New Energy Solutions Optimised for Islands

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EUROPEAN ISLANDS FACILITY

Feasibility study on Electric Vehicle & Renewable Energy

Appendix B – Hall Audits

Z-305- Archipelago of Mull Actions for Zero Emissions

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1. Introduction

This appendix provides the full results of energy audits conducted for seven community halls as part of a Feasibility Study on Electric Vehicle & Renewable Energy Hubs on the Mull Archipelago. Information was gathered via phone audits and desktop surveys, supplemented by client-supplied data during 2023.

The purpose of these energy audits was to collect and collate information regarding current energy consumption, energy efficiency, and the feasibility for renewable generation at each location. These audits focus on providing recommendations for community-owned renewable assets at these sites and understanding the viability of wider energy efficiency measures. The feasibility of installing Electric Vehicle (EV) chargepoints at each hall was also explored.

The scope of this report focuses on the community hall premises, meaning that rooftop solar PV was the main renewable technology assessed in these remote audits. However, there may also be some opportunities for wind power, ground-mounted solar PV, and hydro generation, utilising land adjacent to some of the halls. In addition, "carports" could provide additional roof space for solar PV and a covering for chargepoints and vehicles [1].

Physical on-site audits and surveying is required to obtain any quotation for energy efficiency improvements or renewable energy implementation. However, these audit reports identify the most viable measures that the halls can take to improve energy efficiency performance and lower bills, and guidance towards the capacity of the halls as renewable energy generators.

[1] https://transportandenergy.com/2023/08/17/solar-car-port-opens-at-council-hq/

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

2. Aros Hall

Context and Site Description

Aros Hall was constructed in the late 19th century and was gifted to the Tobermory community by the Aros Estate in 1949. The hall is a focal point of local community events and facilities, and regularly sees daily occupancies of up to 50 people. The property consists of a main hall space which can accommodate 150 seated spectators and is frequently used for local theatrical productions. The property also contains a child's soft-play area, charity shop, toilets, and kitchen facilities. The property is located on Tobermory's harbourfront – and is accessed by on-street parking.

The property's heating is currently supplied by electric-fed quantum storage heaters. It is unknown when these heaters were first introduced. The property recently underwent some refurbishment works, in which all lights were refitted with LED bulbs and all windows double-glazed. The property's insulation, however, is not currently sufficient and has led to major issues with water ingress, particularly in the loft area. It is understood that no floor or wall insulation exist, and that loft insulation dates from a refurbishment around 1986 which will need replacing.

Aros Hall is an important focal point for the local community and visitors to the island, and efforts are currently underway to ensure it remains a sustainable and valuable community asset in the future.

Figure 2.1: External and Internal Appearance

Summary Findings

This section presents the key findings of current energy consumption, and the potential for solar PV, energy storage and energy efficiency improvements. Further detail and analysis in relation to these technologies may be found in section 1.3.

Energy Consumption

The building's current electricity consumption is shown in Table 2.1, averaging 11,500 kWh per year. From assumed energy usage patterns and using typical energy demand profiling for non-domestic buildings, it is estimated that approximately 61% of the energy consumption is used for electric heating.

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Table 2.1: Aros Hall Average Energy Consumption

Average Energy Consumption	Annual	Monthly	Daily
Total Electricity Consumption (kWh)	11,500	958.3	31.5
Of which for electric heating (kWh)	7,015	584.6	19.2

Energy Generation

Table 2.2 presents an overview of the generation potential from rooftop solar PV and the impact of any energy storage. Despite having a roof area of around 200m^2, a section of roof is shadowed by the spire of the neighbouring church. Therefore, for the purposes of this audit, the size of solar PV modelled has been scaled down to account for this obstruction. As modelled, a 5 kWp of solar PV capacity can be installed on the property's south-eastern facing roof, producing ~2,592.15 kWh per year.

The anticipated payback period for the site is 22.6 years for solar PV without storage. If electrical storage is included, financial savings from usage and income from export total £684 per year, with a 22.2-year payback period.

Aros Hall does not have a designated car park but is accessed by on-street parking on the harbourfront (Main Street). Therefore, the suitability on an EV charging facility owned and operated by the hall cannot be suggested. There is currently one EV charging point in the nearby Ledaig Car Park (approx. 0.2 miles from Aros Hall). The expansion of communal EV charging facilities in Tobermory, either on Main Street (A848) or in the Ledaig Car Park, is recommended to increase the use of EVs in the Tobermory area.

