GEELONG SUSTAINABILITY

Climate Safe Rooms Findings and Final Report

Climate Safe Rooms

Building resilience to extreme weather

September 2023

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Climate Safe Rooms: Findings and Final Report
September 2023

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This document is available in PDF format on Geelong Sustainability website.

Geelong Sustainability acknowledges that we walk upon the traditional lands of First Nations peoples. We pay our respects to them and recognise the continuing gift of their cultures to the life and spirit of Australia. Sovereignty has never been ceded. It always was and always will be, Aboriginal land.

Climate Safe Rooms

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Abstract

The Climate Safe Rooms project, funded by the Victorian Government, aimed to retrofit one room in vulnerable households in the Geelong region. Upgrades included insulation, draught-proofing, energy-efficient lighting, solar systems and reverse cycle air-conditioning systems. Participants reported increased thermal comfort, health, and happiness, with reduced depression, anxiety, and pain and discomfort. The project led to substantial energy savings, lowered gas consumption, and reduced exposure to unhealthy temperatures. The initiative's success and cost-effectiveness present a replicable model for similar projects in Victoria. Geelong Sustainability seeks further support to expand this project to help more vulnerable households and to promote sustainability and energy efficiency in the Geelong region.

1. Executive summary

The Climate Safe Rooms project aimed to retrofit one room in a household to create a safe haven in the homes of individuals most vulnerable to the health impacts of climate extremes. The project also sought to improve home energy efficiency and explore its benefits for energy use, thermal comfort, and overall well-being.

Research shows 6.5% of deaths in Australia are attributed to cold weather, and that the average temperature value of nearly 85% of the homes across Victoria is below 18°C during winter, which is the "safe and well-balanced" indoor temperature according to World Health Organisation. Geelong, with its extreme temperature variations and poor energy efficiency standards, provided the context for this initiative.

Geelong Sustainability led the Climate Safe Rooms initiative, which received financial support from the Victorian Government's Climate Change Innovation Grant. The project was conducted through collaboration with City of Greater Geelong, CSIRO, Uniting and ecoMaster.

The project focused on retrofitting one room in the homes of eligible residents who faced financial constraints and chronic health conditions exacerbated by climate conditions. The initiative aimed to provide a cost-effective solution for reducing energy costs and improving living conditions and health.

The houses underwent initial evaluations using the Nationwide House Energy Rating Scheme (NatHERS) and Residential Efficiency Scorecard Assessments. Based on these evaluations, upgrades were planned to optimise thermal performance within the allocated budget in the most frequently used room in the house, typically the living or dining room. The implemented upgrades encompassed measures such as draught proofing, insulation, energy-efficient lighting, and highly efficient reverse cycle air-conditioning systems, as well as solar systems to cover the energy usage of the air-conditioners. The pre and post-retrofit data included self-reported surveys, energy billing records, energy distributor metering data by Powercor, solar generation data from Solar Analytics, and temperature readings from the CSIRO Smarter Safer Homes sensors.

The project was planned from July 2018 to February 2019, with participants recruited by July 2019. However, COVID-19 caused significant delays, and the home energy efficiency upgrades were completed in July 2021. Data monitoring continued until December 2022, and the data analysis and report were finalised in September 2023.

The outcomes of the Climate Safe Rooms project have been remarkable. Participants reported increased comfort, health, and happiness. Participants reported feeling 33% more comfortable during winter, even without the use of heaters, due to insulation and draught proofing. They also experienced 142% fewer days where they felt cold. In hot weather, participants felt 100% more comfortable and encountered 75% fewer days where they experienced discomfort from excessive heat. The enhanced thermal comfort resulted in positive effects on participants' health and well-being with participants reporting reduced levels of depression, anxiety, pain, and discomfort. They also exhibited increased activity levels, higher self-care ability, and fewer visits to doctors.

Participant satisfaction with the program was notably high, with 77% strongly agreeing that they felt more comfortable in their homes during both summer and winter. Additionally, over 70% strongly agreed that they experienced reduced energy bills and benefited from the program, expressing a willingness to recommend it to others.

Another significant outcome of the upgrades was a substantial reduction in energy consumption. Electricity bills were reduced by an average of more than 45% in the months of summer when solar PV efficiency is at its peak. Furthermore, the solar PV systems generated an electricity surplus of 3,226 kWh per year, resulting in an additional annual saving of $168 in electricity bills per household. The upgrades also led to decreased gas consumption, especially during the colder months of the year. Households that switched from gas heater to electricity experienced up to 52% less gas usage throughout the year. In summary, an average participant saved approximately $1,462 on health and energy combined.

Moreover, the upgrades resulted in reduced exposure to unhealthy temperatures. On average, exposure to temperatures below 18°C decreased by two hours per day in 2021 and one hour per day in 2022. In terms of summer comfort after the upgrades, houses were exposed to six and half hours less time at temperatures exceeding 30°C in 2022. These findings strongly support the need for a larger-scale project that can replicate and expand upon the positive outcomes of the pilot study.

The success of the Climate Safe Rooms project has gained recognition through media coverage and presentations, creating opportunities to share the project's success and inspire others. The advantages of the Climate Safe Rooms project go beyond creating a comfortable environment for participants; the flow-on economic and health implications include a lighter load on the public health system, and an overall happier, healthier, more equitable community. A similar study[1] found that the upgrades resulted in cost savings of $887 per person in the healthcare system over one winter period. A cost-benefit analysis indicated that the upgrades would yield net savings of $4,783 over 10 years by saving on energy costs and reducing healthcare expenses.

In summary, the Climate Safe Rooms project has achieved significant improvements in health, sustainability, and energy savings for vulnerable households in Geelong. Looking ahead, the project has the potential for expansion on a larger scale. The initiative's cost-effective approach, targeting those most in need and retrofitting only one room, sets a replicable model that can be implemented across municipalities in Victoria and beyond. Geelong

[1] The Victorian Healthy Homes Program conducted by Sustainability Victoria delivered thermal comfort and energy efficiency upgrades to 1000 homes of low-income Victorians with a health or social care need. It ran over three study years (2018, 2019, 2020) across western Melbourne and the Goulburn Valley.

Sustainability aims to secure further support and funding from both State and Federal Governments to scale the project and deliver 1,000 retrofits for vulnerable households.

2. Introduction and scope of work

In Australia, heatwaves have proven to be deadlier than all other natural hazards combined[2]. For instance, a category five heatwave is projected to result in at least three deaths for every 100,000 individuals exposed. People succumb to dehydration, hyperthermia, heatstroke, and other related causes. Climate change has already intensified and increased the frequency of heatwaves in Australia[3]. These heatwaves are becoming hotter, lasting longer, and occurring more frequently. The occurrence of record-breaking hot days and heatwaves is expected to rise in the future. The most vulnerable groups include the elderly, children, individuals with pre-existing chronic conditions, and those with lower socioeconomic status.

While many individuals are acutely aware of the toll extreme heat can take on human life, especially following the devastating Black Saturday heatwave in 2009, it may be surprising to learn that more Australians die from cold weather than from heat. In fact, 6.5% of deaths in the country are attributed to cold weather, compared to 0.5% from hot weather[4]. Most of these deaths result from cardiovascular and respiratory diseases, as our heart and lungs struggle when exposed to conditions outside our comfort zone.

Furthermore, the energy efficiency standards in Victorian homes are remarkably poor, especially considering the city's temperature fluctuations throughout the year. With inadequate insulation, single-glazed windows, and numerous gaps in ceilings and walls, many Geelong residents find themselves excessively hot in summer and excessively cold in winter. Retrofitting an entire house can be overwhelming and unaffordable for many individuals. Unfortunately, it is often those who can least afford it that are in the greatest need of home upgrades.

To address this issue, the Climate Safe Rooms project offers an affordable solution for the government to support these residents at a low cost by retrofitting a single room in their homes. The objective of this project is to safeguard the most vulnerable members of the community from the impacts of increasingly frequent weather extremes. The designated room within their home serves as a thermal-efficient and economical space that provides protection during periods of extreme heatwaves and cold.

The Climate Safe Rooms program was fully funded by government grants and was offered at no cost to eligible participants. The program targets low-income households where at least

[2] Coates et al, Exploring 167 years of vulnerability: An examination of extreme heat events in Australia 1844–2010, Environmental Science & Policy, Volume 42, October 2014, Pages 33-44, https://www.sciencedirect.com/science/article/pii/S1462901114000999

[3] Steffen W. et al. 2014, Heatwaves: Hotter, Longer, More Often, Climate Council of Australia. https://www.climatecouncil.org.au/uploads/9901f6614a2cac7b2b888f55b4dff9cc.pdf

[4] Gasparrini A. et al. 2015, Mortality risk attributable to high and low ambient temperature: a multicountry observational, Lancet, https://doi.org/10.1016/S0140-6736(14)62114-0

one resident receives home care support services for an existing chronic health condition, placing them at risk during heatwaves and extreme cold. Initial energy assessments, including the Nationwide House Energy Rating Scheme (NatHERS) and Residential Efficiency Scorecard Assessments, were conducted to identify the efficiency of the home. During these assessments the most effective upgrade options are recommended for the most frequently used room in each participating house, typically the living or dining room. This room was then upgraded to ensure comfort during both summer and winter temperature extremes.

The retrofitting process involves enhancing energy efficiency through measures such as draught sealing doors, windows, and other air gaps, installing insulation (ceiling and/or underfloor), and implementing energy-efficient lighting where necessary. Subsequently, a high-efficiency reverse cycle air-conditioner capable of heating and cooling was installed, along with a modest roof-top solar system to generate the required electricity and offset the air-conditioner's running costs. Finally, the positive health outcomes and energy bill savings resulting from a more comfortable home environment throughout the year were identified.

2.1. Project timeline

The planning for this program was conducted between July 2018 and February 2019 and the eligible participants were recruited by July 2019. Unfortunately, the project was severely delayed due to COVID-19 with the home energy efficiency upgrades not reaching completion until July 2021. Non-intrusive data monitoring was continued until December 2022. The data analysis and reporting were finalised in July 2023.

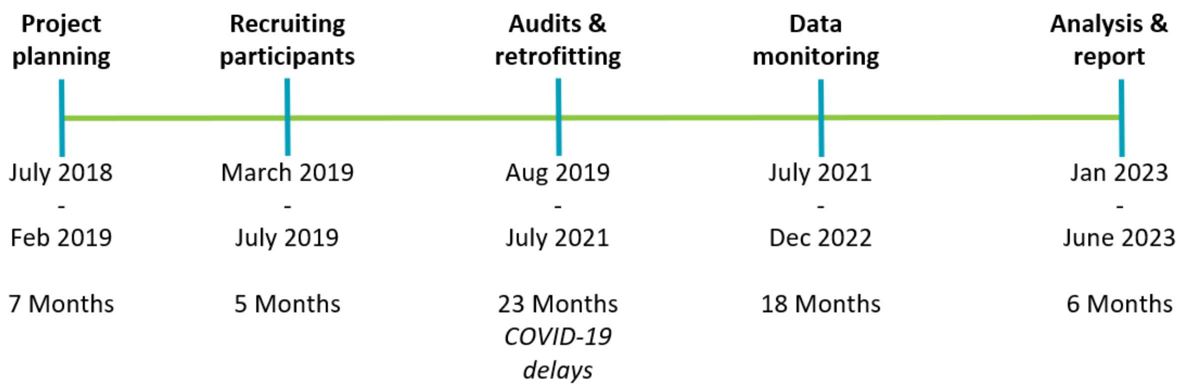


Figure 1. The project timeline.

2.2. Project objectives

The pilot project had six objectives:

1. To deliver an individually designed Climate Safe Room for up to 20 vulnerable residents who matched the selection criteria.
2. To test and prove a model for delivery and the benefits of single room upgrade vs whole home upgrade across diverse building types.

3. To measure each home's thermal efficiency performance, energy usage and affordability, health, and thermal comfort.
4. To research how improving home energy efficiency can benefit household energy use, thermal comfort and the health and wellbeing of the Geelong community.
5. To distribute and publish research findings widely to assist with awareness and developmental growth. Additionally, contribute to the CSIRO research areas linking activities of daily living to environment and thermal comfort.
6. To determine pathways to expand on the project at scale.

2.3. Project partners

Geelong Sustainability led the Climate Safe Rooms initiative, which received financial support from the Victorian Government's Climate Change Innovation Grant. The project was collaboratively executed with the following organisations:

- **City of Greater Geelong:** Responsible for identifying the eligible candidates. They engaged candidates that met the selection criteria through their community care program.
- **CSIRO:** Provided the non-invasive sensor system 'Smarter, Safer Homes' to monitor household temperature, humidity, daily activities, and behaviour patterns.
- **Uniting:** Assisted in engaging and educating participants, offering energy behaviour change visits to help residents understand energy usage and reduce energy consumption.
- **ecoMaster:** Specialising in energy efficiency audit and retrofit services, they provided consulting expertise and practical know-how regarding energy efficiency retrofits.

3. Methods and procedures

3.1. Participant recruitment

With the valuable support and assistance of the City of Greater Geelong's Community Care Program, we successfully identified, shortlisted, and recruited potential participants for the project. Those who expressed interest in participating were provided with a comprehensive Project Information Sheet and Consent Form to complete and return.

The Project Information Sheet offered a clear overview of the study, outlining the criteria used to identify vulnerable individuals eligible for participation. It also provided transparent details on the data collection process and how the collected data would be stored securely.

To ensure full transparency and protect the rights of participants, the Project Information Sheet explicitly highlighted their rights as study participants and included essential contact information for any inquiries or concerns they might have had.

3.2. Initial assessments

Initially, the houses were assessed using Nationwide House Energy Rating Scheme (NatHERS) and Residential Efficiency Scorecard Assessments. NatHERS assessment proved to be a powerful aid to choose the type of the retrofit required to gain higher levels of thermal performance within the budget. As an example, the outcome of a NatHERS assessment for Climate Safe room participant #1 (CSR1) is shown here.

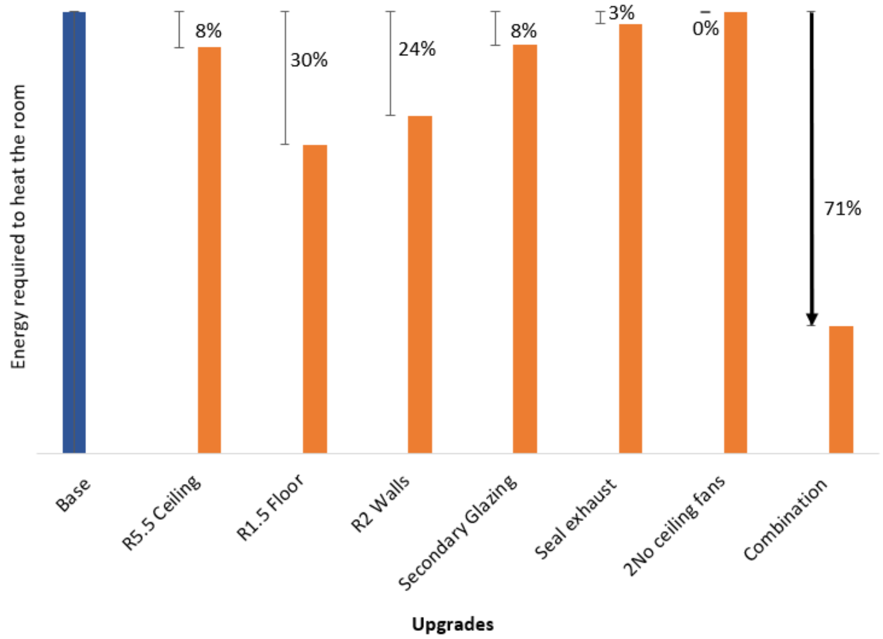


Figure 2. Effect of home energy efficiency upgrades on the thermal performance of CSR1.

Figure 2 corresponds the impact of each home energy efficiency upgrade on the thermal performance. It is shown that underfloor insulation followed by wall insulation in these houses could make immense contributions to reducing the energy required to heat the room.

