Zero Net Emissions by 2030

Zero Emission Retrofits in Mount Alexander Shire

Document Revision Control

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Zero Net Emissions by 2030

1. Introduction

Mount Alexander Sustainability Group has set a target of Zero Net Emissions (ZNET) by 2030. While it has a number of projects underway in other sectors, the aging rural housing stock must be brought up to a low emissions standard to enable us to achieve this. The focus is not on cost payback but on emission reduction, although the cost effectiveness of measures will inform the retrofit choices made.

In keeping with a ZNET strategy, we would be looking to move households away from gas wherever possible, or at least, to create a viable path for them to make this move in the near future. The gas supply charge, typically about $350 per year, would thus be saved. Disconnection costs are one-off and are capped at $220.

We have sought 5 sets of data to enable us to plan this.

1. DELWP Scorecard data for central Victoria
2. REMPLAN community census data
3. MASG Renew Survey
4. Sustainability Victoria's Comprehensive Energy Efficiency Retrofits to Existing Victorian Houses
5. Mount Alexander Shire Development Services data

This has enabled us to identify a population of houses we can draw on, identify the likely retrofits they would need and develop a budget to enact such retrofits.

We have also consulted widely with experts within Sustainability Victoria, DELWP, BZE, NatHERS, and experts in this sector, Alan Pears and Euan Williamson.

We maintain that if we can bring poor performing houses up to NatHERS 6 Stars (approximately 6 stars or more under the Residential Efficiency Scorecard (RES)), then the addition of Solar PV on these can bring them to a near ZNET target rating of 9 or 10 RES.

The houses assessed in SV's study on the Energy Efficiency Upgrade Potential of Existing Victorian Houses, found an average NatHERS star rating of 1.81 for pre-2005 houses, and an average rating of 1.57 for the pre-1991 houses. Note the Residential Efficiency Scorecard (RES) rating averages 3 stars, possibly a little lower if only pre 1991 houses are studied.

From 1991, houses will continue to be poorly insulated and generally energy inefficient despite some BCA standards applied. However, there are 2 major steps in the energy efficiency of the housing stock after this. These are the introduction of mandatory 5 star NatHERS rating in 2004 and of 6 stars in 2010. Given the delay between Building Approval and the actual build completion, these can be considered effective from 2005 and 2011 respectively. Mount Alexander Shire Development Services have provided number of approvals in these categories. Its possible some may not have proceeded but these would be very few.

- 2005 – 2011 521
- 2011 – 2020 1264
- Estimate based on 125 houses per year would suggest that between 1991 and 2004 inclusive would mean 1,750 houses built in this period.
- This would leave 6,720 built prior to 1991 or 75% of the housing stock.

Given the time passed since this, it would be prudent to assume some houses would have had ceiling insulation upgrades and so our pre-1991 target could be assumed to be rated at 1.8 by a NatHERS assessment. Typically, this would require approximately 660MJ/m^2 or 66,000 MJ of energy to be output in a year by the heating and cooling systems to achieve comfort in the Central Victorian climate zone for a 100m^2 dwelling. A NatHERS 6 star house in the climate zone, would require approximately 222 MJ/m^2. Thus a 100m^2 house would need 22,200 MJ of energy to be output by the heating and cooling systems in a year to achieve comfort in the Central Victorian climate over the year. The NatHERS 5 Star house, as achieved by the SV Retrofits, would require of the order of 250MJ/m^2 or 25,000MJ to be output by the heating and cooling system to achieve comfort over the year for this house. If a NatHERS 6 star is the retrofit target, then zero net emissions will look at how that comfort (22,200MJ of heating and cooling output) can be achieved efficiently and how that energy is generated.

Based on SV and DHHS studies, we have arrived at what seem to be reasonable assumptions for energy usage in unrenovated rural housing. An assumption is made for an average household of 59,800 MJ/yr for natural gas and 4,160 kWh for electricity. The ghg coefficient for electricity is declining and now sits at around 1.03 kg/kWh, and the coefficient for natural gas is 0.05543 kg/MJ. A house with this level of consumption would produce around 7.6 tonnes of CO2-e per year at the moment.

We are not seeking to replicate the studies already undertaken, but to embark on a project to apply the knowledge already documented by Sustainability Victoria to the task of raising the standard of the Shire's existing housing stock. The SV project did not model every upgrade possibility and we would seek to expand this to achieve the higher performance.

To quote from the SV report, "SV's *OGA* study identified a significant energy saving and greenhouse gas abatement potential in Victoria's existing housing stock from energy efficiency upgrades: average gas savings of 29,229 MJ per year, or 58% of average household gas use; average electricity savings of 5,563 MJ per year (1,544 kWh per year), or 33% of average household mains electricity use; and, average greenhouse gas abatement of 3.4 tonnes $CO_{2\text{-}e}$ per year, 41% of average household greenhouse gas emissions from energy end-use."

Note we are aiming at achieving 6 star, not the 5 stars of the SV program and would anticipate average emissions savings of the full 7.6 tonnes $CO_{2\text{-}e}$ per dwelling, once solar PV is included..

As reported on by Ian McNicol of Sustainability Victoria, there are a range of benefits that could come from the MASG retrofit program, some will go to the householders and some will go to society more generally.

Following the retrofit there will be a range of savings "streams", including:

- **Energy bill savings:** If you undertake a comprehensive upgrade to the building shell (insulation and draught sealing), major appliances such as heating and water heating, and add rooftop PV this energy bill saving could be very large.
- **Improved thermal comfort and thermal safety:** A comprehensive building shell upgrade should significantly improve the natural thermal comfort of the home in winter, and should also improve the thermal comfort in summer as long as it has good shading. This would be expected to translate to a significant health benefit and reduced medical costs for the households, especially

the low income households in the least efficient houses – some of this will reduce household medical expenses and some will reduce government health costs. Studies have been undertaken by the respected UK organisation the Building Research Establishment, who have undertaken work on this for the UK government and the European Union. They estimated that the investment in measures to reduce the risk of houses being too cold or too hot (e.g. mainly building shell upgrades) resulted in a 7.1 year payback based on the reduced medical costs to the NHS system.