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Table 2.2: Aros Hall Generation Potential

	Rooftop Solar PV Electricity Generation Potential	
Solar PV Power capacity	5 kWp (Single Phase)	
Yearly Generation Potential	2,592 kWh	
Available Roof Space	200m^2, 35° pitch, south-eastern facing	
Battery Storage Capacity	5 kWh	
	Solar PV only	**Solar PV with Storage**
Capital Cost (£)	11,000	15,200
Energy Utilisation (kWh/yr)	518	1,555
Energy Export (kWh/yr)	2,074	1,037
Financial Savings (usage per year)	176	529
Financial Income (export per year)	311	156
Payback Period (yr)	**22.6**	**22.2**
Carbon Saving (kg CO_2e/yr)	110	330

Energy Efficiency

Table 2.3 presents an overview of potential energy efficiency savings.

The village hall space currently uses electricity for its heating, and we propose that this is retained due to the intermittent use of the building. However, we propose that the property's wall, floor, and loft insulation are upgraded to 2023 standards – to improve thermal efficiency and heat retention. Likewise, draught-proofing measures are also suggested as a secondary measure.

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Table 2.3: Aros Hall Energy Efficiency Opportunities

Efficiency Opportunities	Capital Cost (£)	Energy Saving (kWh)/yr)	Carbon Saving ($kgCO_2e/yr$)	Financial Saving (£/yr)	Payback Period (years)
Draught Proofing	£225	101	21.4	£34	6.6
5 kW Solar PV System	£11,000	518	110	£176	22.6
5 kW Solar PV with Battery Storage	£15,200	1,555	330	£529	22.2
Roof Insulation	£3,500	1,341	285	£456	7.7
Wall Insulation	£15,000	2,151	457	£731	20.5
Floor Insulation	£16,000	746	158	£254	63.1
10 Kw Air-Source Heat Pump	£14,000	4,209	894	£1,431	9.8

Full Recommendations and Results

Draught Proofing

It is assumed that the property currently has no draught-proofing measures. It is estimated that up to 101 kWh could be saved if forms of draught-proofing were fitted throughout the property. At an installation cost of only around £225, draught-proofing is a cost-effective, low risk and adaptable measure throughout large, multi-use properties. We project that savings of £34 and 21.4 kg of CO_2e per year can be expected from this measure.

Solar PV and Battery Storage:

The building is not listed, however lies within the Tobermory conservation area, meaning solar PV will likely require planning permission prior to any works. The building is a key community asset, and any works that alter the external appearance should have the consent and support of the local community and stakeholders.

There is a total feasible roof area of around 200m^2. Although this can accommodate a large solar PV system, the rooftop is overshadowed by the spire of the Free Church of Scotland – which would restrict the effectiveness of panels across the whole length of the rooftop. For the purposes of this audit, a smaller solar PV system of 5 kWp is modelled. This is based on the property having a roof angle of approximately 35^o and a suitable south-eastern facing roof area.

A 5-kW array could produce 2,592 kWh of electricity per year. If 60% of this could be used on site, i.e., 1555 kWh, a resulting 1,042 kWh would be available for grid export. This exported electricity has the potential to generate revenue of £156 / year, based on a theoretical preferential energy supplier smart export guarantee rate of £0.15 per kWh. Smart export guarantee rates differ between energy suppliers. The rate specified in this report is offered by Octopus Energy and represents a preferential export rate. Other energy providers offer reduced smart export rates.

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The total cost of implementation is estimated to be £11,000 for rooftop solar PV (22.6 years payback period) and £15,200 with the battery storage system (22.2 years payback period). If a solar PV and battery storage system was installed, there would be a total carbon saving of 330 kg CO_2e per year.

The recommended system is that of the 5-kW solar PV with battery storage.

Roof Insulation

Roof insulation dates from 1986 and is of 50 mm wool fiber make-up. Upgrading the roof insulation to 2023 U-value standards could save the property 1,341 kWh per year. This would come at a cost of £3,500 and an anticipated payback period of 7.7 years. It could save the property 285 kg CO_{2e} per year.