Residential Efficiency Scorecard Assessments rated the home's energy use and comfort, providing tailored recommendations for improvements. Table 1 lists the heating, cooling and hot water systems of the participating houses before the upgrades based on the Scorecard reports.

Table 1. Heating, cooling and hot water systems of the participating houses before the upgrades.

	Heating	Cooling	Hot water system
CSR1	Slow combustion-Pre1993	None	Natural gas - instantaneous type
CSR2	Natural gas space(flued)	None	LPG-instantaneous type
CSR3	Natural gas space(flued)	Air conditioner -reverse cycle	Natural gas - Storage type
CSR4	Natural gas space(flued)	Air conditioner -cooling only	Natural gas - Storage type
CSR5	Natural gas ducted	Evaporative cooling	Natural gas - Storage type
CSR6	Natural gas ducted	Air conditioner -reverse cycle	Natural gas- instantaneous type
CSR7	Natural gas space(flued)	Air conditioner -reverse cycle	Natural gas - Storage type

CSR8	Natural gas space(flued)	Air conditioner -cooling only	Natural gas - Storage type
CSR9	Electric reverse cycle Electric reverse cycle	Air conditioner -reverse cycle	Natural gas - Storage type
CSR10	Electric reverse cycle	Air conditioner -reverse cycle	Natural gas - Storage type
CSR11	Natural gas space(flued)	Air conditioner -reverse cycle	Natural gas- instantaneous type
CSR12	LPG gas space(un-flued) Slow combustion- Pre1993	None	LPG-instantaneous type
CSR13	Electric reverse cycle	Air conditioner -reverse cycle	Natural gas - Storage type
CSR14	Natural gas space(flued)	Air conditioner -reverse cycle	Natural gas - Storage type
CSR15	Electric reverse cycle (ducted) Natural gas ducted	Ducted air conditioner	Natural gas - Storage type
CSR16	Electric reverse cycle	Air conditioner -reverse cycle	Natural gas - Storage type

3.3. Home upgrades schedule

Most homes received a solar system, air conditioner, ceiling and/or underfloor insulation as well as draught proofing. Energy efficient retrofit tasks were employed to improve building fabric and appliance performance. The upgrades provided to participating homes included:

1. Draught proofing: sealing door and window gaps; installation of draft-stoppa for exhaust fans; sealing ceiling and wall vents.
2. Insulation: installation of ceiling and underfloor insulation, R4.0 and R2.5, respectively. Removal of any obstructions from roof cavity to meet building code requirements.
3. Renewable energy: supply and Installation of grid connected solar systems (1.7 - 5.92 kW). The size of solar systems was chosen based on the size of the air-conditioning unit and space availability on the roof.
4. Air Conditioner: supply and installation of highly efficient 2.5 – 5 kW reverse cycle air conditioner units. The size of the unit was chosen based on the size of the room.
5. Miscellaneous: replacement of light fittings and sweep fans.

See Appendix A for details on the upgrades provided to each participating house.

3.4. Project Budget

The Climate Safe Rooms Program was funded by the Victorian government allowing home upgrades to be offered to the participants free of charge. On average, $7,860 was spent on each of the 16 houses for upgrading. The average cost breakdown for the retrofit tasks is illustrated in Figure 3.

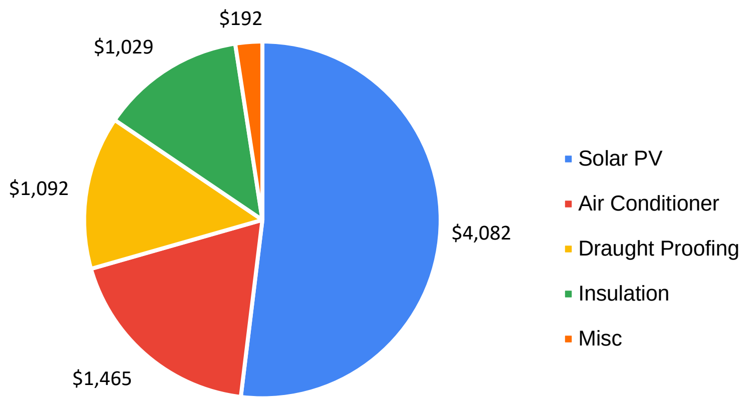


Figure 3. Average cost breakdown for upgrades provided to participating homes.

3.5. Data set overview

In this section an overview of the data collected from each of the 16 Climate Safe Rooms participants is provided (Note: 2 participants are now deceased):

1- **Survey:** 47-question survey conducted before the home upgrades and again 12-18 months after, containing:
   - Self-reported data about the household energy use and thermal comfort.
   - Self-reported health, wellbeing, and quality of life data.

2- **Energy billing data:** Electricity and gas bills collected from participants prior to the intervention and 12 months post (Note: the consistency of number of bills and billing periods vary greatly from participant to participant).

3- **Energy Distributor Metering Data:** Powercor Interval Data of Electricity Usage was obtained for up to 2 years prior to intervention and 20 months post intervention to identify changes in household's energy consumption.

4- **Solar Generation and Energy Usage Data:** Data from Solar Analytics energy monitors containing Solar Generation, whole home electricity consumption, and Air Conditioner electricity consumption data were obtained.

5- **Temperature and Humidity Data:** Temperature data was measured and recorded by the CSIRO Smarter Safer Homes sensors placed throughout the home of each participant. These sensors also looked at the activities of daily living and the behaviour patterns. The daily activity information was collected to be analysed by CSIRO for research purposes.

3.6. Impact of COVID-19

The COVID-19 pandemic emerged as an unforeseen disruptor, presenting numerous challenges for the Climate Safe Rooms project. Given the vulnerable classification of the project participants, the service delivery had to be completely rethought to align with the new government restrictions. Prior to the occurrence of the pandemic and the subsequent delay in safe room installations, 16 houses were assessed for energy efficiency, the necessary works were defined, and associated costs were calculated.

Upon the easing of restrictions in February 2021, various engagement and communication activities had to be repeated, thus causing further set back the project's schedule. Additionally, the pandemic's impact on trade services and supply chains introduced new hurdles. Despite these complexities, the project team proactively navigated the challenges and successfully brought the home upgrade phase to completion.

3.7. Variabilities

Several participants experienced changes in the occupancy or the number of electric devices used in their households before and after the upgrades. The specific changes reported are as follows:

- CSR3: A single individual who had her daughter staying with her for more than a fortnight following the upgrades.
- CSR7: The household saw an addition of electric appliances, including 1 fridge/freezer and a washing machine, after the retrofits.
- CSR8: The household experienced a change in both the number of electric appliances (2 fridges reduced to 1 after the upgrades) and the number of occupants (from 1 individual before the upgrades to 3 after).
- CSR11: The number of individuals living in the house decreased from 3 before the retrofits to 2 after.
- CSR15: The pre-retrofit occupancy ranged from 2 to 3 individuals, which was reported to be 3 individuals after the retrofits.
- CSR12 and CSR16: Deceased during the program.

4. Project outcomes

The outcome of Climate Safe Room (CSR) program is presented here in five categories: participant surveys, electricity consumption, solar exports, gas consumption, and temperature sensor data.

4.1. Participant surveys

The participants of the CSR program were asked to complete a survey before and after their house upgrades. The survey questions aimed to identify the effect of home upgrades mainly on the following three aspects of participants' lives:

- Thermal comfort
- Cost and affordability
- Health and wellbeing

Of 16 participants, 12 surveys were completed and are analysed here. Post-retrofit surveys for CSR12 and CSR16 were not conducted as the participants passed away during the study. Pre-retrofit surveys were not conducted for CSR13 and CSR14.

4.1.1. Methodology

For better comparison of before and after data, the participants' answers were plotted. Each answer was quantified and given a 'value'. In this section it is explained how the survey answers are quantified. For consistency every multiple-choice question was given a value from zero to four; with zero being the worst-case scenario and four the best-case scenario. Tables 2 to 6 show how these values are assigned to each answer.

Table 2. How survey questions 2.6 and 3.14 are quantified.

Q2.6. How in control of your general household finances do you feel? **Q3.14.** How in control of your electricity and gas costs do you feel?	**Value given**
Always in control	4
Mostly in control	3
Sometimes in control	2
Rarely in control	1
Never in control	0

In question 2.7, For every 'Yes' or 'No' that is ticked, a value of zero or four is assigned; respectively; then the average of all the answers is taken and used in the excel graphs. In the occasions that not all the questions are answered, the average is taken based on the number of the questions answered.

Table 3. How survey questions 2.7 is quantified.

Q2.7. During the past twelve months was there a time when you or someone in the household have gone without the following basic essentials due to the cost?		
	Yes	No
Meals	0	4
Medical Treatment	0	4
Medication	0	4
Dental Treatment	0	4
Home Repairs	0	4
Transport (Fuel or public transport costs)	0	4

Other (Please specify)	0	4

Table 4. How survey questions 3.3, 3.4, 3.9 and 3.10 are quantified.

Q3.3. and **Q3.4.** How comfortable is the temperature in your home when you use/do not use air conditioning during a hot day in summer? **Q3.9.** and **Q3.10.** How comfortable is the temperature in your home use/do not use heating during a cold day in winter?	**Value given**
Extremely comfortable	4
Somewhat comfortable	3
Neither comfortable nor uncomfortable	2
Somewhat uncomfortable	1
Extremely uncomfortable	0

Table 5. How survey questions 3.5 and 3.11 are quantified.

Q3.5 and Q3.11. Was your home ever hotter/colder than you would like it this summer/winter	**Value given**
Yes, every day during summer/winter	0
Yes, at least half of the days during summer/ winter	$1 \times (\frac{4}{3}) = \sim 1.3$
Yes, only some days during summer/winter	$2 \times (\frac{4}{3}) = \sim 2.7$
No	$3 \times (\frac{4}{3}) = 4$

Table 6. How survey questions related to health (Q.10) are quantified.

Q4.10. Indicate which statements best describe your own health state today:	**Value given**
Mobility	
No problem walking about	4
Some problems walking about	2
Confined to bed	0
Self-care	
No problems with self-care	4
Some problems washing or dressing	2
Unable to wash or dress myself	0
Usual activities (e.g. work, study, housework, family or leisure activities)	
No problems with performing my usual activities	4
Some problems with performing my usual activities	2
Unable to perform my usual activities	0
Pain/Discomfort	
No pain	4
Moderate pain	2
Extreme pain	0
Anxiety/Depression	

No anxiety/depression	4
Moderate	2
Extreme	0

4.1.2. Survey outcomes

The comfort levels of participants in their houses before and after the upgrades are reported in Figure 4, ranging from extremely comfortable to extremely uncomfortable. This graph shows the average values taken over all houses. There are significant improvements to general comfort in the hot and cold days across all the participants. People in general felt more comfortable in their houses in winter with a heater. This indicates that occupants found the new air conditioning systems that replaced their old heaters (whether they had a wood burner or an old air conditioning unit) more efficient in terms of heating. They also felt 33% more comfortable without a heater indicating the positive and noteworthy impact of draught proofing, insulation installation, and gap sealing on maintaining the internal temperature of the houses on cold days with the absence of a heating source.

General comfort on hot days has a notable improvement of 100%. The high score of this answer shows that nearly all the participants felt extremely comfortable in their houses on summer days after the upgrades. This is due to the fact that many participants did not have any efficient cooling system prior to the upgrades. The answers to the questions (whether the house was colder/hotter than desired) are shown as "how many comfortable days in summer and winter" in Figure 4. Occupants reported substantial improvements of 75% and 142% in summer and winter, respectively.

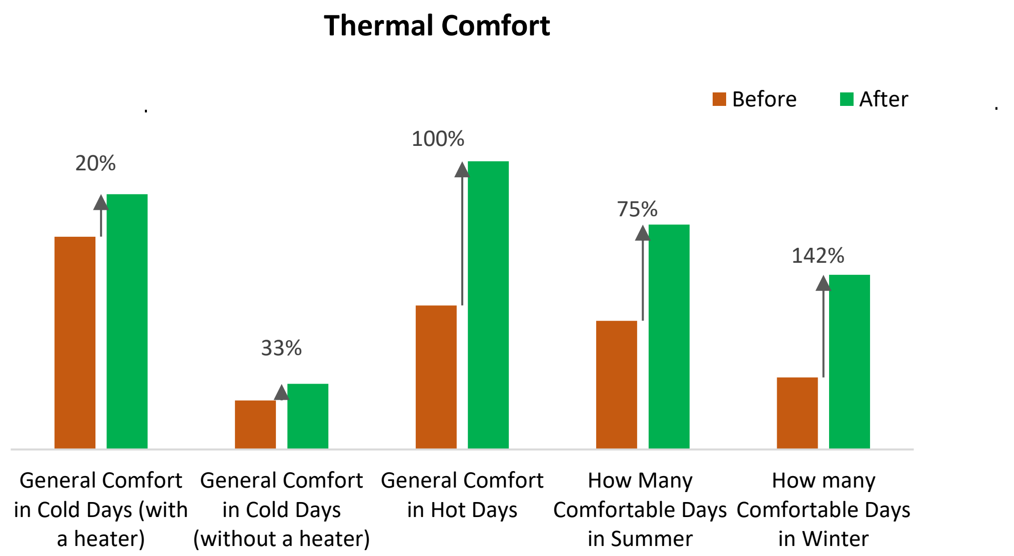


Figure 4. Average of participants' responses to their houses comfort in cold and hot days before and after the upgrades

Figure 5 shows the general financial situation of the participants before and after the upgrades. Participants were asked to mark their financial status by answering 'never in control' to 'always in control'. Note that this graph is plotted purely based on the participants' 'feel' of their financial status. While the financial status and the energy affordability seem to have slightly declined after the upgrades across all the participants, this simply could be the case of increased cost of living within the three years from the start of the program to the time that the surveys were completed by the participants. Also, in another question asked in the surveys, 71% of the participants strongly agreed that being part of the CSR program helped them reduce their energy bills (Figure 12).

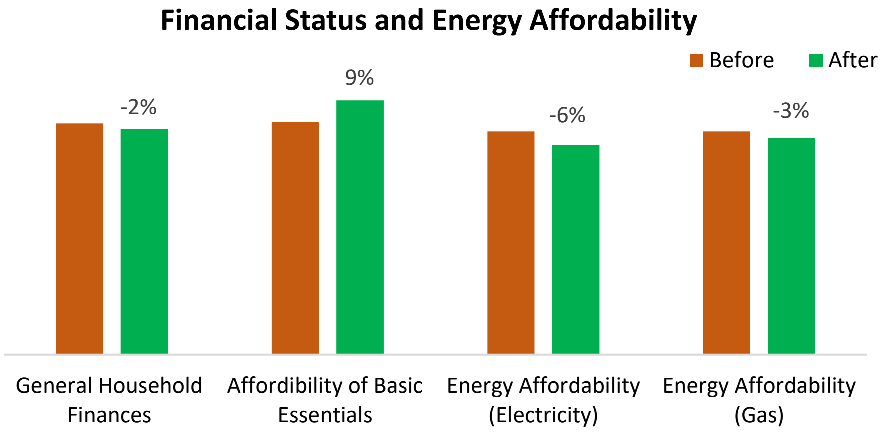


Figure 5. Financial status and affordability based on responses to surveys

Self-reported health and well-being status of the participants are summarised in Figure 6. Details on how these questions were plotted can be found in Table 6. Generally, participants reported a positive impact on their health as a result of the CSR program. The highest impact was reported to be on mental health. The participants felt 17% less depressed or anxious after the upgrades. There are also improvements in the general level of pain they experience, how active they are and how able they are to look after themselves after the upgrades.