- **Reduced greenhouse gas emissions:** The on-going greenhouse gas savings due to the energy savings have an economic value. One issue is that over time Victoria's electricity supply will become much less greenhouse intensive, so the greenhouse savings from efficiency upgrades that reduce electricity consumption and the greenhouse offset provided by the rooftop PV system will reduce over time. On the flip side, the economic value of the greenhouse gas savings – expressed in $ per tonne of carbon-dioxide equivalent (CO2-e) will increase.
- **Reduced electrical peak demand:** The building shell, appliance and PV upgrades reduce the electricity demand of the houses. This can be on the peak (hottest) summer day and also the peak (coldest) winter days. This reduction in demand reduces the future investment required in the electricity generation and supply infrastructure. For Victoria this is currently estimated as $1,050 per kW. Victoria currently has it's highest electricity demand on hot summer days. However, if there is a strong trend towards electrification of gas heating, water heating and cooking, this could add significantly to the morning and evening electricity demand peaks in winter. In this case, building shell and heating efficiency upgrades will be an important way to manage the growth in this peak demand.
- **Economic stimulus to build back better**: Another great benefit is the economic stimulus a large-scale retrofit project can provide. The recent IEA *Sustainable Recovery* report found that of all the energy-related measures that they studied, the retrofit of existing buildings and the installation of rooftop PV systems generated the most employment. This work tends to be quite labour intensive. Also, the building shell upgrades could make use of locally produced products, so this could increase local manufacturing. This work is great for our local economy providing jobs across a range of skills and services.
- **Get off gas:** Shortfalls have been predicted in Victoria's natural gas supply as early as 2023 (in the worst case) and 2024. Measures that significantly improve the efficiency of gas use (e.g. building shell and heating upgrades), or the replacement of gas appliances with high efficiency electrical ones could be one way for Victoria to reduce it's gas demand. Note there is no clean way of producing and delivering gas likely to be available in the life of this project and as usage of gas drops in industrial use, we would expect it to become more expensive to the householder.

The Victorian Environmental Upgrade programme has not been taken up by the shire for residential buildings. It seems unlikely any shires will take this up. However Clean Energy Finance Corporation funds are being made available through major Financial institutions. It is hoped that these will be structured such that our target houses can be met and that loans provided will be able to be over a period so as to see payments met by electricity/gas savings.

We acknowledge that income and cost data is at a snapshot in time. We believe that the movement in these to today will maintain the same relativity.

2. Selecting the Houses

The data below sets out the criteria for selecting houses and associating a retrofit to them from the trial houses in the SV exercise. Note that our focus is on the house not the householder, who may be transient. To achieve our ZNET target it is the houses we must upgrade.

In saying this however, there needs to an awareness of energy efficiency by the householder which will translate in sustainable practises and therefore houses selected will require a willingness by the householder to embrace this.

The REMPLAN community 2016 Census data gives some statistics for Mount Alexander Shire. This shows:

- 75% of residents are in houses that are owned outright or with a mortgage.
- 16% of residents are in houses that are rentals or occupied rent free.

This also shows that family income:

- 19% have a household income less than $41,599
- 48% have a household income less than $77,999
- 55% have a household income of less than $90,999

While this is not clear in the REMPLAN statistics obtained, if we assumed 2.5 people on average per household, as suggested in MASG-RENEW data, we would have about 7,000 households. Council rate records project approximately 10,255 houses in 2020. Note we know from Building Approvals that 2,000 of these have been built under 5 Star or 6 Star regulations. Of the 10,255:

- 19% (approximately 2,000) would have a household income below $41,599,
- 48% (approximately 4,900) would have an income of less than $77,999,
- 55% (approximately 5,600) an income less than $90,999.
- This leaves 45% (approximately 4,625) with a household income in excess of $90,999.

We know from the MASG- RENEW survey that slightly over 30% of owner/occupiers are over 64 years of age and possibly on fixed incomes. Approximately 55% are aged between 40 and 65 years of age. We also know that some 75% have more than one person in the household with 60% being a couple with or without children living at home. Some of these lower incomes, particularly where over 64, may be asset rich, and income poor. Other of the lower income brackets will be tenants and it will be difficult, but not impossible, to bring their landlords into the scheme.

Typically:

- Retirees, on fixed incomes will not require or be eligible for commercial finance but may still benefit from access to the programme
- Pensioners will not be eligible for commercial finance and, as they already receive discounted rates, may not be able to pay back a substantial figure. Government assistance would be required to include these.
- Working low to middle income earners are the more obvious targets if they can satisfy commercial lenders that they can service the loans.

Taking this into account we would expect few of the less than $41,599 income bracket to be eligible and perhaps 75% of those in the next brackets of less than $77,999 to eligible. This would leave 3525 houses in the target population.

The DELWP data shows that approximately 50% of the housing stock who undertook Scorecard assessments were in houses of pre 1991 vintage. Brick Veneer (BV) represented 40% of these and Weatherboard /Lightweight construction 47%. Weatherboard/Lightweight (WB/LW) houses tend to have poorer thermal comfort and lower NatHERS ratings than brick-veneer houses of the same size/era. They cool down more quickly in winter, and they heat up more quickly in summer. They tend to have higher heating/cooling energy consumption and bills, creating a bigger health risk for low income households who can't afford to heat/cool them adequately. The other 13% were mainly double brick or concrete and are excluded initially as it will be too hard to come up with common solution to these that is going to be acceptable. Post 1991, BV houses represent more than 90% of the houses.

