note that the 'background' or BAU rate of fuel switching to electricity in Victoria's commercial sector appears to have slowed on average over time. Also, many electrification opportunities identified have paybacks of 5 years or more, and these are unlikely to proceed on those terms. Since modelled (and modest) levels of VEU support can, in some cases, reduced paybacks by 1 – 3 years, then such support could well be material and effective in inducing additional electrification.

Appendix 1: Data Tables

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Table 9: Example of Detailed Analysis by Opportunity: Hotels: Incremental Cost Scenario

Opportunity No.	Share of End-Use Captured in Opportunity	Existing carbon source	Replace with	End Use Category	Efficiency - base case	Efficiency - electrification case	Energy costs - base case	Energy costs - electrification case	Installed capital cost - base case	Installed capital cost - electrification case	Value of VEU subsidy	Costs difference after 10 years (simplified without inflation, maintenance or energy cost increase)	Simple Payback without VEU support	Simple payback with VEU support
							[$/kWh$_{FE}$]	[$/kWh$_{FE}$]	[$/kW]	[$/kW]	[$/kW]	[k$]	Years	Years
1.1	**20%**	Gas Space Heater (unducted, supplemental)	Split system heat pumps - Air to Air	Space heating	0.85	3.5	0.12	0.08	361	1000	140	**352**	**6.8**	**5.3**
1.2	**20%**	Gas Space Heater (unducted, supplemental)	Split system heat pumps - Ground to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**23.5**	**22.4**
1.3	**20%**	Gas Space Heater (unducted, supplemental)	Split system heat pumps - Water to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**23.5**	**22.4**
1.4	**20%**	Gas Space Heater (unducted, supplemental)	Variable refrigerant flow (VRF) heat pumps - Air to Air	Space heating	0.85	3.5	0.12	0.08	361	1000	140	**352**	**6.8**	**5.3**
1.5	**20%**	Gas Space Heater (unducted, supplemental)	Variable refrigerant flow (VRF) heat pumps - Ground to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**23.5**	**22.4**

Opportunity No.	Share of End-Use Captured in Opportunity	Existing carbon source	Replace with	End Use Category	Efficiency - base case	Efficiency - electrification case	Energy costs - base case	Energy costs - electrification case	Installed capital cost - base case	Installed capital cost - electrification case	Value of VEU subsidy	Costs difference after 10 years (simplified without inflation, maintenance or energy cost increase)	Simple Payback without VEU support	Simple payback with VEU support
1.6	**20%**	Gas Space Heater (unducted, supplemental)	Variable refrigerant flow (VRF) heat pumps - Water to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**23.5**	**22.4**
1.7	**10%**	Gas radiant heaters	Electric radiant heaters	Space heating	0.85	1	0.12	0.28	209	209	28	**-4062**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
1.8	**100%**	Gas Boiler HHW	Heat pump - Air to Water	Space heating	0.85	3.5	0.12	0.08	72	250	140	**887**	**1.9**	**0.4**
1.9	**100%**	Gas Boiler HHW	Heat pump - Ground to Water	Space heating	0.85	4.5	0.12	0.06	72	875	150	**619**	**6.0**	**4.9**
1.10	**100%**	Gas Boiler HHW	Heat pump - Water to Water	Space heating	0.85	4.5	0.12	0.06	72	875	150	**619**	**6.0**	**4.9**
2.1	**100%**	Gas Boiler DHW	Heat pump water heater (HPWH)	Domestic hot water	0.85	2.5	0.12	0.11	500	3500	122	**-410**	**97.4**	**93.5**
2.2	**100%**	Gas Boiler DHW	Solar water heater (SWH)	Domestic hot water	0.85	10	0.12	0.03	500	3750	169	**-71**	**11.7**	**11.1**

Opportunity No.	Share of End-Use Captured in Opportunity	Existing carbon source	Replace with	End Use Category	Efficiency - base case	Efficiency - electrification case	Energy costs - base case	Energy costs - electrification case	Installed capital cost - base case	Installed capital cost - electrification case	Value of VEU subsidy	Costs difference after 10 years (simplified without inflation, maintenance or energy cost increase)	Simple Payback without VEU support	Simple payback with VEU support
3	**5%**	Gas-fired absorption	Solar absorption chiller	Space cooling	1.2	7.5	0.09	0.04	478	917	155	**121**	**8.8**	**5.7**
4.1	**100%**	Gas kitchen cooktops	Induction cooktops	Cooking	0.4	0.9	0.26	0.31	1400	1300	103	**0**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
4.2	**100%**	Gas kitchen cooktops	Electric cooktops	Cooking	0.4	0.75	0.26	0.38	1400	2800	86	**-2**	**16.8**	**15.8**
5.1	**100%**	Gas dryer	Electric dryer	Clothes drying	0.85	1	0.12	0.28	2000	500	28	**1**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
5.2	**100%**	Gas dryer	Heat pump dryer	Clothes drying	0.85	2.2	0.12	0.13	2000	2000	113	**0**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
6.1	**100%**	Swimming pool gas heater	Heat pump heater	Swimming Pool	0.85	3.5	0.12	0.08	212.5	300	140	**5**	**2.7**	**-1.6**
6.2	**100%**	Swimming pool gas heater	Solar pool heater	Swimming Pool	0.85	10.0	0.12	0.03	212.5	190	169	**15**	**Lower/ equal capital cost**	**Lower/ equal capital cost**