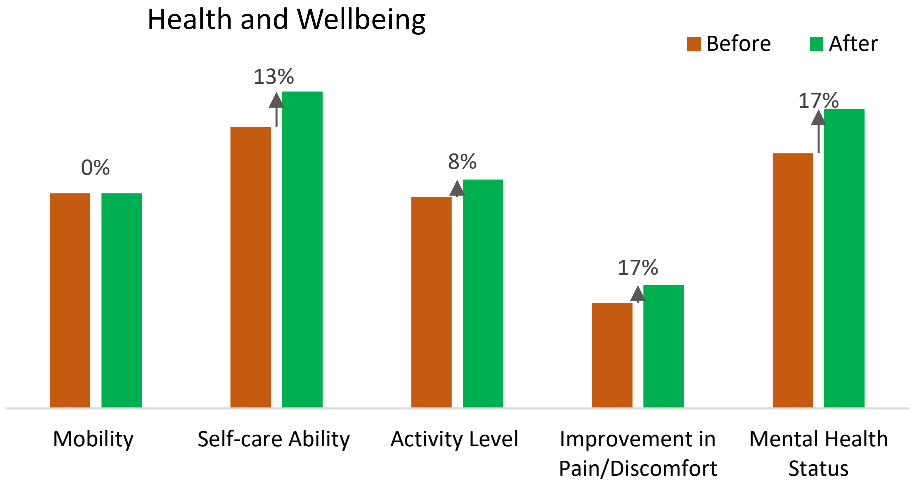


Figure 6. Health and wellbeing of participants before and after upgrades

Another indication of the influence of the CSR program on the participants' health is demonstrated in Figure 7. The participants were asked to mark their overall health status from zero to 100 (100 being the best) before and after the upgrades. The average of overall health status increased from 52 to 61.5. The participants also reported that they visited doctors less often (19.1 relative to 26.4 times a year). However, hospital admissions were reported to increase from 3.3 to 3.7 admissions per year as shown in Figure 8.

It should be noted here, due to the delays incurred by COVID-19, there was more than two years gap between the pre- and post-surveys. Unfortunately, both time and COVID-19 are likely to have had an adverse impact on the physical and mental health of these participants which cannot be measured here. For example, one participant (CSR6) has a neurological/muscular disease which worsened during the program. This participant reported that they felt an immense health benefit due to the thermal comfort provided to their home as a result of the upgrades. However, their mobility and self-care ability were reduced because of their health condition which affects the general outcomes.

In conclusion, considering the time factor, as well as the impact of COVID-19, even small improvements in the health and well-being of these participants is considered a significant achievement for this program.

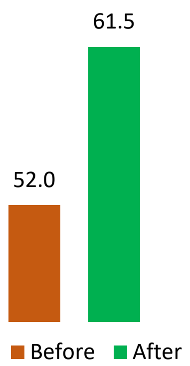


Figure 7. Self-reported overall health status out of 100.

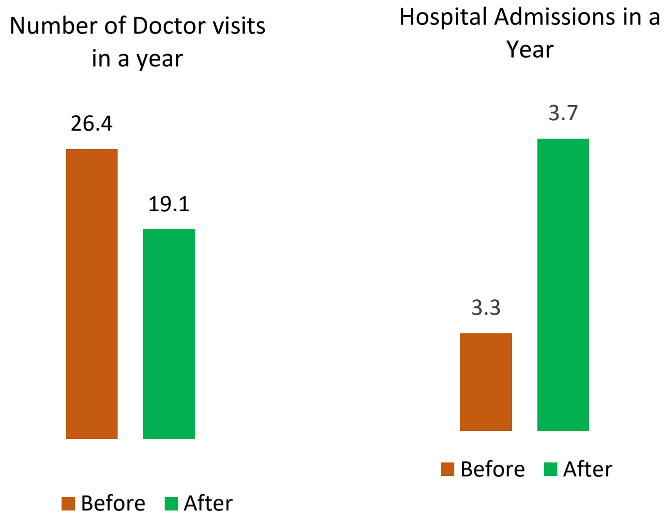


Figure 8. Number of doctor visits (left) and hospital admissions in a year (right) compared before and after home upgrades.

A closer look at each individual shows that each household benefited from the upgrades differently. For instance, one occupant (CSR1) benefited from the upgrades remarkably due to their health condition. This participant has a chronic lung disease and used to use a wood burner in winters which would have an adverse impact on their symptoms. They also did not have a cooling system in their house. As a result of the home upgrades, this participant reported they achieved 50% more comfort in winter and 200% more comfort in summer as shown in Figure 9. This significant comfort level has a notable positive influence on the participant's physical and mental health. They report their ability to self-care and activity level and pain improvement were double; they also felt a massive 300% improvement in their mental health to the point that they did not feel anxious or depressed, compared with moderate to extreme anxiety/depression before the home upgrades (

Figure 10). In general health status, this participant reported an improvement from 35 to 75, and far fewer doctor visits (reduced from 100 to 20 times a year) as illustrated in Figure 11.

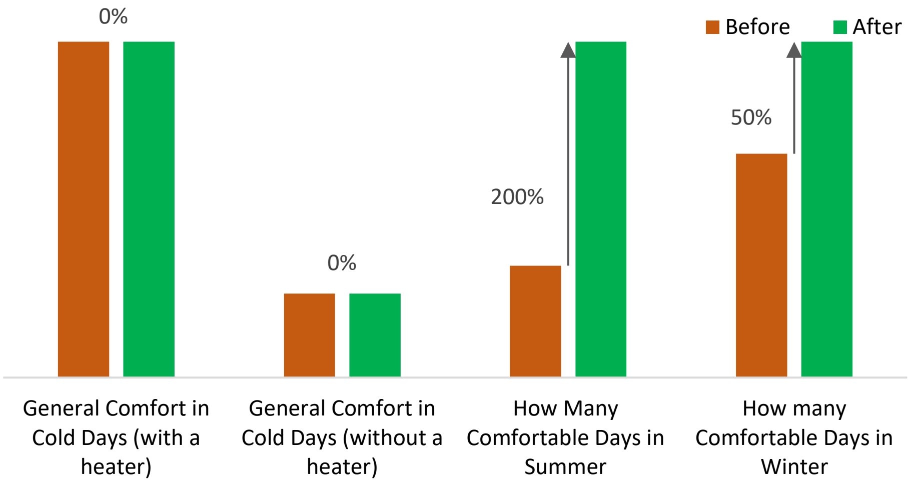


Figure 9. Thermal comfort for CSR1 before and after upgrades.

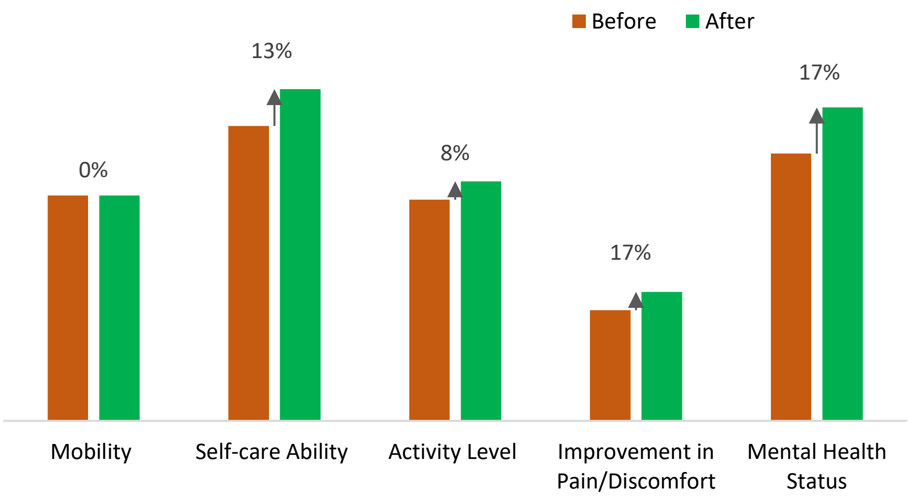


Figure 10. Health and wellbeing for CSR1 before and after upgrades

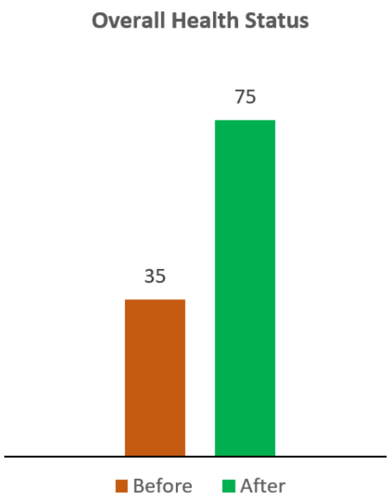


Figure 11. Overall Health status for CSR1 before and after upgrades

As a final measure, participants were surveyed on the general impact of the CSR program on their lives. This is presented in Figure 12. The actual questions asked of the participants are presented in Table 7.

Table 7

The actual questions asked in the survey	Reference in Figure 12
My health has improved from being part of the CSR Program	Improvement in health
My Quality of Life or Wellbeing has improved from being part of the CSR Program.	Improvement in quality of life
Being part of the CSR Program has helped reduce my household energy bills.	Reduction in energy bills
Being part of the CSR Program has been useful for my household.	Benefit for household
Being part of the CSR Program would benefit other people in my community.	Benefit for community
Being part of the CSR Program has helped me feel more comfortable in my home during Summer.	More comfort in summer
Being part of the CSR Program has helped me feel more comfortable in my home during Winter.	More comfort in winter
I would recommend this program to other people in my community	Recommend the program
The benefits of home energy efficiency and thermal comfort should be promoted as an important issue in my community.	promote energy efficiency

Majority of participants felt very positively about the CSR program; 79% of the participants strongly agreed that they would recommend this program to other people and that the benefits of home energy efficiency should be promoted in the community. 77% felt more comfortable in their houses after the upgrades. 71% claimed that the program is useful for their household and has helped them to reduce their energy bills. 23% of the participants strongly agreed that their health has improved as a result of being part of CSR program.

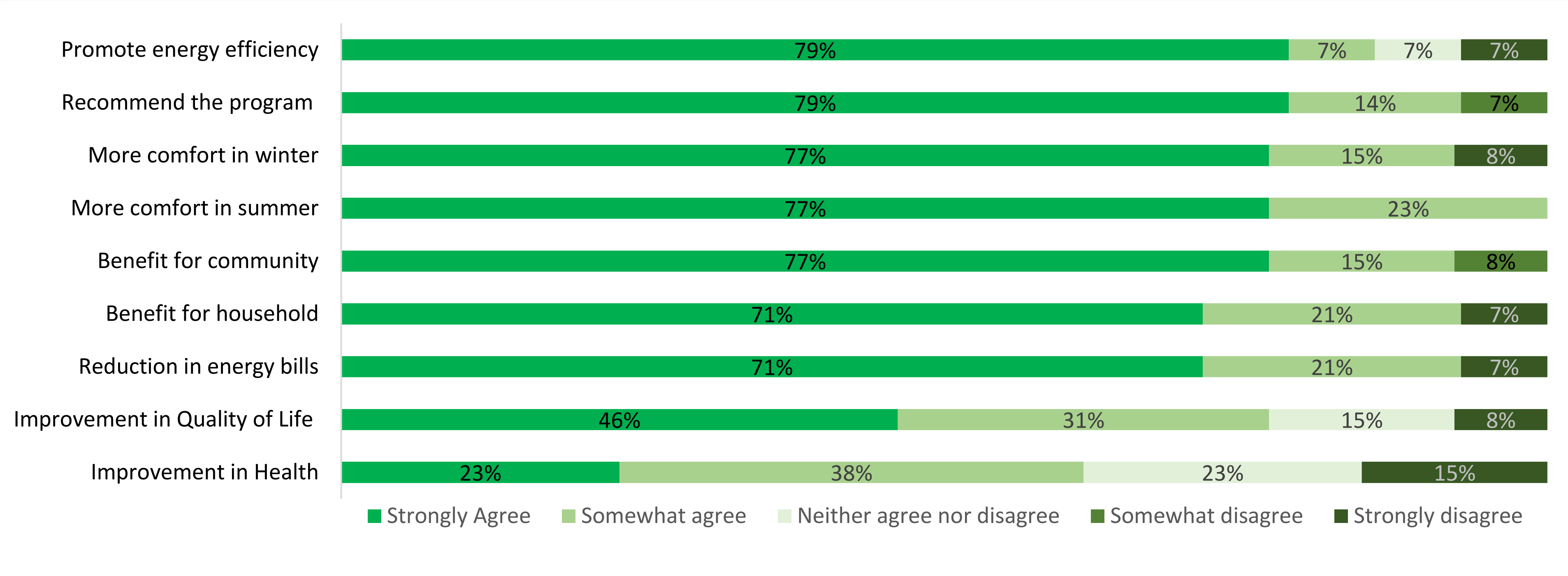


Figure 12. How participants feel about the CSR program.

4.2. Impact of upgrades on electricity consumption

As part of home upgrades, a solar PV system was installed in participating houses to offset a portion of their electricity costs. Data on electricity consumption and export (the surplus electricity generated by the solar panels) were obtained from Powercor, recorded in 30-minute intervals over a 24-hour period. This valuable dataset allows us to compare energy consumption before and after the upgrades.

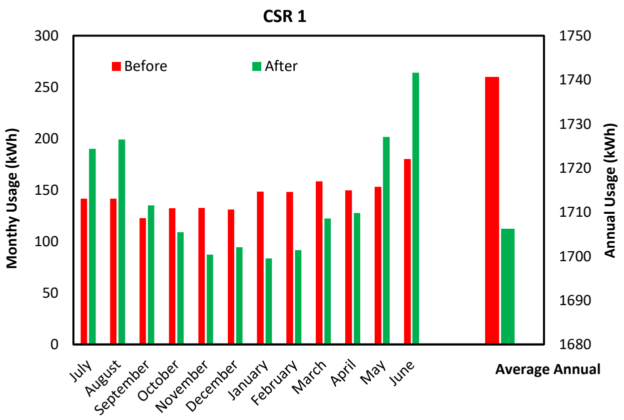
The electricity consumption data for houses 1 to 15 are presented in the following pages. The "before" data (shown in red) covers the period from 1st January 2019 to the end of June 2021. The "after" data (shown in green) encompass the period from 1st July 2021 to the end of March 2023. To visualise the changes, the consumption is plotted based on monthly usage, with averages calculated for each month within the before and after periods, and displayed on the left vertical axis. Additionally, the annual average consumption is indicated on the right vertical axis, providing a comprehensive overview of the energy consumption patterns.

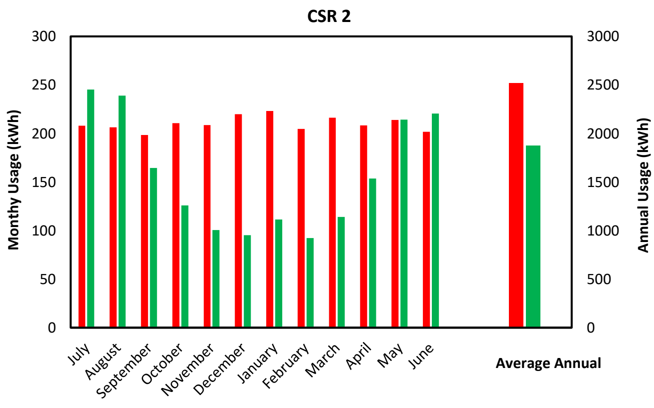
Significant reductions in electricity consumption are evident in the majority of houses, as detailed in Table 8. For example, CSR11, CSR12, and CSR13 experienced notable average reductions of 3798 kWh, 1204 kWh, and 1093 kWh per year, respectively, resulting in impressive annual reductions of 48%, 50%, and 43% in electricity usage, respectively.