We propose to target the BV and WB/LW houses (87%) that were built before 1991 (6,720), have a household income up to $77,999 (48%) and have an owner aged between 40 and 65 (55%).

Estimated House Target Calculated: 6,720 x 87% x 48% x 55% = 1,543

A realistic target is thought to be 500 houses.

This is because we anticipate that there may be houses excluded as they have already undertaken significant upgrades, thus rendering them a low priority. Others may not be willing to take on electrification and other significant upgrades. Should we fail to select 500 in the nominated group, we will select houses in the next category, those before 2005, beyond which houses were required to be rated at a minimum of 5 stars under NatHERS.

This is in addition to the selected 10 to be retrofitted in the Pilot.

3. Assessing Likely Costs

We have considered the research done by Ian McNicol at Sustainability Victoria in the trial comprehensive retrofits of 14 houses. These retrofits generally included the addition of wall and underfloor insulation where possible, ceiling insulation top-ups, comprehensive draught sealing, and upgrades to the heating system (most had ducted gas heating). In some cases, the lighting, water heater and major appliances such as the refrigerator were also upgraded. Some of these house types have been ignored as being rare in rural Victoria or rare in low income households. The lightweight/WB constructed houses, generally being older, will likely have more complex retrofit needs.

https://www.sustainability.vic.gov.au/About-Us/Research/Household-retrofit-trials

a) BV Houses selected are:

- 1940's CR8 Cost $21,120
- 1950's CR12 Cost $11,375
- 1960's CR13 ` Cost $10,741
- 1970's CR4, CR11 Cost $10,602, $12,683
- 1980's CR10 Cost $13,143

DELWP Scorecard Data of BV houses in Central Vic. (Note BV are rare before 1961)

Age	Houses	Percentage of total house assessments
1941-1960	4	1%
1961-1980	34	12%
1981-1990	33	12%

b) Lightweight/WB Houses:

- 1910's CR7 Cost $12,927
- 1920's CR6 Cost $13,070
- 1950's CR9 Cost $13,054

DELWP Scorecard Data of WB houses in Central Vic. (Note WB are rare after 1981)

1901-1920	15	5%
1921-1940	12	4%
1941-1960	29	10%
1961-1980	14	5%

Houses have been taken from the table of retrofit trial houses below. Those not included have not been considered as a good fit for the Central Victorian house populations.

Table 4: Building shell characteristics of the *Comprehensive Retrofit Trial* houses

House	Floor area (m^2)	Decade house built	Ceiling / roof		External walls		Floor		Air leakage rate (ACH)
			Type	Insulation	Type	Insulation	Type	Insulation	
CR1	176	2000	Metal	R2.0	Brick veneer	RFL	Slab on ground	None	0.99
CR2	216	1990	Tiled	R1.5	Brick veneer	None	Suspended timber	None	0.83
CR3	235	1990	Tiled	R2.5	Brick veneer	RFL	Slab on ground	None	0.87
CR4	98	1970	Tiled	R2.0	Brick veneer	None	Suspended timber	None	0.86
CR5	80	1980	Metal	None	Cavity brick	None	Slab on ground	None	1.57
CR6	122	1920	Metal	R1.0, poor coverage	Weather-board	None	Suspended timber	None	1.88
CR7	126	1910	Metal	R3.2	Weather-board	None	Suspended timber	None	1.20
CR8	130	1940	Tiled	R2.0	Brick veneer	None	Suspended timber	None	1.89
CR9	122	1950	Tiled	R1.5 to R2.0	Weather-board	None	Suspended timber	Living areas	2.09
CR10	174	1980	Tiled	R3.0	Brick veneer	RFL	Suspended timber	None	1.02
CR11	70	1970	Tiled	R2.0, gaps	Brick veneer	None	Suspended timber	10m^2 insulated	2.10
CR12	80	1950	Tiled	R2.5	Brick veneer	None	Suspended timber	None	2.30
CR13	114	1960	Tiled	R2.0	Brick veneer	None	Suspended timber	None	1.70
CR14	101	1960	Tiled	R4.0 in some areas	Brick veneer	None	Suspended timber	None	0.98

While this suggests that we should be expecting Retrofits to cost in the order of $14,000 on average, it should be noted that in many of these trial cases, they have been retrofitted with more efficient gas appliances. We intend to move these away from gas by moving inefficient hot water services to electric heat pumps and inefficient gas ducted heating systems to reverse cycle heat pumps.

The following sections 4 and 5 show the impacts that such a change will have on the cost projections.

4. Typical Retrofit Actions

a. Lighting

LED fittings will replace any incandescent, halogen, compact fluorescents and fluorescent tubes. Good quality LEDs are now much more efficient than CFLs and provide higher quality service. These will reduce energy consumption. Where recessed downlights are found, they will be replaced by LED IC-4 compliant downlights which will also enable repair of ceiling insulation by sealing of insulation penetrations.

b. Draught Sealing

Draughts will be sealed where found. They will typically be around doors and windows but can include wall vents, ceiling vents and exhaust fans, poorly fitting skirting boards, poorly ducted heaters and evaporative coolers. There can be tricky leaks such as open areas above built-in wardrobes. Ideally a blower door test should guide action. We would be seeking to achieve the current construction code standard of 10ACH at 50Pa as a minimum but will target 7ACH at 50Pa.