Table 10: Example of Detailed Analysis by Opportunity: Hotels: Total Cost Scenario

Opportunity No.	Share of End-Use Captured in Opportunity	Existing carbon source	Replace with	End Use Category	Efficiency - base case	Efficiency - electrification case	Energy costs - base case	Energy costs - electrification case	Installed capital cost - base case	Installed capital cost - electrification case	Value of VEU subsidy	Costs difference after 10 years (simplified without inflation, maintenance or energy cost increase)	Simple Payback without VEU support	Simple payback with VEU support
							[$/kWh$_{FE}$]	[$/kWh$_{FE}$]	[$/kW]	[$/kW]	[$/kW]	[k$]	Years	Years
1.1	**20%**	Gas Space Heater (unducted, supplemental)	Split system heat pumps - Air to Air	Space heating	0.85	3.5	0.12	0.08	361	1000	140	**352**	**10.6**	**9.1**
1.2	**20%**	Gas Space Heater (unducted, supplemental)	Split system heat pumps - Ground to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**26.2**	**25.1**
1.3	**20%**	Gas Space Heater (unducted, supplemental)	Split system heat pumps - Water to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**26.2**	**25.1**
1.4	**20%**	Gas Space Heater (unducted, supplemental)	Variable refrigerant flow (VRF) heat pumps - Air to Air	Space heating	0.85	3.5	0.12	0.08	361	1000	140	**352**	**10.6**	**9.1**
1.5	**20%**	Gas Space Heater (unducted, supplemental)	Variable refrigerant flow (VRF) heat pumps - Ground to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**26.2**	**25.1**

Opportunity No.	Share of End-Use Captured in Opportunity	Existing carbon source	Replace with	End Use Category	Efficiency - base case	Efficiency - electrification case	Energy costs - base case	Energy costs - electrification case	Installed capital cost - base case	Installed capital cost - electrification case	Value of VEU subsidy	Costs difference after 10 years (simplified without inflation, maintenance or energy cost increase)	Simple Payback without VEU support	Simple payback with VEU support
1.6	**20%**	Gas Space Heater (unducted, supplemental)	Variable refrigerant flow (VRF) heat pumps - Water to Air	Space heating	0.85	4.5	0.12	0.06	361	3500	150	**-2099**	**26.2**	**25.1**
1.7	**10%**	Gas radiant heaters	Electric radiant heaters	Space heating	0.85	1	0.12	0.28	209	209	28	**-4062**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
1.8	**100%**	Gas Boiler HHW	Heat pump - Air to Water	Space heating	0.85	3.5	0.12	0.08	72	250	140	**887**	**2.7**	**1.2**
1.9	**100%**	Gas Boiler HHW	Heat pump - Ground to Water	Space heating	0.85	4.5	0.12	0.06	72	875	150	**619**	**6.6**	**5.4**
1.10	**100%**	Gas Boiler HHW	Heat pump - Water to Water	Space heating	0.85	4.5	0.12	0.06	72	875	150	**619**	**6.6**	**5.4**
2.1	**100%**	Gas Boiler DHW	Heat pump water heater (HPWH)	Domestic hot water	0.85	2.5	0.12	0.11	500	3500	122	**-410**	**113.7**	**109.7**
2.2	**100%**	Gas Boiler DHW	Solar water heater (SWH)	Domestic hot water	0.85	10	0.12	0.03	500	3750	169	**-71**	**13.5**	**12.9**

Opportunity No.	Share of End-Use Captured in Opportunity	Existing carbon source	Replace with	End Use Category	Efficiency - base case	Efficiency - electrification case	Energy costs - base case	Energy costs - electrification case	Installed capital cost - base case	Installed capital cost - electrification case	Value of VEU subsidy	Costs difference after 10 years (simplified without inflation, maintenance or energy cost increase)	Simple Payback without VEU support	Simple payback with VEU support
3	**5%**	Gas-fired absorption	Solar absorption chiller	Space cooling	1.2	7.5	0.09	0.04	478	917	155	**121**	**18.4**	**15.3**
4.1	**100%**	Gas kitchen cooktops	Induction cooktops	Cooking	0.4	0.9	0.26	0.31	1400	1300	103	**0**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
4.2	**100%**	Gas kitchen cooktops	Electric cooktops	Cooking	0.4	0.75	0.26	0.38	1400	2800	86	**-2**	**33.6**	**32.6**
5.1	**100%**	Gas dryer	Electric dryer	Clothes drying	0.85	1	0.12	0.28	2000	500	28	**1**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
5.2	**100%**	Gas dryer	Heat pump dryer	Clothes drying	0.85	2.2	0.12	0.13	2000	2000	113	**0**	**Lower/ equal capital cost**	**Lower/ equal capital cost**
6.1	**100%**	Swimming pool gas heater	Heat pump heater	Swimming Pool	0.85	3.5	0.12	0.08	212.5	300	140	**5**	**9.3**	**5.0**
6.2	**100%**	Swimming pool gas heater	Solar pool heater	Swimming Pool	0.85	10.0	0.12	0.03	212.5	190	169	**15**	**Lower/ equal capital cost**	**Lower/ equal capital cost**

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