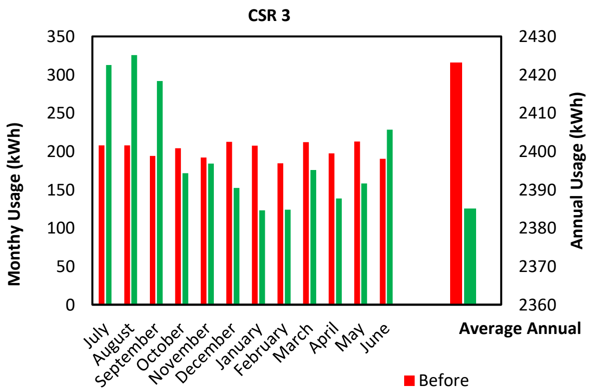
While many participating houses witnessed notable changes in their consumption, some, such as CSR1, CSR3, CSR6, and CSR10, experienced relatively minor alterations. Let's delve into their individual cases:

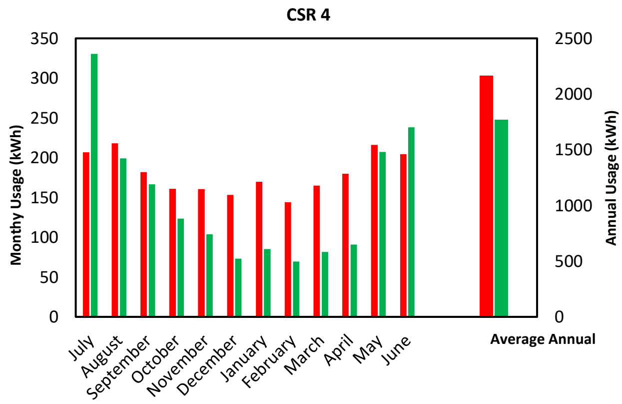
- CSR1: Previously reliant on a wood burner for heating and lacking a cooling system, this participant's electricity usage must have increased upon switching to a reverse cycle air conditioner. However, the installation of solar PV effectively offset this extra electricity usage over the course of a year.
- CSR3: Originally a gas user, this household transitioned to electricity. While there is not sufficient gas billing data on their gas consumption, the fact that they did not incur additional costs after switching to electricity is a commendable achievement.
- CSR6: This household had already installed solar PV before the upgrades, resulting in minimal changes to their energy consumption patterns.
- CSR10: Surprisingly, this household did not experience a reduction in energy consumption. Possible explanations for this could be increased visitors or additional residents at this household following the upgrades.

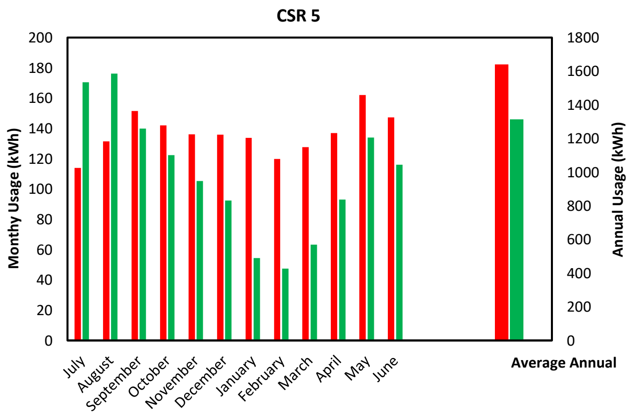
On the other hand, CSR8, CSR14, and CSR15 recorded increases in their electricity consumptions. This was mainly due to the fact that these participants had been using gas heaters before the upgrades and subsequently switched to electricity after the updates. However, it's essential to note that these houses also observed reductions in their gas consumption, which will be further elaborated upon in the next section.

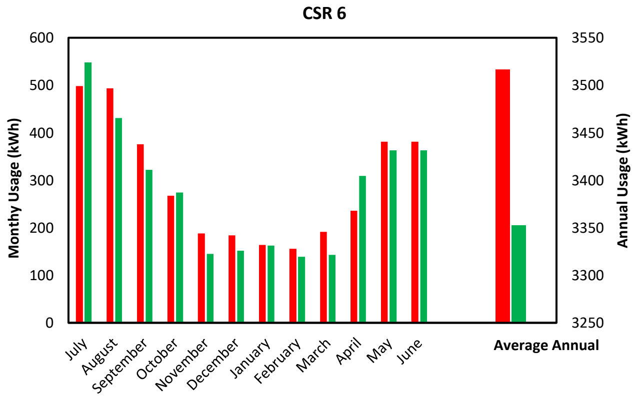

CSR 1
Before
After
Monthy Usage (kWh)
Annual Usage (kWh)
300 250 200 150 100 50 0
1750 1740 1730 1720 1710 1700 1690 1680
July August September October November December January February March April May June
Average Annual

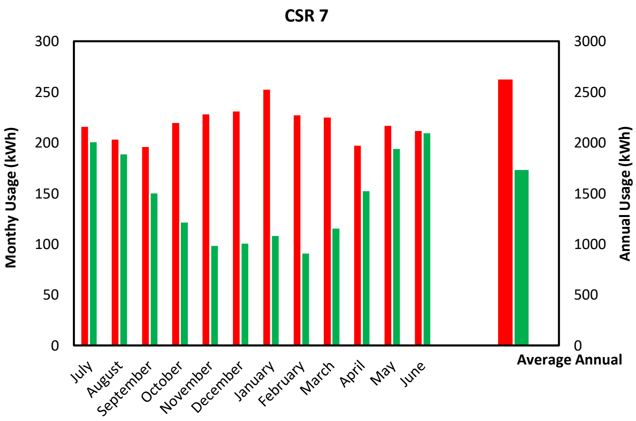

CSR 2
Monthy Usage (kWh)
Annual Usage (kWh)
300 250 200 150 100 50 0
3000 2500 2000 1500 1000 500 0
July August September October November December January February March April May June
Average Annual

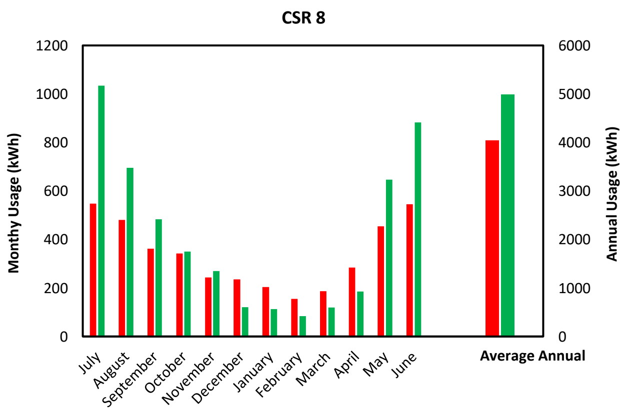

CSR 3
Monthy Usage (kWh)
Annual Usage (kWh)
350 300 250 200 150 100 50 0
2430 2420 2410 2400 2390 2380 2370 2360
July August September October November December January February March April May June
Average Annual
Before

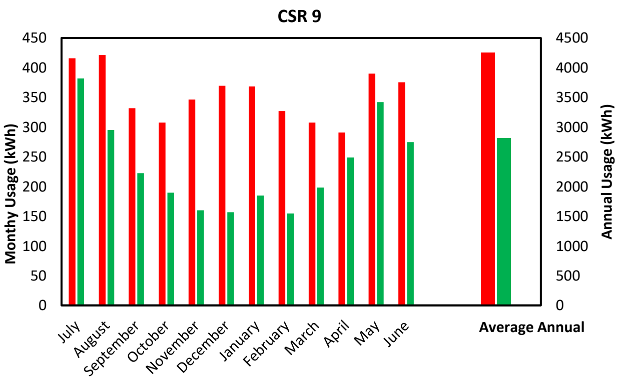

CSR 4
Monthy Usage (kWh)
Annual Usage (kWh)
350 300 250 200 150 100 50 0
2500 2000 1500 1000 500 0
July August September October November December January February March April May June
Average Annual

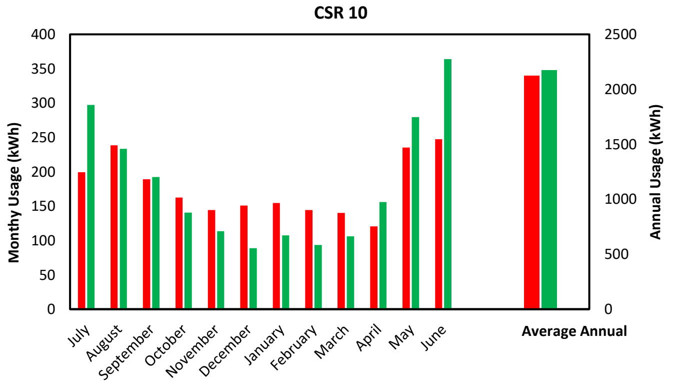

CSR 5
Monthy Usage (kWh)
Annual Usage (kWh)
200 180 160 140 120 100 80 60 40 20 0
1800 1600 1400 1200 1000 800 600 400 200 0
July August September October November December January February March April May June
Average Annual

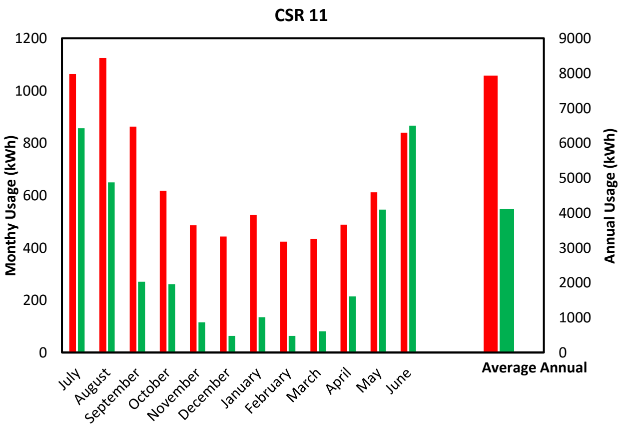

CSR 6
Monthy Usage (kWh)
Annual Usage (kWh)
600 500 400 300 200 100 0
3550 3500 3450 3400 3350 3300 3250
July August September October November December January February March April May June
Average Annual

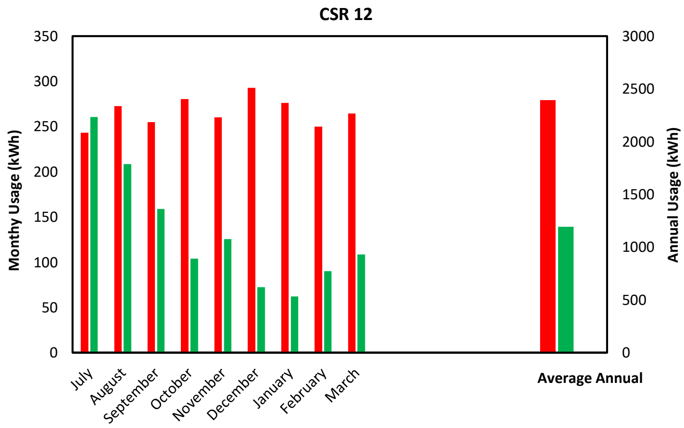

CSR 7
Monthy Usage (kWh)
Annual Usage (kWh)
300 250 200 150 100 50 0
3000 2500 2000 1500 1000 500 0
July August September October November December January February March April May June
Average Annual

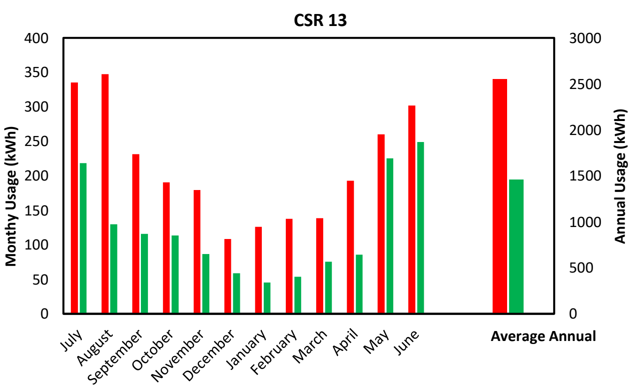

CSR 8
Monthy Usage (kWh)
Annual Usage (kWh)
1200 1000 800 600 400 200 0
6000 5000 4000 3000 2000 1000 0
July August September October November December January February March April May June
Average Annual

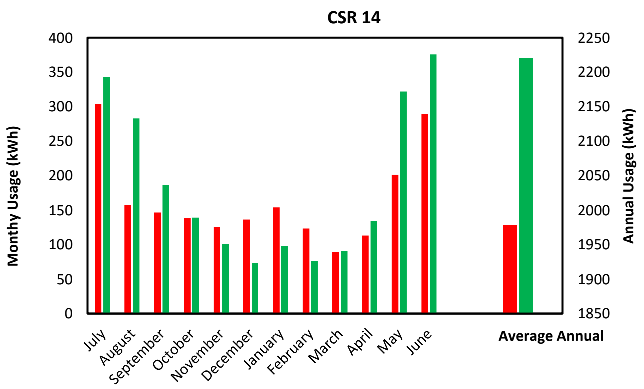


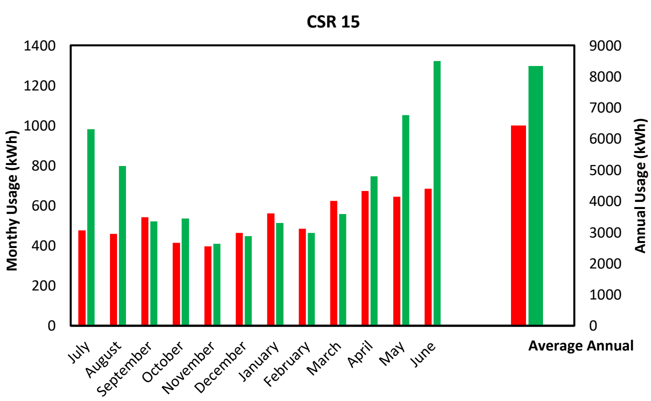












Note:

In all the graphs, the right-hand side Y-axis illustrates the average monthly electricity usage, while the left-hand side Y-axis represents the average annual usage before and after the upgrades. The colour scheme remains consistent across all graphs, with 'Red' indicating the data before the upgrades, and 'Green' representing the data after the upgrades.

Figure 13. Average monthly and annual electricity consumption before and after the upgrades.

Table 8. Average annual electricity consumption.

House	Annual Consumption Before Upgrades (kWh)	Annual Consumption After Upgrades (kWh)
CSR1	1,740.7	1,706.2
CSR2	2,519.7	1,877.0
CSR3	2,423.2	2,385.1
CSR4	2,161.5	1,769.1
CSR5	1,638.4	1,314.9
CSR6	3,516.8	3,352.7
CSR7	2,621.2	1,727.3
CSR8	4,037.3	4,985.4
CSR9	4,252.2	2,810.1
CSR10	2,126.6	2,172.0
CSR11	7,919.8	4,121.2
CSR12	2,395.3	1,190.9
CSR13	2,550.8	1,457.7
CSR14	1,978.2	2,221.3
CSR15	6,419.7	8,344.4
Average	3,220.1	2,762.3

As would expected, the most substantial reductions in electricity consumption were observed during the summer months when the solar PV systems operated at their highest efficiency. Figure 14 provides an overview of the average monthly electricity consumption for all participating houses, and Table 9 presents the percentage reduction in consumption for each month. Notably, significant reductions of approximately 46% were seen during December, January, and February.

Subsequently, as the months progress, the reduction starts to decrease, and electricity consumption increases compared to the pre-upgrade period. This trend is primarily influenced by households using air-conditioning as a heater while the solar PV systems generate less energy during those months. As a result, more power is used thus negative reduction values are evident in May, June, and July.

Despite these variations in consumption patterns, when considering the entire year, the average electricity consumption changed from 3,280 to 2,827 kWh revealing a reduction of 453 kWh in electricity consumption. This indicates the overall effectiveness of the upgrades in avoiding a net energy increase across the participating households.

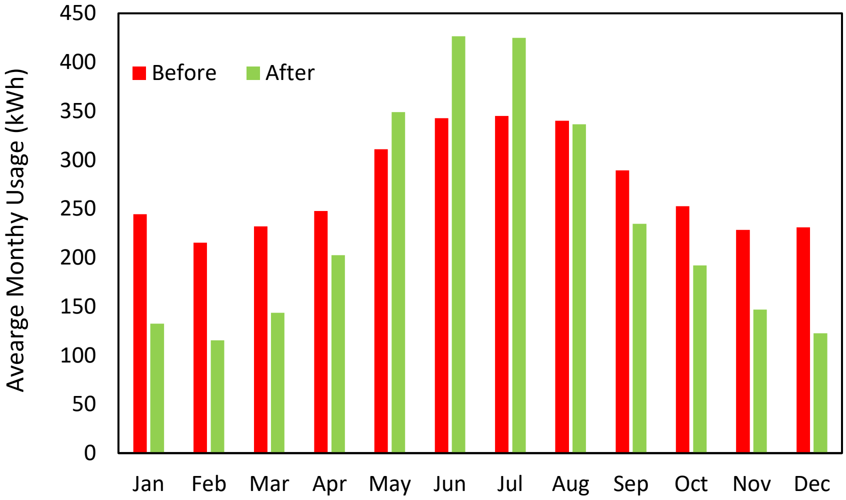


Figure 14. Average monthly electricity consumption before and after upgrades.