In conjunction to the draught sealing, we will ensure that the houses have adequate provision for controlled ventilation (e.g. exhaust fans) in areas such as bathrooms, laundry, kitchen and toilets, and that care will be taken where houses have gas appliances. One advantage of electrification is that it means we don't have to worry about the safety issues associated with unflued or open flued gas heating.

c. Ceiling Insulation

Ceiling insulation is the primary contributor to energy efficiency. However before retrofitting a solution, we must ensure that we have minimized the ceiling penetrations from lighting and vents as described previously. Ceiling insulation could be topped up or replaced depending on the condition of the existing insulation. We would seek to achieve a minimum of R4.

d. Floor Insulation

Floor insulation is an important contributor. Sometimes there will not be sufficient sub floor room to install such insulation. Where possible, R2 Extruded Polystyrene insulation can be installed. The sub floor should also be made "enclosed" by cladding the subfloor walls to leave only the mandatory ventilation. This maybe done inside the bargeboards or by replacing these boards with metal or FCD sheet.

e. Wall Insulation

This is the most difficult task but maybe necessary to achieve the optimum result. There will be some instances where it may be justified to reclad the walls, thus providing the opportunity to fit R2.5 batt insulation. In other cases, it will be necessary to install insulation by a blow in process. This is a specialist task and requires expertise to ensure the wall cavities are filled. Some installers drill holes either into weatherboards or in plasterboard, fill the holes and repaint. Linking wall insulation to planned internal or external repainting (via painting contractors) may reduce costs of repairing the holes, as special repainting would not be required. Electrical safety checks will be undertaken prior to any wall insulation work, to ensure that any electrical wiring present can be safely covered with insulation. As a compromise, we would focus on the living areas.

Condensation is to be avoided and must be considered when planning a solution.

Where acceptable, specifically for brick cavity and double brick walls, an inside layer such as Kingspan K18, which is EPS lined with plaster board may be used.

Should an acceptable solution not be found, the lack of wall insulation can be compensated for by an increase in ceiling insulation.,

f. Retrofit Double Glazing and Shading

Glazing is a great source of heat loss and gain. The focus will be on the living areas. Bedrooms don't need to be heated to the same degree as a living area and heat gained in these does not matter so much as they are considered to be normally occupied only at night. Bathrooms and laundry doors can be closed. The first exercise will be to look at shading to the north, east and west. Fitting of external shading devices may be necessary and can be a relatively cheap option. Shading of west bedroom windows can be very useful to limit discomfort on summer nights.

We would then look at retrofitting a second panel of Perspex or glass on these living room windows. There are a number of commercial products that can be considered. Low E films may be appropriate in some instances and more likely would be applied to bedrooms. In some instances, reglazing of windows with Low E and or laminated glass such as Comfort Plus may be an option.

Heavy drapes and pelmets will reduce the heat loss in winter and are an option that can be considered. They will not help to keep heat out in summer however as the heat will have already penetrated the glass. Similarly cellular or honeycomb blinds may be fitted to limit winter heat loss.

g. Heating Electrification

Many of the houses will have ducted gas heating. Where these are older units with inadequate ducting, rather than upgrade these we would look to replace them with Reverse Cycle heat pump units. This would give us the opportunity to remove vents and ducts. In some instances, an owner may elect to install a ducted or a 'multi-head' unit with several split system units but the cost of this would mean the owner would have to justify this. It may be that 2 or 3 reverse cycle units may replace the ducted system economically. Many homes may already have one or more split systems that people don't realise can be used for heating. Existing units should have filters checked and efficiency evaluated from information on specification plates or manufacturer websites.

h. Hot Water Electrification

Gas hot water systems, storage or instant, will be replaced by an electric heat pump. As it is planned to install a solar PV system, water will be heated during the day and act to store the energy until used. The heat pump should have a user-friendly interface and effective pipe insulation.

i. Other Electrification

Induction cookers now offer an electric alternative. In this process it is the saucepan that is heated not the stove surface. Cooking vessels must be ferrous, that is iron or steel. It is possible to get an induction cook top that can just sit over your gas cook top.

Induction cooking has good electrical coupling between the pan and the coil and is thus quite efficient, which means it puts less waste heat into the kitchen, can be quickly turned on and off, and has safety advantages compared to gas stoves. Cooktops are also usually easy to clean, because the cooktop itself does not get very hot.

j. Evaporative Coolers

These are gross sources of energy wastage as they are rarely sealed in winter – hot air can escape through the ceiling outlets, through the ductwork and often out through the cooler unit located on the roof. The repair of the ceiling insulation will be greatly compromised by the vents and ducting. The case should be put for removing these given the plan to repair the insulation and the use of reverse cycle heat pumps for cooling.

5. Savings in Energy & Costs of Typical Retrofit

The Retrofit programme run by Sustainability Victoria provides us with some good estimates to base this on.

Table 1: Average impact of all upgrade measures modelled, across the stock of 60 *OGA* Study houses (updated)

Upgrade measure	% Houses upgraded	Av. Energy Saving (MJ/yr)		Av. GHG saving (kg/yr)	Av. Bill Saving ($/yr)	Av. Cost ($)	Av. Payback (yrs)
		Gas	Elec				
Low flow shower rose	56.7%	1,333	69	96	$65.3	$48.8	0.7
Swimming pool pump	6.2%	0	231	75	$16.6	$33.9	2.0
Ceiling insulation (easy)	11.7%	958	32	63	$24.9	$79	3.2
Lighting	93.3%	0	1,202	391	$110.6	$363	3.3
Ceiling insulation (difficult)	33.3%	1,630	68	112	$43.6	$278	6.4
Heating	80.0%	6,239	215	414	$162.7	$1,111	6.8
Draught sealing	98.3%	5,779	164	372	$147.4	$1,020	6.9
Clothes washer	55.0%	135	16	13	$26.0	$191	7.4
Water heater – to HE Gas	58.3%	460	1,004	352	$62.2	$477	7.7
Refrigerator &/or freezer	86.7%	0	1,202	391	$110.6	$1,104	10.0
Reduce sub-floor ventilation	21.7%	589	12	36	$14.6	$167	11.4
Seal wall cavity	50.0%	903	24	58	$22.9	$270	11.8
Gas heating ductwork	12.6%	1,126	9	65	$26.6	$350	13.1
TV	95.0%	0	696	226	$64.0	$964	15.1
Ceiling insulation (top up)	43.3%	853	22	54	$21.5	$335	15.6
Underfloor insulation	40.0%	1,803	10	103	$42.2	$785	18.6
Dishwasher	43.3%	0	112	36	$12.0	$258	21.6
Cavity wall insulation	95.0%	5,283	130	334	$132.9	$3,959	29.8
Cooling	40.0%	0	160	52	$14.7	$465	31.5
Drapes and/or pelmets	100.0%	2,209	54	140	$55.6	$2,036	36.6
Clothes dryer – heat pump	60.0%	0	124	40	$11.4	$728	64
Double glazing	100.0%	2,278	66	147	$58.2	$12,145	209
External shading	31.7%	0	9	3	$0.8	$464	587
Total – inc. drapes		**29,299**	**5,563**	**3,426**	**$1,189**	**$15,485**	**13.0**
Total – inc. double glazing		**29,369**	**5,575**	**3,434**	**$1,192**	**$25,594**	**21.5**

[3] Household averages were obtained by combining the Victorian residential energy consumption data for 2016-17 from *Australian Energy Statistics, Table F – Australian energy consumption, by state, by industry, & fuel type, energy units*, Dept. of the Environment and Industry, August 2018, and estimates of the number of occupied private dwellings from the *ABS Census of Population and Housing 2016* accessed from .idcommunity (https://profile.id.com.au). Greenhouse gas coefficients were obtained from *National Greenhouse Accounts Factors*, Dept. of the Environment and Energy, July 2018.

From the SV trials we can see the energy efficiency gains achieved by the building fabric improvements. These correspond most closely to the NatHERS rating upgrade from 1.8 stars to 5 stars. Using the houses we have selected by type and age as most applicable, excluding C13 as an outlier, it suggests an average saving of 46% in energy use, that is 20,502 MJ/yr but only aimed at 5 stars.

While only considering energy consumed in achieving a comfortable temperature, not hot water, cooking, etc., the 5 star NatHERS rating indicates consumption of 25,000 MJ/yr would be required. Targeting 6 stars would require only 19,000 MJ/yr to achieve the same level of comfort, a further energy saving of some 25%. The overall savings could now be expected to be in the order of 27,000 MJ/yr or 60%.

Table 9: Impact of the building shell and heating system upgrades on heating energy use

House number	Annual heating energy use - main fuel (MJ/yr)	Annual heating energy saving – main fuel (MJ/yr)	Heating energy saving – main fuel (%)
CR1	111,012	54,058	48.7%
CR2	56,566	17,878	31.6%
CR3	46,538	20,636	44.3%
CR4	40,916	17,602	43.0%
CR5	4,391	396	9.0%
CR6	78,259	37,624	48.1%
CR7	42,494	14,530	34.2%
CR8	51,120	27,841	54.5%
CR9	55,643	11,764	21.1%
CR10	50,110	15,050	30.0%
CR11	32,707	14,365	43.9%
CR12	47,458	27,654	58.3%
CR13	59,396	5,283	8.9%
CR14	37,752	13,535	35.9%
Average	**51,026**	**19,873**	**38.9%**

We are informed by this but differ in a number of respects. We propose to move the houses away from gas. This will require heat pumps to replace gas hot water, Reverse Cycle systems to replace ducted or space heating gas. We are initially focussing on houses built before 1991.

Average Energy Saving

The data used in the table below is not from these Comprehensive Retrofit Trial houses, but from the On Ground Assessment study. This is reported on in "Energy Efficiency Upgrade Potential of Existing Victorian Houses", SV 2015, and a summary is also provided in the more recent report on the Comprehensive Retrofit Trail. The data is the average energy saving (elec + gas) across the 60 houses that were assessed in this trial.

The Supply to Comfort Level below, based on NatHERS data is an idealised figure that is a useful indication but makes no account of how heating and cooling is achieved or how efficient it is. It is a useful measure to cross check against savings measured in the trials.

Element	Saving MJ/yr 5 stars	Saving MJ/yr 6 stars
BUILDING FABRIC		
Lighting	1,202	1,202
Draught Sealing/shading	8,030	8,030
Ceiling Insulation/top up/repair	1,698	4,698
Floor Insulation / ventilation	2,414	3,500
Cavity Wall insulation	5,412	6,000
Retrofit Double Glazing and Shading	2,344	4,000
Subtotal	**21,100**	**27,430**
Heating / Cooling (60%) Electrification (adjusted)	6,300	6,300
OTHER ENERGY DEMANDS		
Hot Water Electrification (19%)	500	500
Appliances – e.g. Clothes washer, Dryer, Cooking, etc.	4,000	4,000
Retrofit Energy Savings	**31,900**	**38,230**
Average Annual Household Gas Use	**59,800**	**59,800**
Average Annual Household Electricity Use	**4,160**	**4,160**
Total Annual Usage	**63,960**	**63,960**
Net Usage	**32,060**	**25,730**
Supply Via Solar PV (5kW)	**26,000**	**26,000**
Net Usage with Solar	**6,060**	**-270**

Notes:

1. 1 MJ = 0.28 kWh. Solar MJ calculated assuming 5kWh per day per rated kW.
2. Whereas the SV trials focussed on cost savings we will be targeting energy efficiency more aggressively.