Table 9. Average Reduction in electricity consumption by percentage

Month	Consumption reduction (%)
Jan	45.8
Feb	46.3
Mar	38.2
Apr	18.2
May	-12.2
Jun	-24.5
Jul	-23.1
Aug	1.1
Sep	18.9
Oct	24.0
Nov	35.7
Dec	46.9

4.3. Solar export

As mentioned earlier, as part of the upgrades, each participating house had a solar PV system installed. These solar systems not only led to significant reductions in electricity consumption but also generated surplus electricity that was exported to the electricity grid. To quantify this, the average solar export over nearly two years (from the PV installation date until March 2023) was calculated based on data provided by Powercor, and the results are presented in Table 10 for all participating houses.

The average amount of solar export across all houses was 3,225 kWh per year. This translates to an impressive $167.70[5] in extra savings on annual electricity bills for each household. The

[5] The value is calculated on the assumption of 5.2c/kilowatt-hour for exported energy.

additional financial benefit from exporting excess solar energy highlights the overall effectiveness of the solar PV systems in not only reducing grid consumption but also contributing positively to the households' energy costs.

Table 10. Average solar export in a year (kWh)

House	Average solar export in a year (kWh)
CSR1	2,304.4
CSR2	1,843.6
CSR3	2,381.4
CSR4	2,307.0
CSR5	4,460.4
CSR6	3,216.3
CSR7	5,460.2
CSR8	4,316.4
CSR9	4,301.0
CSR10	2,397.6
CSR11	834.9
CSR12	6,554.4
CSR13	2,497.6
CSR14	3,692.4
CSR15	1,820.9
Average Annual export	3,225.9 kWh

4.3.1. Electricity consumption and solar export pattern

To gain deeper insights into electricity usage and the solar generation pattern, a detailed analysis of the electricity meter data conducted for CSR1 is presented here. This particular house is of special interest as, prior to the upgrades, the occupant relied on a wood burner heater for warmth during winters with access to free wood for burning, and had no cooling system. After the upgrades, the occupant had a reverse cycle air conditioner, to provide both heating and cooling. The data presented below demonstrates that switching to the air conditioner did not incur any additional costs for the household while significantly improved the comfort of the homeowner.

Figure 15 illustrates the solar export data for CSR1 in 2022, following the completion of the house upgrades. This graph displays the average amount of electricity exported during a 24-hour period, from midnight till 11.30 PM, for each month of the year. As expected, solar energy is exported during daylight hours, specifically from 6 AM to 7 PM, with variations across different months. Higher solar energy exports are observed in the summer months (Dec, Jan, Feb), while the lowest exports are recorded in May, June, and Jul, as depicted in Figure 15.

Figure 16 presents the electricity consumption data for CSR1 in the same year (2022), averaged over the same time intervals. Unsurprisingly, energy consumption peaks during the colder months, namely June, July, and August, when the performance of solar panels is low due to shorter days and reduced sunlight intensity. However, for the remainder of the year, electricity consumption from the grid remains remarkably low (0.04 kWh) from 8 AM to 4 PM, indicating that the solar panels provide the required energy for the household during these hours.

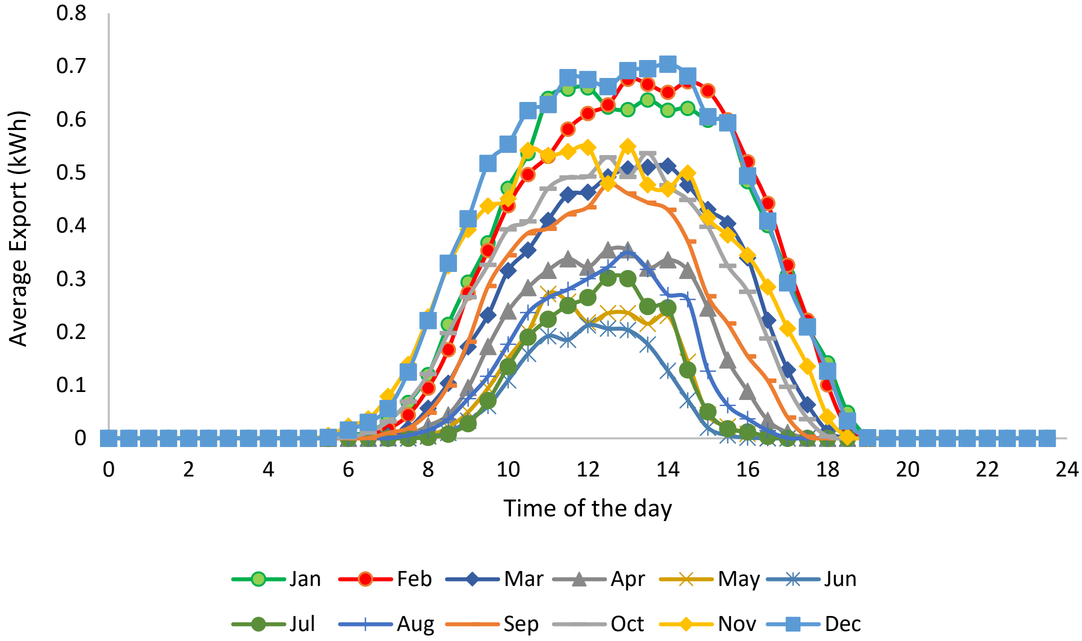


Figure 15. Average export to the grid in 24 hours in 30-minute intervals shown for different months in 2022 (after upgrades) for CSR1.

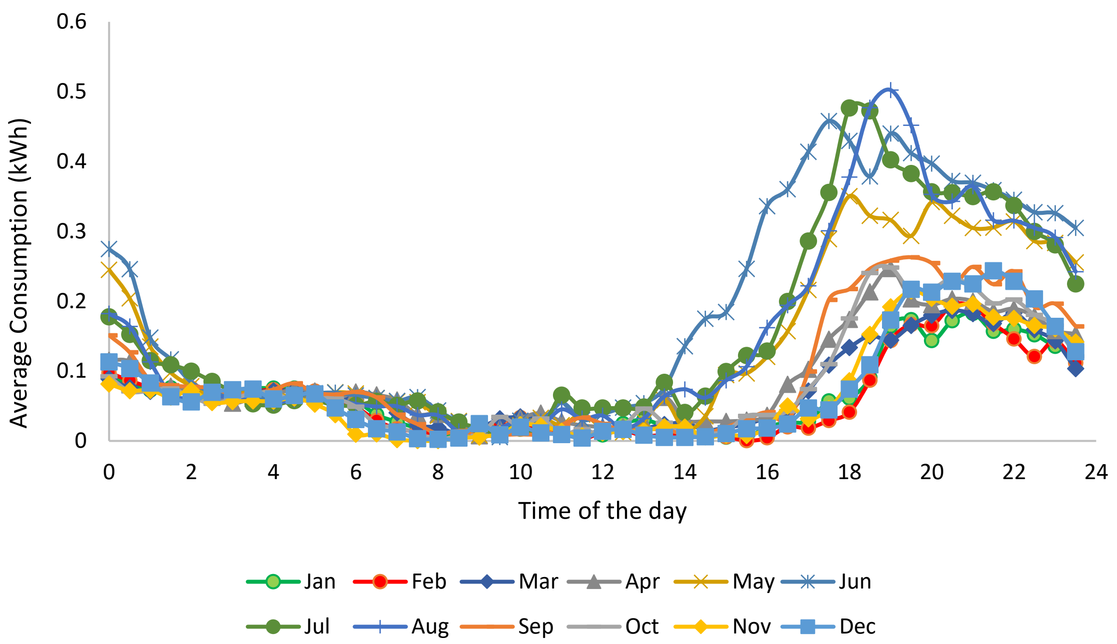


Figure 16. Average consumption after the upgrades. Consumption is plotted in 24 hours in 30 minutes intervals shown for different months in 2022 for CSR1.

To provide a comprehensive comparison of the impact of solar systems on energy consumption, the average values of consumption and export from Figure 17 and Figure 18 for two months of June and December are analysed These months are chosen to represent the two extremes in solar PV performance, influenced by varying weather conditions.

Figure 17 illustrates that during December, the solar panels not only cover the electricity needs of this household's during the day (from 6 AM until 7 PM), but they also generate a notable surplus of energy (up to 0.7 kWh in 30 minutes) that is exported back to the grid. This demonstrates the efficiency of the solar panels in offsetting the energy consumption associated with cooling during the daytime in hot and sunny months, as is typically the case. As previously shown (Figure 4 and Figure 9) most occupants reported significant improvement in home comfort after the upgrades, particularly during summer. Figure 17 further illustrates that this substantial increase in comfort comes with almost zero additional energy costs.

Additionally, Figure 17 suggests that, when feasible, it is advantageous to run high-energy-consuming appliances such as dryers, washing machines, or dishwashers during the daytime to capitalise on the surplus energy generated by the solar PV.

Next, we turn to Figure 13, which presents the electricity consumption and export data for the month of June. Due to shorter days and reduced sunlight intensity, the solar system does not cover all the energy required for the entire day during this month. However, it still produces a remarkable amount of energy, meeting (exceeding) the household's consumption from 9 AM until 2 PM.

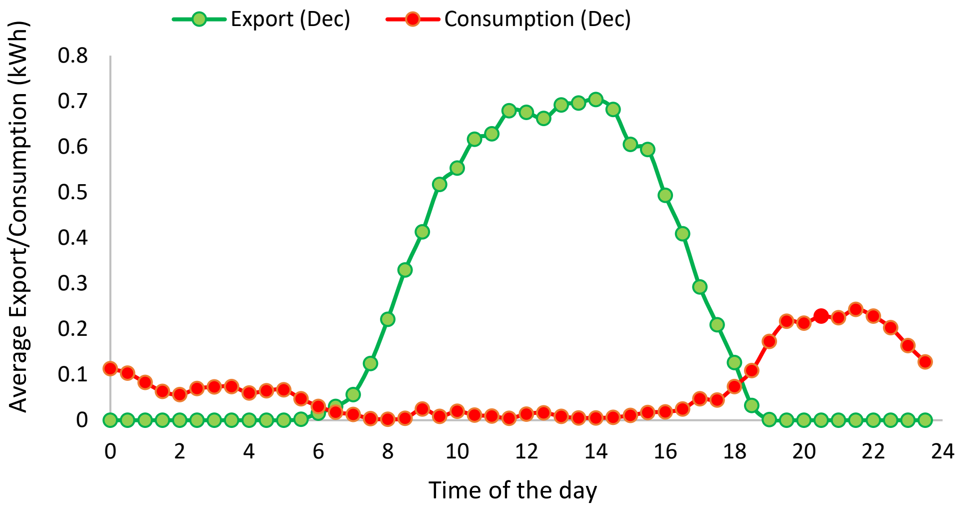


Figure 17. Electricity consumption and export in December 2022 (After upgrades) for CSR 1

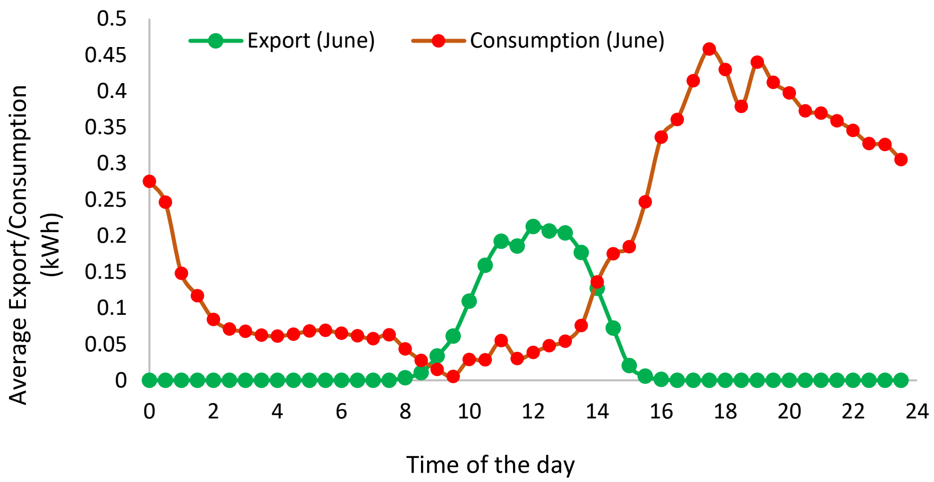


Figure 18. Electricity consumption and export in June 2022 (After upgrades) for CSR 1

Figure 19 illustrates the monthly electricity consumption and solar export data for CSR1 spanning from January to December 2022. The analysis reveals a remarkable trend wherein the electricity generated by the solar system surpasses the household's energy requirements for seven months of the year, specifically from September to April. Even during the remaining months (May to August), although solar generation does not fully cover the household's electricity needs, a surplus of energy is still exported to the grid.

These findings suggest the potential benefit could be gained from installing a battery system for this household. With a battery, the resident could effectively eliminate electricity bills for seven months of the year, experiencing a net-zero cost during this time. Additionally, for the remaining months, their electricity bills would reduce significantly, coming close to half of their current amount.

In summary, this household did not incur extra energy expenses after the upgrades, as indicated in Table 8, and even benefited from exporting 2,304 kWh of solar energy, which is equivalent to approximately $120 in savings per year.

In conclusion, these analyses further highlight the significant benefits of the solar systems for both household comfort and environmental sustainability. These results shows that the home owners can greatly reduce energy drawn from the grid to heat and cool their homes as needed without fearing energy costs and also avoid gas use for heating.

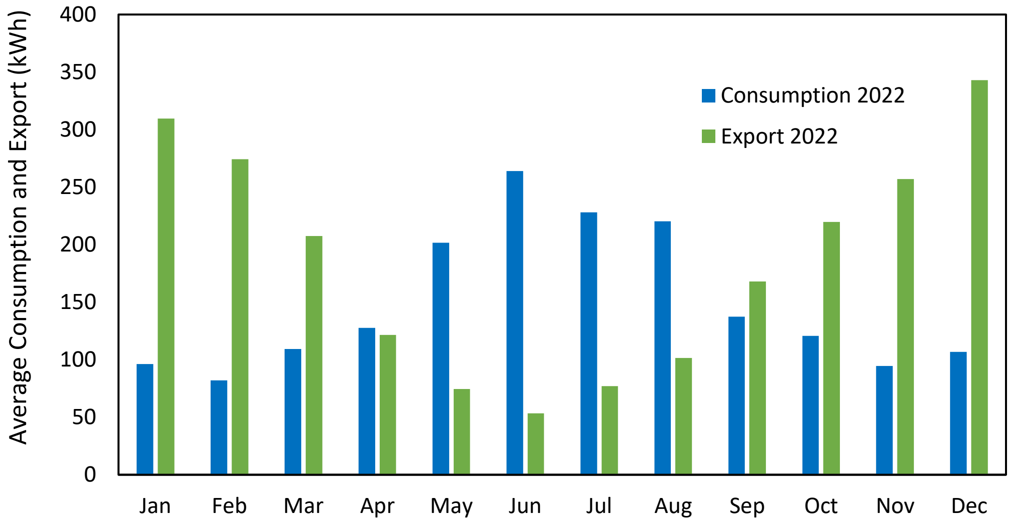


Figure 19. Electricity consumption and solar export after the upgrades for CSR1.

4.4. Gas consumption

4.4.1. Methodology

To analyse the scanned gas bills, ImageJ software was used. ImageJ is a free public domain image processing software and was used here to extract the average daily usage values from the bar charts presented on the gas bills. First the software is calibrated based on the scale provided on each bar graph, then the monthly values were measured. Upgrades for all houses were completed at the end of June 2021, this date was used to define 'before' and 'after'.