6. Savings in Emissions of Programme

Greenhouse Gas emissions are more difficult to nail down as we are seeing a move from brown coal to gas generation. However, what we are also finding out is that gas is not that different from coal once the fugitive emissions are taken into account. As more renewables come on stream the level of emissions change from electricity generation and from gas extraction and distribution change. However we are looking at a slow progression and projects such as this can be part of the solution.

The GHG coefficient for electricity is declining and now sits at around 1.03 kg/kWh, and the coefficient for natural gas is 0.05543 kg/MJ. A house with this level of consumption indicated by the selected population would produce around 7.6 tonnes of CO2-e per year at the moment. If we can reduce the energy consumption to 40% as per the table above, then we would expect the emissions to be reduced to 3.04 tonnes of CO2-e. If we satisfy this demand with Solar PV, then this can be reduced to zero.

If we were to save 7.6 tonne of CO2-e per year for 510 houses then this would represent 3,876 tonnes saved.

7. Household Energy Costing Savings

The Retrofit looks to have a zero net energy use as a result. We have considered the current rates announced (2021) by the principal retailers. If we look at the average gas usage of 59,800 MJ over a year we would expect this to cost $350 per year supply charge and $1,255 in usage over the year. If we look the average electricity usage of 4,160 kWh over a year we would expect this to cost $383 per year supply charge and $874 in usage over the year. A total cost of energy $2,862 per year.

Of these only the electricity supply charge of $383 will remain. Thus a saving of $2,479 on the average house above.

Recent analysis by Sustainability Victoria of older houses, adjusted to incorporate 5kW of Solar PV, suggests that the cost of energy would be $2,450 per year and supports this.

Financing over 20 years through a supplement to council rates via the Victorian Environmental Upgrades programme or other CEFC supported programme could see it fully paid off and provide a net annual saving in the order of $200 until completion of the term. After this of course, the full saving of $2,450 per year would be realised.

Note a householder who was capable of paying the cost upfront, would get a full return on their investment in 11 years.

8. Costing of Retrofit Actions

Note: Costs are exclusive of GST.

BV Construction (based on trials CR4, CR8, CR10, CR11, CR12, CR13)

Element	Cost Budget	Vic Program	Rebate Amount	Post Pilot Projected
Lighting	$300	VEU		Not in scope
Draught Sealing	$1,000	VEU	$660	$1,391
Ceiling Insulation	$2,000	Pending VEU		$1,940
Floor Insulation	$1,700	Pending VEU		$1,940
Wall Insulation	$4,500	Pending VEU		Not in scope (outside budget)
Retrofit Double Glazing – living rooms only	$3,000	VEU	$1,000	$2,000
Shading				$1,507
Drapes – as alternative to double-glazing – living rooms only				$1,847
Heating Electrification	$5,000	VEU	$2,200	$2,800
Hot water Electrification	$3,500	STC, VEU, Solar Vic	$1,369	$2,131
Cooking electrification	$5,400		To be reviewed once government incentives offered	Out of Scope
Blower Door Testing & Analysis	$ 700			$ 233
Before and After RE Scorecard assessment and appropriate Thermal Imaging Testing	$ 600			$ 550
Installing Monitors	$ 362	VEU	$70	Only for pilot
Temperature & humidity loggers	On loan $0			Only for Pilot
Retrofit Total	**$28,062**		**$5,299**	**$16,339**
Solar PV (5.4kW)	$8,500	STC Solar Vic rebate	$2,065 $1,400	$5,895
ZNet Total	**$36,562**		**$8,764**	**$22,234**

Lightweight/Weatherboard Construction (based on trials CR6, CR7, CR9)

Note: Only 1 weatherboard property in Pilot Project

Element	Cost Budget	Vic Program	Rebate Amount	Post Pilot projected
Lighting	$300	VEU		Not in scope
Draught Sealing	$1,000	VEU	$660	$2,295
Ceiling Insulation	$2,000	Pending VEU		$1,940
Floor Insulation	$1,700	Pending VEU		$1,940
Wall Insulation	$6,000	Pending VEU		Not in scope (outside budget)
Retrofit Double Glaze – living rooms only	$3,000	VEU	$1,000	$2,000
Shading				$1,336
Drapes – as alternative to double-glazing – living rooms only				$1,718
Heating Electrification	$5,000	VEU	$2,200	$2,800
Hot water Electrification	$3,500	STC, VEU, Solar Vic	$1,369	$2,131
Cooking electrification	$5,400		To be reviewed once government incentives offered	Out of Scope
Blower Door Testing & Analysis	$ 700			$ 466
Before and After RE Scorecard assessment and appropriate Thermal Imaging Testing	$ 600			$ 550
Installing Monitors	$ 362	VEU	$70	Only for pilot
Temperature & humidity loggers	On loan $0			Only for Pilot
Retrofit Total	**$29,562**		**$5,299**	**$17,176**
Solar PV (5.4kW)	$8,500	STC Solar Vic rebate	$2,065 $1,400	$5,895
BASE ZNet Total	**$38,062**		**$8,764**	**$23,071**

Notes:

a) Cooking electrification cost includes new rangehood and tiling of splashback for building code compliance. Cooking is seen as a low contributor to greenhouse gas emissions, however the intention to move all residences off the gas grid means that this is still a priority. However it may have to be costed on a house by house basis.

b) Blower door testing was done before and after. 10 ACH at 50 pascals, the current NCC standard for new builds, will be the target.
c) Wall insulation will generally be difficult but would be looked at on a case by case basis. Failure to improve the walls may be compensated for by increased ceiling insulation.
d) Only those monitors available free under the VEU will be provided.
e) Draught sealing is covered under VEU's but was not claimed in the Pilot. We expect this cost may be reduced.
f) The pilot included no window glazing treatment. We would plan on doing this to the living room windows where possible. VEU rebates are available but difficult to calculate. Accredited suppliers would be sought.
g) Water heating in the pilot was as shown below. We believe there are cheaper reasonable options and also more rebates available. Solar Vic, VEU and STC rebates are available. A post rebate cost of $2,131 seems achievable.

h) Budget	i) Rebate	j) Rebate amount	k) Cost
l) $4,300	m) STC	n) $820	o) $5,850

p) The pilot Solar PV average cost has been retained. We would hope to get this reduced with a volume purchase.

Given the age of the houses we are dealing with, any introduction of new wired electrical appliances or Solar PV could incur rewiring and new power boxes. It is difficult to assess but it may be prudent to assume such could cost $4,000 in some houses. The percentage of houses that would be affected is difficult to assess. However, this rewiring is likely to be just bringing forward a needed renewal on safety grounds. We have therefore excluded it from the retrofit costing.

In budgeting for the post pilot 500 houses, we believe that most houses will have some of these elements done. Some cost savings are expected in bulk buying and in the expected drop in the cost of solar.

9. Pilot Programme

A pilot has been undertake as a proof of concept.

10 lightweight/WB or brick veneer houses have been retrofitted. The processes, trades and costs are being reviewed following this. These houses have been done in conjunction with CEHL for the Forest Creek Cooperative Housing. All 20 of their houses were assessed using the RE Scorecard and 10 of these were selected and willing to proceed. CEHL is the owner of the properties and have sourced most of the funding. It had been hoped that the tenants of these properties could contribute as a supplement to their rents, however this proved impossible under existing tenancy regulations. Legal advice is required to understand the issues and how these agreements can be used in the context of the Residential Tenancies Act, Local Government Act and any other relevant legislation.

MASG was able to secure an Innovation Grant of $50,000 from the Lord Mayors Charitable Foundation which support this. The overall budget for the Pilot was assessed as $246,000 as outlined below.

Pilot Budget

1. Select houses for Pilot (10)		$ 5,100
2. Legal Advice – (re rental)		$ 4,000
3. RE Scorecard Assessments of 20 houses		$ 6,400
4. Safety and suitability inspection		$ 2,000
5. Plan of Retrofits		$ 4,000
6. Selection of Contractors		$ 4,000
7. Conduct Pilot Retrofits	(@$19,000 ea)	$ 152,000
8. Solar PV with rebates	(@$4,000 ea)	$ 32,000
9. Blower Door Testing		$ 5,000
10. Monitoring		$ 5,000
11. Post Retrofit Inspection		$ 4,000
12. Scorecard Revision (10 houses)		$ 2,500
13. Tailored Building User Guides		$ 8,000
14. Performance Review		$ 4,000
15. Project Management		$ 12,000
Total Pilot		$ 250,000

The pilot has successfully demonstrated that these houses can be brought up to a RE Scorecard of at least 9 stars and become net exporters of energy. The table below shows these results.

Zero Net Emissions by 2030

Property Code	HOUSE	Build Year	Property Type	Type	Floor Type	Storeys	No of bedrooms	Floor area m2	RE Scorecard Before	RE Scorecard After	GHG Emissions Before	GHG Emissions After	Energy Cost Before	Energy Cost After
10845	1	1991	House	brick veneer	CSOG	Single	3	94	6	10	1525	-4397	777.6	-670.35
10846	2	1960	House	brick veneer	Suspended	Single	4	133	5	10	4314	-3206	1177.66	-358.35
10847	3	2005	House	brick veneer	CSOG	Single	4	106	7	10	2392	-4387	667.55	-667.8
10848	4	2006	Unit	brick veneer	CSOG	Single	2	86	6	10	2930	-3762	806.63	-504.23
10850	5	1990	House	brick veneer	CSOG	Single	5	126	5	10	4749	-3589	1293.16	-3967.11
10860	6	1975	House	brick veneer	suspended	Single	4	125	6	10	3745	-3239	1038.91	-458.85
10862	7	1990	House	brick veneer	CSOG	Singke	3	102	6	10	2918	-4119	857.21	-597.6
10864	8	1967	House	brick veneer	suspended	Single	2	65	7	10	2509	-3721	743.54	-493.23
10865	9	1940	House	weatherboard	suspended	Single	3	144	5	9	4759	-2477	1371.52	-167.37
10866	10	1991	House	brick veneer	suspended	Single	4	108	7	10	2420	-4382	668.79	-666.57

The GHG column (after) shows that the reduction in usage and the inclusion of Solar PV has resulted in net zero emissions from these houses with a surplus of energy supplied to the grid.

While the Scorecard assessment of costs makes a number of assumptions and uses the default bid costs, and service charges can vary from $450 to $950 per year, it is fair to say that there is essentially no energy cost to the household when viewed over the year.

Removing the gas connection is a one off cost which may require to be factored in also. Gas disconnection Costs have been capped at $220.

10. Programme Execution

We propose to divide these into 2 manageable groups, pre 1991 Lightweight/Weatherboards and pre 1991 Brick Veneer. There are expected to be 255 houses fitting each group. By focussing on these we believe we can find common solutions to most.

Planned stages:

1. Pilot 10 Pre 1991 Lightweight/WB and BV houses – now completed
2. Stage 1 50 Pre-1991 Lightweight/WB clad houses
3. Stage 2 50 Pre-1991 Brick Veneer houses
4. Stages 3 – 6) 200 Pre-1991 Weatherboards
5. Stages 7 - 10 200 Pre- 1991 Brick Veneer houses

To be eligible to participate in the programme, the houses have to be constructed prior to 1991 and not have been recently renovated significantly (e.g. within the last ten years). The programme could later expand to include houses up to 2005, when the NatHERS energy rating of 5 stars became mandatory.