To assess the impact of transitioning from a gas heater to a reverse cycle air conditioner on household energy costs, gas consumption data for houses that had a gas heater prior to the upgrades was compared. The houses included in this analysis are CSR2 to CSR8, CSR11, and CSR14, based on the available data from scanned gas bills. It is important to note that not all participants retained their gas bills for the entire period before and after the upgrades, resulting in limited data coverage. Unfortunately, gas bills for CSR6 are not accessible, and there is very limited information for CSR3 and CSR7.

(a) (b)

Figure 18. Calibration (a) and measuring values (b) of a bar graph from a gas bill using ImageJ software.

4.4.2. Impact of upgrades on gas consumption

The comparison of average daily gas consumption before and after the upgrades is represented in Figure 20. The changes in consumption for individual houses are elaborated here:

CSR2: some increase in gas consumption is observed during July, September, and November. However, the overall gas consumption for the entire year has decreased after the upgrades.

CSR3: Unfortunately, we only have data available for the month of September for CSR2, which limits the ability to draw meaningful conclusions from this data point.

The rest of the houses (CSR4, CSR5, CSR7, CSR8, CSR11 and CSR14) demonstrated a notable reduction in their gas consumptions. For CSR4, CSR8, CSR11, and CSR14, these reductions are particularly significant. These participants observed 48%, 52%, 73% and 43% reductions respectively in their average daily consumption after the upgrades. A summary of results is shown in Table 11.

Table 11. Gas consumption before and after upgrades.

House	Average daily gas consumption (MJ)		Reduction in consumption
	Before	After	
CSR2	104.3	100.1	4.0%
CSR4	67.1	34.5	48.6%
CSR5	215	170.5	20.7%
CSR8	145.6	69.9	52.0%
CSR11	101.5	26.5	73.9%
CSR14	90.1	50.8	43.6%
Average	120.6	75.4	40%

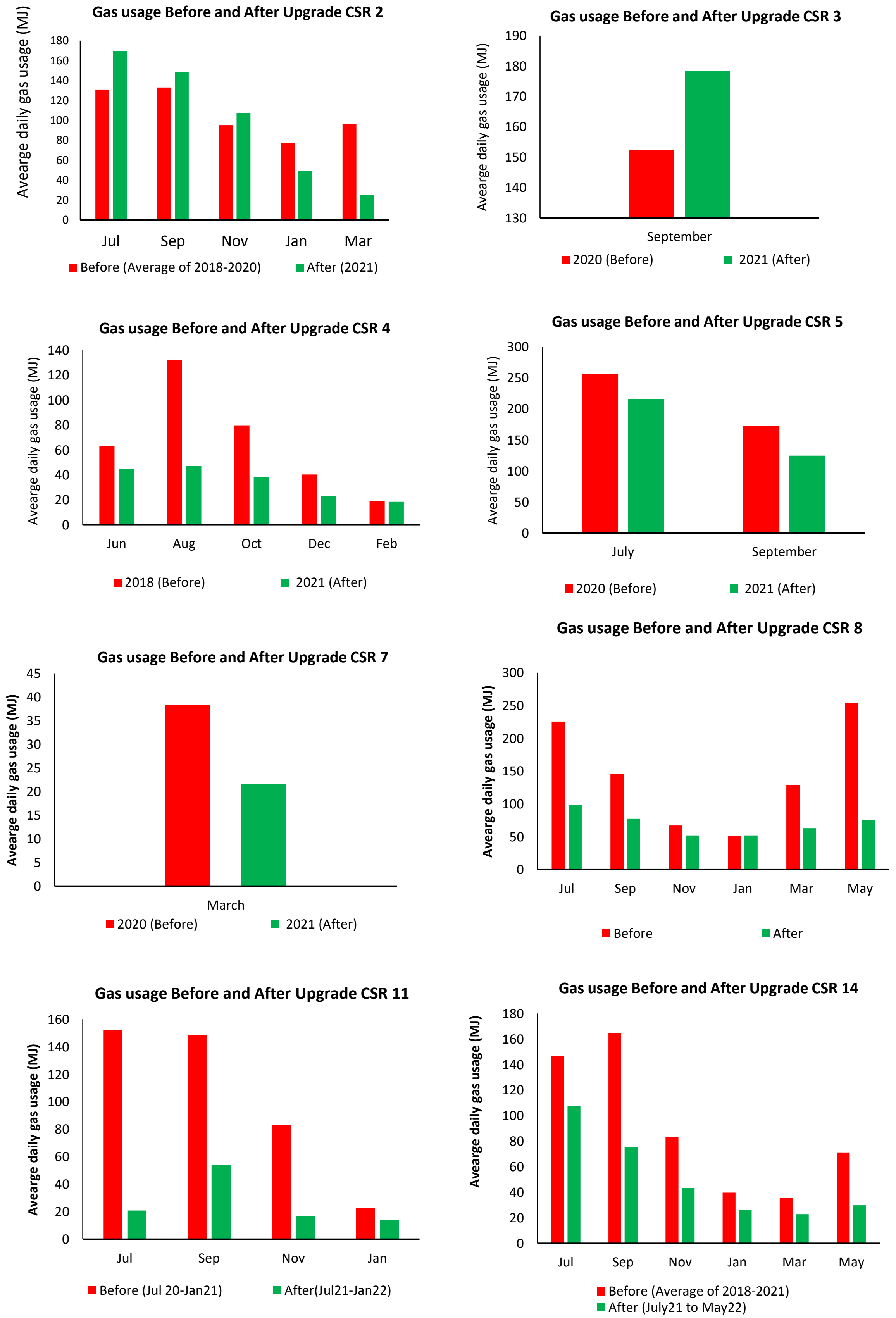


Figure 20. Average daily gas consumption before and after the upgrades for the households that used gas heater before the upgrades (subject to data availability).

4.5. Impact of upgrades on homes temperature

The impact of upgrades on the temperature within homes was investigated using non-invasive sensors provided by CSIRO. These sensors were strategically placed throughout the participating households to monitor the internal temperature of various rooms at hourly intervals from 2019 to 2022. Although certain time frames lack sensor data (specifically, post-upgrade data for CSR7 and CSR9 in upgraded rooms, and pre-upgrade data for CSR11), analysis yielded valuable insights through observing exposure times to cold and hot conditions.

The collected temperature data were analysed to determine the amount of time the retrofitted rooms in the houses were exposed to temperatures under 18°C and above 30°C. These exposure times were then compared for before and after the upgrades.

4.5.1. Winter

"Cold temperatures" is defined as any temperature below 18°C which is the minimum temperature recommended by the World Health Organization (WHO) for a "safe and well-balanced" indoor environment[6].

To verify the comparison, minimum temperatures in winter, recorded by the Bureau of Meteorology (BOM) at Geelong Breakwater (Racecourse Station) from 2020 to 2022, were plotted in Figure 21. The data revealed that minimum temperatures remained relatively consistent across the three winters.

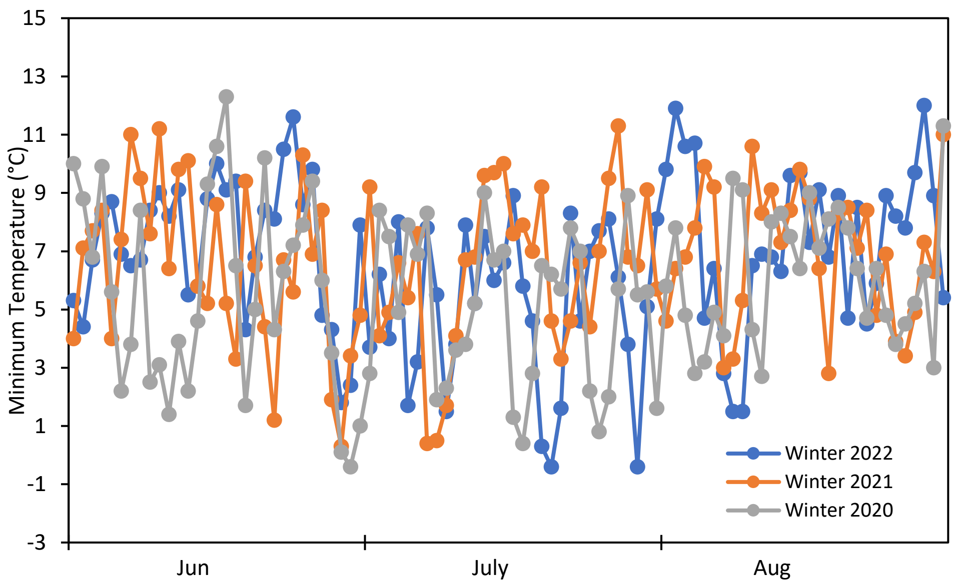


Figure 21. Minimum temperature in Geelong in winters 2020-2022 (based on BOM data)

[6]https://apps.who.int/iris/bitstream/handle/10665/276001/9789241550376-eng.pdf

Table 12 and Figure 22 illustrate the exposure to cold temperatures during the winter seasons for three consecutive years (2019 to 2022) in CSR1's kitchen, living room, and dining room – the areas where retrofitting tasks were conducted. Since these rooms are normally not occupied during the night, the data was filtered to only include the information from 7AM until 12 midnight.

Taking into consideration that the upgrades were completed in June 2021, the results showed significant reductions in exposure times after the upgrades. For instance, comparing the exposure times in August 2022 and August 2020, the rooms experienced 381.1 and 477.7 hours of cold temperature, respectively. This means a notable 96.6 hours less exposure to cold (less than 18°C) in just one month was observed, equating on average 3.1 fewer 'cold' hours per day.

It is worth mentioning that while reduced, the exposure times are still high even after the upgrades. This is probably due to the fact that the participants were not using the air conditioner for heating as much as needed, most likely due to the concerns about energy costs. This issue should be addressed through education and assuring residents about the cost-effectiveness of operating a highly efficient air conditioner, especially with the support of a solar system.

Table 12. Duration of exposure to cold temperatures for CSR1 in retrofitted rooms (kitchen, living room and dining room) at day time (7AM-12 midnight)

Year	Month	Exposure to extreme cold (less than 18C) in hours
2020	Jun	393.5
	Jul	497.9
	Aug	477.7
2021	Jun	311.9
	Jul	457.9
	Aug	458.0
2022	Jun	351.1
	Jul	400.5
	Aug	381.1

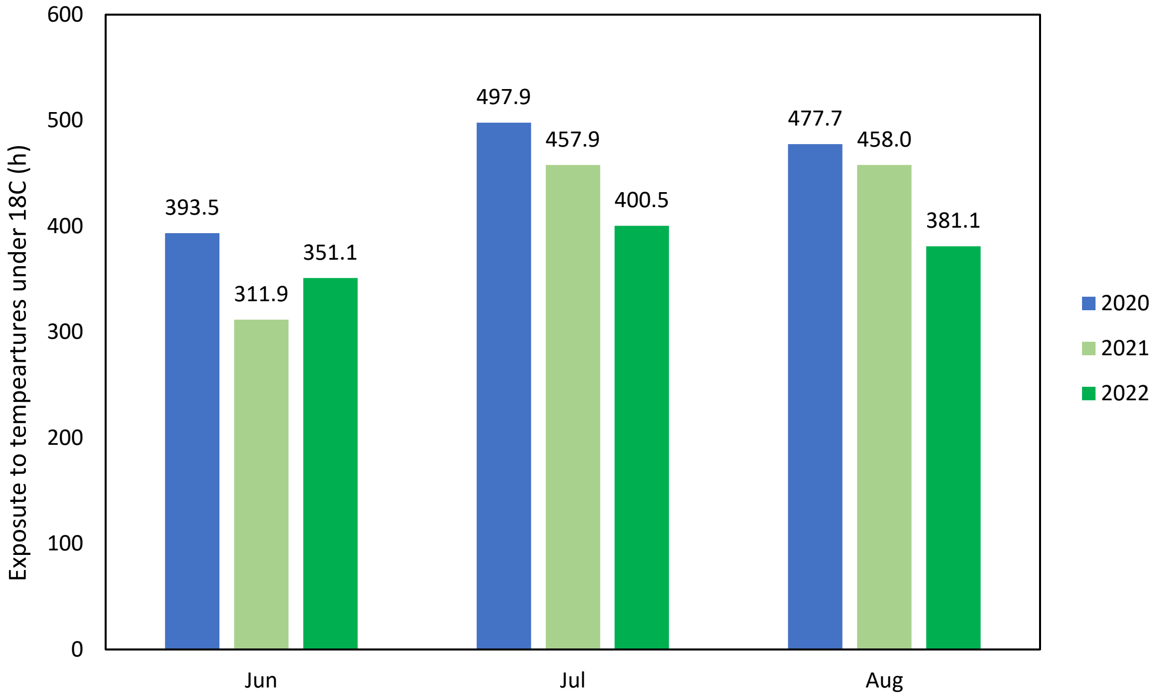


Figure 22. Exposure time to temperatures less than 18°C during day (7AM-12) in 2020, 2021 and 2022 for CSR1 recorded in kitchen, living and dining room.

The average exposure times to temperatures below 18°C, during 7 AM till 12 midnight, for winters of 2020, 2021, and 2022 were calculated across all participating houses (based on data availability). It was found that after the upgrades in winters 2021 and 2022, the retrofitted rooms were exposed to 196.2 and 99.8 hours less cold temperature relative to winter 2019. On average, the exposure to cold temperature was reduced by 128 and 65 minutes per day in 2021 and 2022, respectively. It's worth noting that the decrease in exposure time in 2021 was likely influenced by the COVID-19 lockdown, as people stayed indoors more often. In 2022, participants needed to use their heaters less frequently, resulting in the observed reduction.

4.5.2. Summer

The same approach was employed to study exposure times to hot temperatures, defined as temperatures exceeding 30°C in 2019 to 2022. Prior to analysing the sensor data, we examined the temperature records of these summers in Geelong, relying on data reported by the Bureau of Meteorology (BOM) at Geelong Breakwater (Racecourse Station). The summers of 2019 to 2022 exhibited considerable variations in temperature. Figure 23 displays the maximum temperature of each day in January, February, and December for those years, and Table 14 summarises the number of days with outdoor temperatures exceeding 30°C in Geelong. Notably, summer 2019 experienced extreme heat, with 20 days having temperatures over 30°C, whereas 2020 and 2021 had only 10 such days, and 2022 saw 16 days with temperatures exceeding 30°C.

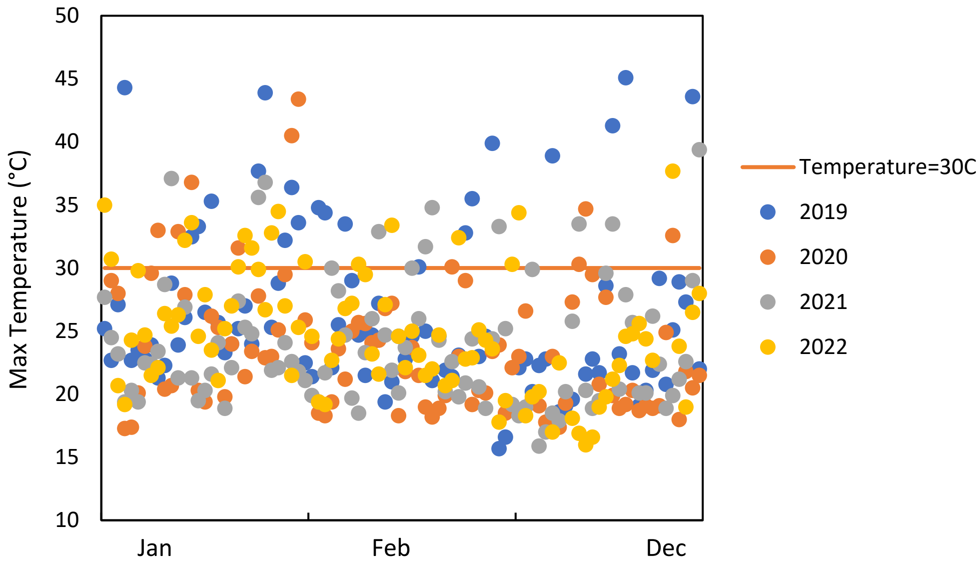


Figure 23. Maximum tempearture recorded by Bureau of Meteorology (BOM) at Geelong Breakwater in summers of 2019-2022. Each point represents one day, the points above the orange line represent the days the temperature exceeded 30°C.