The Programme Post Pilot

Stage 1 to 4 will be somewhat reduced per house as procedures of identifying houses will be known as will the retrofit planning. Contractors will be re-evaluated but could be assumed to be known also.

Stage 1 Batch 1 of 50 Lightweight/WB

1.	Identify houses (first 50)	$ 8,000
2.	Safety and suitability inspection	$ 20,000
3.	RE Scorecard assessment of 50 houses	$ 27,500
4.	Planning of Retrofits	$ 5,000
5.	Selection of Contractors	$ 8,000
6.	Manage Programme	$ 10,000
7.	Upgrades @ $17,176 ea.	$ 858,800
8.	Solar PV @ $5,895 ea.	$ 294,750
	Total	$ 1,232,050

Cost per house = $24,641

Stage 2 Batch 1 of 50 BV

1.	Identify houses (first 50)	$ 8,000
2.	Safety and suitability inspection	$ 20,000
3.	RE Scorecard assessment of 50 houses	$ 27,500
4.	Planning of Retrofits	$ 5,000
5.	Selection of Contractors	$ 8,000
6.	Manage Programme	$ 10,000
7.	Upgrades @ $16,339 ea.	$ 816,950
8.	Solar PV @ $5,895 ea.	$ 294,750
	Total	$ 1,190,200

Cost per house = $23,804

After this initial 110 houses, a major review would be undertaken. This will reflect on the experience with the programme but will also consider technologies and priorities that may have changed. An allowance of $10,000 would be budgeted for this review. An example could be off grid or local grid opportunities for those currently on the electricity grid.

The remaining 400 could be expected to be done in 8 stages, Stages 3 to 10, at a rate of 50 houses as for stages 2 and 3.

It would be intended to only contract suppliers and trades for lots of 50 houses at a time although contracts may be negotiated with options should both parties wish to proceed as per the prior stage.

Post retrofit review should be undertaken to collect meaningful data on performance of housing post retrofit. This will be undertaken by revisiting the houses, preferably after a full summer and spring has been experienced. It may be prudent to select half for a post winter and half for a post summer review to save some elapsed time. The RE Scorecard will have been used to assess what the retrofit was hoped to achieve in terms of a star rating. Reference to this would be a useful guide. $20,000 would be budgeted for this activity.

11. Budget Summary

MASG believe that this programme, involving 510 homes, will have a major impact on improving the housing stock of the Mount Alexander Shire and will contribute to the achievement of Zero Net Emissions by 2030. MASG will consider Registering with the Essential Services Commission so as to claim the VECs from these activities. This would be part of the administration required of the programme. The need for this will depend on the tendering contractors status in this regard.

The total cost of the Programme would be:

1.	Pilot (Completed	*$ 331,820*
2.	Retrofit 50 LW/WB	$ 1,266,000
3.	Retrofit 50 BV	$ 1,132,200
4.	Review Programme	$ 10,000
5.	Remaining Retrofit 200 LW/WB	$ 5,000,000
6.	Remaining Retrofit 200 BV	$ 4,500,000
7.	External Audit	$ 10,000
8.	Post Retrofit Review	$ 10,000
	Programme Total	$12,260,020
	Post Pilot	$11,928,200

Note: Included in this post pilot are the establishment, planning, management, audit and administration tasks:

• *Identify houses `*	*$ 80,000*
• *Safety and Suitability inspection*	*$ 200,000*
• *RE Scorecard Assessments*	*$ 275,000*
• *Planning of Retrofits*	*$ 50,000*
• *Selection of Contractors*	*$ 80,000*
• *Manage Programme*	*$ 100,000*
• *External Audit*	*$ 10,000*
• *Review Programme*	*$ 10,000*
Total	*$ 805,000*

Cost per households: $1,610

Appendix 1 Notes on Rebates

Note VEU VEECs and STCs are tradable certificates and their value can change over time.

Draft Sealing

Partially covered by VEU rebates. Can vary between $300 and $660.

Insulation

Currently under review

Glazing Upgrades

To generate certificates a minimum of 5 m2 must be upgraded. Upgrading 6 m2 with secondary glazing would generate around 1 to 2 certificates (depending on climate zone), which would provide a rebate of around $45 to $90 if paid $45 per certificate. Shading is not an eligible VEU activity.

Hot Water

Solar Vic rebates for eligible households can claim $1,000

VEUs are available depending on what you are transitioning from $490 to $1050.

STC's can also be available from the Federal Government in the order of $950.

Solar PV

Solar Vic rebates for eligible households can claim $1,400.

On a 5kW system, Federal STC rebates could contribute $2,065 and Solar Vic of $1,400.

Electrification – Heating, Cooling

VEU rebates are available and typically can provide $2,200 on a $5,000 RCAC. It will differ if a ducted system is installed.

Appendix 2. Other Measures to Optimize Efficiency

Evaporative Coolers

Reverse-cycle air conditioners should be able to replace the cooling provided by the ducted evaporative coolers but maybe not provide cooling through the entire house. Winter covers for the ceiling outlets are cheap and provide an effective way of cutting some air leakage where ducted evaporative coolers are still used. However these are still major weaknesses in the coverage of the ceiling insulation.

Note that SV measured air leakage due to ducted evaporative coolers in our "Draught Sealing Retrofit Trial", and found that they were a significant source of air leakage.

An added advantage of removing ducted evaporative coolers is that they use a lot of water.