Table 13. Number of hot days (maximum temperature reaching over 30°C) in Geelong in Januray, Februray and December 2019 to 2022.

Year	Number of hot days
2019	20 days
2020	10 days
2021	10 days
2022	16 days

Having gained insight into temperature variations in the years before and after the upgrades, the total exposure to temperatures over 30°C in the retrofitted rooms for January, February, and December were calculated. Table 14 provides the average exposure to hot temperatures for these three months in 2019 to 2022.

To ensure data comparability, exposure times have been normalised to a baseline of 10 hot days per year. Table 14 presents the net average exposure time based on sensor data, along with the corresponding normalised exposure times. For instance, in 2019, with 20 hot days, an exposure of 44.1 hours changes to 22.05 hours, while in 2022, with 16 hot days, 25.1 hours of exposure becomes 15.7 hours. This consistent approach facilitates accurate comparisons. It is demonstrated that 2019 and 2020 (prior to upgrades) now present a similar value of around 22 hours of exposure to temperatures over 30°C.

Comparing hot months in 2021 with 2020, there is a reduction of 1 hour in exposure to hot condition, indicating some improvement was achieved despite the houses not benefiting from the full upgrades throughout 2021. It should be noted, the upgrades were completed in June 2021 for majority of the houses. As a result, the houses were upgraded in November and December 2021, but not in January 2021.

Most notably, when comparing the normalised data from hot months of 2022, after the upgrades were completed, with 2020 (before the upgrades), households experienced a significant improvement of 6.5 hours less exposure to hot temperatures during three hot months of year.

Note that the analysis is based on data availability, and the sensor data for CSR 7,8,9,11,12 were not accessible for the period of interest.

Table 14. Average exposure to temperatures exceeding 30°C for in the retrofitted rooms across all the participating houses.

Year	Exposure to hot temperature (Hours)	Normalised exposure time based on 10 hot days per year (see Table 14)
2019	44.1	22.0
2020	22.2	22.2
2021	19.2	19.2
2022	25.1	15.7

5. Discussion

In this study, we provided evidence on how poorly designed and constructed houses can significantly jeopardize the health and well-being of the most vulnerable members of our community. The Climate Safe Rooms program, proposes a practical, cost-effective solution that enhances the thermal performance of households through energy-efficient retrofitting. This approach carries health and potential life-saving benefits for individuals, it also brings about substantial energy savings and cost reductions, and takes us a step closer to achieving our zero emissions target.

The urgency of addressing the impact of housing on vulnerable communities cannot be overstated. The increasing cost-of-living, coupled with financial constraints, has created an alarming situation where low-income and vulnerable households find themselves excluded from the benefits of housing upgrades. Without government support, these individuals are effectively locked out of the opportunity to enhance their living conditions due to the financial burden associated with retrofitting. This runs the risk of leaving them behind in the ongoing energy transition, further perpetuating inequality. As a society committed to sustainable progress, it is imperative to ensure energy equality, where no segment of the population is left behind.

Additionally, the challenges faced by renters compound the problem. These individuals are often at the mercy of their landlords regarding property upgrades. Landlords, often motivated by minimising costs and maximizing profits, may neglect investing in energy-efficient improvements, resulting in growing inequality.

To bridge this gap, funded initiatives such as Climate Safe Rooms Program are an absolute necessity. These programs can provide vulnerable and low-income households with the support and resources required to navigate the complex landscape and heavy costs of home upgrades. By offering dedicated project coordination and acting as a comprehensive "one-stop shop," these initiatives would simplify the process and empower individuals with the means to uplift their living conditions. Such funded programs are both practical and essential to pave the way to a more sustainable and equitable future for all.

The impact of Climate Safe Rooms Program on saving and sustainability is summarised here:

5.1. Savings

Beyond the remarkable health and comfort enhancements, our program has yielded significant cost savings, as summarised in Table 15. These accomplishments include:

- A 40% reduction in gas consumption (average reduction calculated based on Table 11). Assume a two-person household consuming 50,500 MJ of Gas in a year[7], this reduction translates to 20,200 MJ less gas consumption that is equal to $505 saving per year.
- A 14% decrease in electricity consumption across all households, amounting to a $138 reduction in costs per year per household, with a cumulative $2,000 saved on electricity for the 15 participants.
- An average solar export of 3,225 kWh per year per household, resulting in an additional $168 in yearly electricity bill savings.

While health savings are evident, to have a quantitative measure on savings on health, we drew on data from a similar study by Sustainability Victoria due to our limited sample size. “The Victorian Healthy Homes Program” delivered energy efficiency upgrades to 1000 homes of low-income Victorians with a health or social care need. In that study, health benefits of the upgrade were reflected in $887 saved in the healthcare system per person over the winter period[8].

Beyond easing the strain on public health services, our project also offers indirect governmental savings. By providing safe spaces for vulnerable individuals, we align with initiatives like home care packages, promoting extended stay in personal residences rather

[7] Based on statistics provided by the Australian Energy Regulator for Victoria: https://www.aer.gov.au/system/files/Residential%20energy%20consumption%20benchmarks%20-%209%20December%202020_0.pdf

[8] https://www.sustainability.vic.gov.au/research-data-and-insights/research/research-reports/the-victorian-healthy-homes-program-research-findings

than relocating to aged care facilities. Also, by reducing the cost of energy bills, there is potentially less likelihood for a need for utility bill support and/or other indirect governmental financial assistance.

Referring to Table 15, the average participant saves around $1,462. This signifies a potential return on the initial investment in under five and half years.

Table 15. Savings on energy, solar and heath in a year as a result of Climate Safe Rooms program.

Costs Saving	**Gas**	**Electricity**	**Solar Export**	**Savings on health**	**Total**
Tariff	2.5c/MJ	30c/kWh	5.2c/kWh		
Saving per household	$505	$138	$168	$887[9]	$1,462
Total for all participants Per year	$4,040 (8 participants)	$2,070 (15 participants)	$2,520 (15 participants)	$13,305 (15 participants)	$21,935

5.2. Sustainability and emission reduction

The program's reduction in gas and electricity consumption, coupled with solar energy generation, has substantially curbed greenhouse gas emissions, as summarised in Table 16. A collective reduction of around 58 Tonnes of greenhouse emissions (carbon dioxide equivalent) per year has been achieved across the 15 participants. This marks a meaningful shift towards Victoria's net-zero emissions target by 2045.

Table 16. Greenhouse emissions reduction per year

Emissions reduction	Gas	Electricity	Solar Export	Total
Reduced/exported energy per year	20,200 MJ	458 kWh	3,225 kWh	
Rate[10]	0.07 Kg CO2-e/MJ	0.85 kg CO2-e/kWh	0.85 kg CO2-e/kWh	
Emission reduction per household	1,414	389.3	2,471.2	
Total reduction	11,312	5,839.5	41,118.7	58,270.2 kg CO2-e

In summary, Geelong Sustainability presents an economically viable solution that cultivates comfortable environments for participants and delivers remarkable health enhancements. Furthermore, the initiative leads to impressive energy and cost savings, while actively contributing to greenhouse gas reduction aligned with our zero emissions goals.

[9] Based on "The Victorian Healthy Homes Program" data by Sustainability Victoria.
[10] Based on data provided by Environmental Protection Agency (EPA), Clean Energy Regulator

5.3. Comparing Room Upgrades and whole-house transformations

Our research introduces a viable approach where the upgrade focuses on a single room within the house, typically the living or dining room—a space predominantly used during daylight hours. By strategically improving one room instead of an entire house, we've observed a notable reduction in initial investment. To illustrate, consider the budgetary snapshot for upgrading a single room compared to renovating the entire house:

Under the Climate Safe Room Program, the average cost of upgrading one room was around $7,800. This includes $1,000 spent on draught proofing, $1,000 spent on insulation, $1,500 spent on air conditioner and around $4,100 spent on solar systems. In contrast, a comprehensive whole-house upgrade would incur extra $5,700 approximately. The breakdown of this figure is detailed as follows (please note these are based on assumptions and estimates provided by trades):

Assuming a 200 sqm house, insulation installation for the roof would cost $3,000 ($15 per sqm). Draught-proofing doors and windows—with 2 external doors and 8 windows—adds up to roughly $220 per unit, totalling around $2,200. Furthermore, a larger air conditioner (or another unit costing $2,500) and additional solar panels would further contribute to expenses.

It is worth mentioning that the idea of Climate Safe Rooms is applicable to everyone. while the whole house upgrades can present overwhelming prospects in terms of cost and complexity, this approach can provide a practical and cost-effective solution to any poorly designed and constructed house.

6. Lessons learnt

The Climate Safe Rooms project team learnt many valuable lessons regarding the project's delivery. These include:

1. Candidate intake was slow due to their belief that the offer looked ‘too good to be true’. Partnering with the City of Greater Geelong provided invaluable assistance in recruiting participants as the majority of the participants were encouraged to take part in the program through their community care workers. In the future this could be expanded to other councils and community care service providers such as GenU, NDIA and Uniting.

2. Providing an option for the participants to make a financial contribution towards the upgrades could have given participants the option to expand the upgrades to other parts of their homes. Additionally, the project could have provided the business case analysis to validate that investing in home efficiency upgrades is a wise financial decision.

3. In general, communications with the participants were done by non-electronic means. Most participants preferred communication methods including letters, phone calls, or face to face visits. For some participants engaging with third party carers or family members became the best method of communication. Only a few participants were comfortable using electronic (email or SMS) communications.

4. Project Managers reported that whilst working with participants they experienced a mental and emotional toll on their wellbeing. Ensuring that the project team had appropriate training that focused on the needs of vulnerable people and how to manage their personal mental health would be beneficial in the future.

5. It was identified at the start of the project that specialised trades were hard to obtain. As this work requires a range of skills and competencies. We believe that there is an obvious gap in the market that needs to be filled, and the provision of education that could upskill or provide a qualification is necessary. The COVID-19 pandemic brought further challenges with the delivery of retrofits and availability of trades causing delays. This further highlighted the need for skilled specialised trades who can provide energy efficiency retrofits.

6. It was found out that a significant amount of work was required to coordinates the trades. This included scheduling the trades, liaising the time with the participants, verifying the completion of the tasks and confirming the satisfaction of the participants with the experience and the retrofitting tasks. Effective communication was seen as a high priority when selecting trades. As time was valuable, we quickly learnt that if a contractor was not responding to our communications, then we needed to move on. Additionally, as the participants had a high level of need, the project may not have got across the line if we contracted trades with poor communication skills.

7. We found that NatHERS assessment proved to be a powerful aid to choose the type of the retrofit required to gain higher levels of thermal performance within the budget. NatHERS assessments enable a comprehensive understanding of the impact of each retrofit task on the overall energy demand for heating and cooling within a house. This insight empowers us to prioritise retrofitting tasks based on their significance and cost-effectiveness, ensuring that the most impactful upgrades are given precedence.

8. In regard to energy usage education, half the participants received behaviour change visit from Uniting energy experts before the upgrades, and half after. Still, we noted significantly more education was required as some participants remained using gas, or didn't prioritize health using heating/cooling over trying to save money. In home displays could have been something more to make the energy use and savings more evident. We needed explainer documentation and easy to understand info to leave participants about how to use the home.

9. There is no one size fits all model with retrofitting Victoria homes – commentary about each home requiring custom audit and retrofitting plan. The process is labor intensive and requires central coordination by dedicated staff, including the communication with the

participant, home audit, retrofitting plan, coordination of trades and quality check and ensuring participant satisfaction.

10. In regard to the surveys; it is advisable to structure the format to accommodate all answers for multiple-choice questions on a single page. This approach mitigates potential confusion. Considering participants' age and physical abilities, the option of providing assistance for comprehension and response clarification should be explored. Furthermore, certain questions (not used for investigation in this report) are unrelated to the core topics of interest and could be omitted in future assessments to streamline the process. A more detailed breakdown of responses, similar to the approach taken for Question 2.7 (see section 4.1.1), yields superior insights compared to a binary "in control or not" inquiry. This nuanced method has the potential to yield more accurate and realistic results.

11. The weather information required for temperature analysis was extracted from the Bureau of Meteorology (BOM) website, after the program. It would have been easier to collect this information during the program. Accessing historical weather data can incur additional expenses.

12. Many participants did not keep their electricity/gas bills and the information could not be used for data analysis. For improved data collection and prevent any missing information relating to energy bills, it is advised to establish a system such as conducting regular visits to collect energy bills from participants.

13. Lastly, while the Smarter Safer Homes Sensors proved valuable in understanding the impact of upgrades on internal temperatures, the data analysis process encountered several challenges related to them including stopping data collection and inconsistencies in temperatures recorded. To enhance accuracy, temperature sensors should be strategically positioned, and their functionality and data capturing should be meticulously controlled and monitored. These sensors also looked at the activities of daily living and the behaviour patterns which is currently being analysed by CSIRO for research purposes.

7. Recommendations

Here are some recommendations to enhance the implementation of this program for future reference.

Recommendations for Geelong Sustainability

1. Forge Strategic Partnerships and Secure Funding:

Geelong Sustainability should actively seek out strategic partnerships with community service organisations and leverage their expertise and resources to expand the Climate Safe Rooms program. Collaborative partnerships with community service organisations can significantly enhance the reach and impact of the program. By pooling resources and knowledge, Geelong Sustainability can tap into a broader network of potential participants and extend the program's benefits to more vulnerable households. Furthermore, these partnerships can facilitate access to vital funding streams from government agencies and philanthropic sectors, enabling the program to scale up effectively. Geelong Sustainability should actively engage in grant applications, fundraising initiatives, and advocacy efforts to secure the necessary financial support for expanding the program.

2. Address Energy Efficiency for Low-Income Households and Renters:

Geelong Sustainability should focus on developing tailored solutions and pilot programs specifically aimed at addressing the energy efficiency needs of low-income households and renters. These programs should be designed to provide accessible and affordable retrofitting options, taking into account the unique challenges faced by this demographic.

Low-income households and renters often face greater barriers to improving energy efficiency in their homes due to financial constraints and limitations imposed by rental agreements. To ensure the program's inclusivity and equity, Geelong Sustainability should conduct thorough research and engage with stakeholders to understand the specific needs and preferences of this demographic. By piloting local programs tailored to their circumstances, such as subsidised or incentive-based retrofitting initiatives, Geelong Sustainability can make significant strides in reducing energy poverty and improving living conditions for a wider segment of the community. Additionally, advocating for policy changes and incentives that promote energy-efficient upgrades in rental properties can further enhance the program's impact.

Recommendations For Government

1. Commit Substantial Funding for Vulnerable Residents:

Government agencies should allocate a significant funding commitment to support the expansion of initiatives such as the Climate Safe Rooms program. Adequate funding is essential for the successful implementation and scaling of these programs, especially when targeting vulnerable households. Geelong Sustainability proposes an initial investment of $10 million to scale up the CSR program, aiming to retrofit 1,000 households. The $10 million allocation would not only cover the cost of retrofitting but also support outreach, program management, and ongoing monitoring.

Additionally, both national and state-based funding programs should be established to ensure broad coverage. Establishing these funding streams allows for flexibility in tailoring programs to local needs while ensuring a comprehensive approach to addressing energy efficiency and climate resilience at a broader scale. As mentioned earlier, findings in both Climate Safe Rooms program and the Victorian Healthy Homes by Sustainability Victoria prove that investment in such funding streams can reduce healthcare costs substantially which translate into savings for governments in the future.

2. Develop Retrofit Programs for High-Priority Households:

Government agencies should work in collaboration with organisations like Geelong Sustainability to develop and implement retrofit programs specifically designed for households in need, including low-income individuals and renters. Low-income households and renters often face barriers to improving energy efficiency in their homes, and government intervention is crucial in addressing these disparities. By partnering with organisations with expertise in this area, government agencies can design and implement programs that cater to the unique needs of these demographics. These programs should include incentives, subsidies, access to affordable financing options, and expert support and resources.

3. Implement Minimum Standards for Rental Properties:

Government agencies should consider the implementation of higher standards for mandatory minimum energy efficiency for rental properties.

Setting minimum standards for rental properties is an effective way to drive energy efficiency improvements in a substantial portion of the housing market. By requiring landlords to meet these standards, tenants can enjoy better comfort and lower energy bills.

Government agencies should collaborate with relevant stakeholders, including property owners and tenant advocacy groups such as Australian Council of Social Service “ACOSS” to establish reasonable and enforceable standards that benefit both landlords and renters.

4. Mandatory Disclosure of Home Energy Efficiency:

Government agencies should consider mandating the disclosure of a home's energy efficiency and running costs at the time of lease or sale, such as Residential Energy Efficiency Scorecard assessments, similar to the Residential Energy Efficiency Disclosure Initiative (REEDI) established in the Australian Capital Territory (ACT).

This empowers consumers to make informed decisions about their housing choices, taking into account energy costs and the environmental impact of a property. Such disclosure requirements not only promote transparency in the real estate market but also incentivise homeowners and landlords to invest in energy-efficient upgrades to enhance their property's market value.

5. Explore the Use of Home Care Packages for Home Upgrades:

Government agencies should explore the possibility of using Home Care Packages as apart of ‘My Aged Care’ services to fund home energy efficiency upgrades for vulnerable individuals. ‘Minor home modifications’ is one of the services currently provided under the Home Care Packages to support elderly individuals who wish to remain in their homes. Expanding the scope of these packages to include energy-efficient upgrades can improve the living conditions and well-being of vulnerable seniors.

Educating home care providers about the potential health benefits, energy savings, and long-term cost reductions resulting from these upgrades will encourage their inclusion as part of care plans, ultimately benefiting both the individuals and the broader healthcare system.

8. Awards and media coverage

- The program was a topic an article and television news segment published by ABC:
    - https://www.abc.net.au/news/2023-04-02/project-makes-houses-safer-during-heatwaves-and-extreme-cold/102164200).
    - https://vimeo.com/815210212/6aaf2bdbde
- Shortlisted for "Keep Victoria beautiful, Tidy Towns & Cities" award in the wellbeing stream.
- Nominated for The Premier's Sustainability Award.

9. Acknowledgements

Geelong Sustainability acknowledges the following contributors who supported the development and implementation of the Climate Safe Rooms Project. Without their specialised knowledge, expertise, and assistance we would not have executed and navigated the many COVID-19 lockdown challenges as smoothly as we did.

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- Geoff Barber, City of Greater Geelong
- Irene Kadenbach, City of Greater Geelong
- Scott Barnes, CSIRO & Geelong Sustainability Group
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Project Team, Geelong Sustainability Group

- Dan Cowdell
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10. Appendix A: Detailed list of completed home upgrades

Climate Safe Rooms - List of Completed Retrofits			
Participant ID:	**CSR1**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Front Door x 1	
	Draft-stopper	Draft-stopper - Kitchen exhaust fan	Kitchen
	Window Seals	Seals on aluminum windows x 8	Lounge/dinning/kitchen
	Gap Sealing	Gap sealing - miscFocus on Lounge/dinning/kitchen	Lounge/dinning/kitchen
Insulation	Ceiling Insulation	Supply & Install up to R4.0 – 205mm total thickness -Eco wool Batts to ceiling cavity to Lounge/dinning/kitchen ONLY 52m2 - Good Access	Lounge/dinning/kitchen
Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2k-S)	N/A
Air Conditioner	Split System Air conditioner	Supply and Installation of 3.5 kw Mitsubishi Electric Model MUZ-AP35VG S/N 0012464T	Lounge / Kitchen
Air Conditioner	Aircon Isolator		
Misc	Light fitting replacements	Replace 10 x light globes with LED globes Replace 2 x metal can downlight fittings Install sweep fan above lounge chairs	3 x living/lounge 3 x passage 1 x laundry 3 x bedrooms
Participant ID:	**CSR2**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Door x 1	Front ext door
	Gap Sealing	Seal wall vent x 1 with sealant between gaps Lounge	Lounge
		4 x Gap fill vents above windows in Dinning/LoungeMesh vent at top of	Dinning/Lounge
Insulation	Ceiling Insulation	Tidy up existing insulation batts prior to top up in Dininng/lounge & passage way Supply & Install up to R4.0 – 205mm total thickness Eco Wool Batt Insulation to Dining/lounge & passage, 35m Strapping/Suspend Ducting off insulation	Dinning/Lounge
Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2k-S)	N/A
Air Conditioner	Aircon Isolator		
Air Conditioner	Split System Air conditioner	Supply and Installation of 2.5 kw Mitsubishi Electric Model MUZ-AP25VG S/N 0039550T S/N 0023140T	Lounge, on west wall
Participant ID:	**CSR3**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	Front External Door + Seal around glass panelling Internal & External Rear External Door	
	Draft-stopper	1 x Draft Stoppa on ceiling vents	
	Gap Sealing	2 x Wall vents	
		Sealed kitchen cupboards	
Insulation	Ceiling Insulation	Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Lounge / Kitchen(dinning), 41m2 Strapping/Suspend Ducting off insulation if required	Lounge / Kitchen / Dinning
Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2k-S)	N/A
	Existing Airconditioner - no upgrade		
Misc	Light fitting replacements		
Participant ID:	**CSR4**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Door x 1 Front Door External Laundry Door x 1	
	Draft-stopper	Draft-stoppa on exhaust fan, Bathroom	Bathroom
		Draft-stoppa on exhaust fan, Laundry	Laundry
	Gap Sealing	Gap seal around basin waste, Kitchen Sealant or foam seal	Kitchen
		Skylight	
Insulation	Ceiling Insulation	Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Lounge/Dinning/Kitchen, 36m2 Strapping/Suspend Ducting off insulation if required	Lounge/Dinning/Kitchen

Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2k-S)	N/A
Air Conditioner	Split System Air conditioner	Supply and Installation of 2.5Kw Mitsubishi Electric Model MUZ-AP25VG S/N 1000415T S/N 0004068T	
Misc	Light fitting replacements	Replace 2 x sweep fans	Lounge Dinning
Participant ID:	**CSR5**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Door x 1, Front Door	Front Door
	Window Seals	Timber Window Seals x 2, Kitchen/Lounge	Kitchen/Lounge
	Draft-stopper	Draft-stopper for exhaust fans x 2, WC & Bathroom	WC & Bathroom
Insulation	Ceiling Insulation	Supply & Install up to R4.0 Jet Stream Max Blow-in Insulation to the ceiling cavity to Kitchen/Lounge/Dinning, 37m2 Strapping/Suspend Ducting off insulation if required	Kitchen/Lounge/Dinning
Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2k-S)	N/A
Air Conditioner	Split System Air conditioner	Installation of 2.5 kw Mitsubishi Electric Model: MUZ-APVGD-A1 S/N 0040284T S/N 0004823T	Lounge
Misc	Light fitting replacements	Replace gimbal light fittings with sealed IC4 LED units x 13	Lounge Dinning Kitchen
Participant ID:	**CSR6**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Door x 1	
	Draft-stopper	Draft-stopper for exhaust fan, Bathroom	Bathroom
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing R4.0 Eco Wool Batt Insulation Rectify missing batts Living Room/Kitchen	Living Room/Kitchen
		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Living Room/Kitchen, 42m2 + Single garage 18m2 = 60m2 Strapping/Suspend Ducting off insulation if required	Living Room/Kitchen + Garage
Renewable Energy	Solar PV	Supply and install 1.3kW added to existing 2.17kW system using existing inverter 4 x Trina 330W (TSM 330DD06M.08(II))	N/A
Air Conditioner	Aircon Isolator		
Air Conditioner	Split System Air conditioner	Supply and Installation of a 5 kw Mitsubishi Electric Model MUZ-AP50VG S/N 0010779T S/N 0013546T	Living
Misc	Light fitting replacements	19 x downlights with sealed LED SAL downn lights	
Participant ID:	**CSR7**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	1 x External Door - Entrance Door	
	Gap Sealing		
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing R4.0 Eco Wool Batt Insulation	Living Room/Dinning
		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Living Room/Dinning, 32m2 Strapping/Suspend Ducting off insulation if required	Living Room/Dinning
Renewable Energy	Solar PV	Supply and install 5.2kW Grid Connected Solar System 16 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase 5kW (SG5K-D)	N/A
	Existing Airconditioner - no upgrade		

Participant ID:	CSR8		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Door x 1, Draught dodgers and raven seal	
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing Jet Stream Blow-in Insulation	Kitchen/Dinning/Living
		Supply & Install up to R4.0 Jet Stream Max Blow-in Insulation to the ceiling cavity to Kitchen/Dinning/Living 45m2 Strapping/Suspend Ducting off insulation if required	Kitchen/Dinning/Living
Renewable Energy	Solar PV	Supply and install 4.6kW Grid Connected Solar System 14 x Trina 330W (TSM 330DD06M.08(II))	N/A
Air Conditioner	Split System Air conditioner	Supply and Installation of a 3.5kw Mitsubishi ElectricModel; MUZ-AP35\	Living
Air Conditioner	Aircon Isolator		
Misc	Light fitting replacements	Replace 3-4 x Bayonet Fitting with LED globes (60W equiv)	Living & Entrance
Participant ID:	**CSR9**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Door x 1 - Entrance Door, Draught dodgers and raven seal	
	Window Seals	6 x Aluminum windows & sliding doors seals - Foam seal on (internal) &	Living, Kitchen, Hallway
	Draft-stopper	Draft-stopper for exhaust fan	Unknown
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing R4.0 Eco Wool Batt Insulation	Living, Kitchen, Hallway,
		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Living, Kitchen, Hallway, 44m2 Strapping/Suspend Ducting off insulation if required	Living, Kitchen, Hallway,
Renewable Energy	Solar PV	Supply and install 5.2kW Grid Connected Solar System 16 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase 5kW (SG5K-D)	N/A
	Existing Airconditioner - no upgrade		
Misc	Light fitting replacements	Replace gimble downlights with with sealed LED IC4 units x 13	Living Room / Kitchen
Misc	Additional Electrical Works		
Participant ID:	**CSR10**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Door x 2, Entrance / Kitchen Front Entry Door x 1	
	Draft-stopper	4x Draft Stoppa on exhaust fans	Kitchen/ Bath/ Laundry / WC
	Gap Sealing	Foam seal ceiling vents	
		Seal Double hung aluminium windows x 12, fixed vents at top	
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions out of the way of the roof cavity to meet current requirements prior to installing R4.0	
		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Lounge / Kitchen Ceiling, 53m2 Strapping/Suspend Ducting off insulation if required	
Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2k-S)	N/A
Air Conditioner	Split System Air conditioner	Supply and Installation of a 2.5 kw Mitsubishi Electric Model MUZ-AP25VG S/N 0039534T S/N 0022636T	Living
Air Conditioner	Aircon Isolator		
Misc	Light fitting replacements	Replace 1 x halogen bayonett bulb with LED	Lounge/kitchen
Participant ID:	**CSR11**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draught Proofing	Door Seals	External Alum Sliding Door x 1, KitchenDouble Sliding Door x 1	
	Draft-stopper	Draft Stoppa x 1, Kitchen	Kitchen
	Gap Sealing	Gap Seal Wall Vents - Not sure how many	
		Draught proofing to Internal Doors x 2 (1 slider, 1 std door), Living / Kitchen, Bifold Door in lounge/kitchen	Living / Lounge / Kitchen
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing R4.0	Living / Kitchen

		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Living / Kitchen, 37m2	Living / Kitchen
Renewable Energy	Solar PV	Supply and install 1.6kW Grid Connected Solar System 5 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2K-S)	N/A
Air Conditioner	Split System Air conditioner	Supply and Installation of 3.5kw Mitsubishi Electric Model MUZ-AP35VG S/N 0012512T S/N 0013531T Decommission and	
Participant ID:	**CSR12**	DECEASED Aug 2021	
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draughtproofing	Door Seals	Draft Sealing front door	
Insulation	Ceiling Insulation	Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Lounge room/ dining room/ Pantry & half of bathroom area, 45m	Lounge room/ dining room/ Pantry
		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to 2x bedrooms, 36m2	Bedrooms
Renewable Energy	Solar PV	Supply and install 5.92kW Grid Connected Solar System 16 x Trina 330W (TSM 330DD06M.08(II)) 1 x Goodwe (GW5000D-NS) 5kW Inverter	N/A
Air Conditioner	Split System Air conditioner	Supply and Installation of 3.5kw Mitsubishi Electric Model MUZ-AP35VG S/N 0012455T S/N 0013705T	Dining, west wall
Participant ID:	**CSR13**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draughtproofing	Door Seals	External Door x 1, Entrance Door	
	Draft-stopper	1 x Draught Stopper on exhaust fan, Kitchen	Kitchen
	Gap Sealing	Foam Sealant to ceiling vents	
		2 x Silicone Sealant to external windows, Kitchen & Lounge	Kitchen & Lounge
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing R4.0 Eco Wool Batt Insulation	
		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Lounge & Kitchen, 28m2 Strapping/Suspend Ducting off insulation	
Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2K-S)	N/A
Renewable Energy	Solar PV	Supply and install 2.3kW Grid Connected Solar System 7 x Trina 330W (TSM 330DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase (SG2K-S)	N/A
Participant ID:	**CSR14**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draughtproofing	Door Seals	External Door x 2, Entry / Dinning	
	Draft-stopper	3 x Draught Stopper on Exhaust Fans, Kitchen/Laundry/Ensuite	Kitchen/Laundry/Ensuite
	Gap Sealing	Seal all wall vents	
		Approved to insulate all ceilings and then focus on draught proofing for windows and doors up to the value of $4090	
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing R4.0 Eco Wool Batt Insulation	Living/Kitchen/Dinning/Laundry
		Supply & Install up to R4.0 –205mm total thickness - Eco Wool Batt Insulation to Living/Kitchen/Dinning/Laundry, 38m2 Strapping/Suspend Ducting off insulation if required	Living/Kitchen/Dinning/Laundry
Renewable Energy	Solar PV	Supply and install 3.3kW grid-connected solar system 10 x Trina 330W (TSM 330DD06M.08(II))	N/A
Misc	Solar PV	Switchboard work required	
	Existing Airconditioner - no upgrade		
Participant ID:	**CSR15**		
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draughtproofing	Door Seals	External Door x 2, Entrance & Back door	
	Draft-stopper	1 x Draught Stopper on Fan, Ensuite	Ensuite
	Gap Sealing	Caulking Floor & Ceiling gaps, Entrance hallway, living	
Insulation	Ceiling Insulation	Tidy/fix/re-lay existing insulation batts, remove any obstructions/rubbish from roof cavity to meet current requirements prior to installing R4.0 Eco Wool Batt Insulation	Living /Kitchen/Passage

		Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Living /Kitchen/Passage, 48m2	Living /Kitchen/Passage
Renewable Energy	Solar PV	Supply and install 3.3kW Grid Connected Solar System10 x Trina 330W	N/A
Air Conditioner	Aircon Isolator		
Air Conditioner	Split System Air conditioner	Supply and Installation of 3.5 kw Mitsubishi ElectricModel MUZ-AP35VG	Living
Participant ID:	**CSR16**	DECEASED, Jan 2021	
Retrofit Catagory	**Retrofit Item**	**Retrofit Details**	**Locationeg. living room**
Draughtproofing	Door Seals	External Door x 1, Entrance	
	Window Seals	Window brush seals, Living room	Living Room
	Gap Sealing	Seal all wall vents, Whole unit	Whole Unit
		Caulking Floor & Ceiling gaps, Entrance, living, kitchen	Entrance, living, kitchen
Insulation	Ceiling Insulation	Supply & Install up to R4.0 – 205mm total thickness - Eco Wool Batt Insulation to Whole unit, 30m2: Note: Flat roof	Whole Unit
Renewable Energy	Solar PV	Supply and install 1.675kW Grid Connected Solar System 5 x Trina 335W (TSM 335DD06M.08(II)) 1 x Sungrow Crystal Second Gen Single Phase 2kW (SG2K-D)	N/A