Wall Insulation

Walls currently have no form of insulation. It is recommended that the walls are internally insulated, to ensure permissibility with the Tobermory Conservation Area. Insulating these to 2023 u-value standards could save the property 2,151 kWh of energy and around £731 per year. This will come at a cost of £15,000 providing a payback of around 20.5 years. It could also reduce the carbon footprint of the property by 457 kg CO_{2e} per year.

Floor Insulation

It is understood no floor insulation currently exists. Insulating the approximate 200m^2 area of floor space to 2023 standards could save 746 kWh and £254 per year. This recommendation would come at a cost of £16,000, with a payback period of 63.1 years. If fitted alongside an air-source heat pump, there is the possibility that underfloor heating could be installed. More information should be gathered by contacting a specialist installer.

10 kW Air-Source Heat Pump

An air-source heat pump (ASHP) is modelled as a potential replacement for the current quantum storage heating system. This renewable heat strategy is dependent on insulation of the property to current insulation standards. ASHPs require sufficient levels of insulation to work optimally as they function on a basis of lower operating temperatures (60°C / 40°C flow temperatures). Based on estimated current energy usage, implementing an ASHP could save 4,209 kWh per year and provide a £1,431 energy bill reduction, based on an energy price cap of £0.34 per kWh of electricity. This strategy will come at a cost of around £14,000, with an anticipated payback period of 9.8 years.

Conclusions

Implementing all recommendations, as set out in this report, will save **10,103 kWh** of energy / year, resulting in a saving of **£3,435** and **2.1 tonnes CO_2e** per year.

Due to the property's high footfall and prominent place within the local community, it is feasible that Aros Hall could act as an EV hub for slow EV charging via its current electricity connection. However, the property does not have site-specific parking, therefore any upgrades to the adjacent street area would come under the jurisdiction of local council bodies. Consideration of solar PV and EV charging, as well as upgrading to a three-phase system, should be considered to increase the sites value as an EV hub.

It should be noted that these calculations are high level and specialist installers should be consulted to provide a better understanding of the property and its energy efficiency and electricity generation potential. They would also be able to provide a quote for installation, helping to better understand initial investment costs and potential payback periods.

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There are also many funding opportunities for Scottish and UK businesses, charities, and community buildings, for example the Business Energy Scotland SME loan scheme, the Community and Renewable Energy Scheme (CARES), which can help with implementation costs for both energy efficiency and renewable heat strategies. Full detail on available funding

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3. Bunessan Hall

Context and Site Description

Bunessan Village Hall was built in 1988, serving the Bunessan community as a venue for music, local sports clubs and other events. The hall is a focal point of the local community, regularly used by Bunessan Primary School – and often plays host to music and theatre productions. The property is one storey, largely consisting of one main hall space with a capacity for 120 attendees. The property also has a small kitchen, toilets and two dressing rooms to the rear of the hall. Plans to extend the kitchen to increase storage space are anticipated in the near future.

The hall's heating is currently supplied by multiple coin-operated infrared heating units. Lighting is composed of around 25 non-LED lights, found throughout the property. Loft and wall insulation dates from time of construction, following building regulations set in 1986. Similarly, windows throughout the property follow double-glazing standards from regulations set in 1980.

The property is not a listed building, nor lies within a designated conservation area. As a result, energy recommendations are less likely to require planning permission and, for those that do require permision, will be relatively straight forward to gain necessary consents.

Figure 3.1: External and Internal Appearance

Summary Findings

This section presents the key findings of current energy consumption, and the potential for solar PV, energy storage, and energy efficiency improvements. Further detail and analysis in relation to these technologies may be found in Section 2.3.

Energy Consumption

Table 3.1 displays the buildings' current electricity consumption, which averages 2,061 kWh per year. From information gathered, it can be estimated that 50% of this is used for electric heating. Throughout 2022 (Figure 3.2), electricity usage is highest in the first quarter. This is followed by a decline in usage throughout the remainder of the year.

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Average Energy Consumption	Annual	Monthly	Daily
Total Electricity Consumption (kWh)	2,061	172	5.6
Of which for electric heating (kWh)	1,031	86	2.8

Table 3.1: Bunessan Village Hall Average Energy Consumption

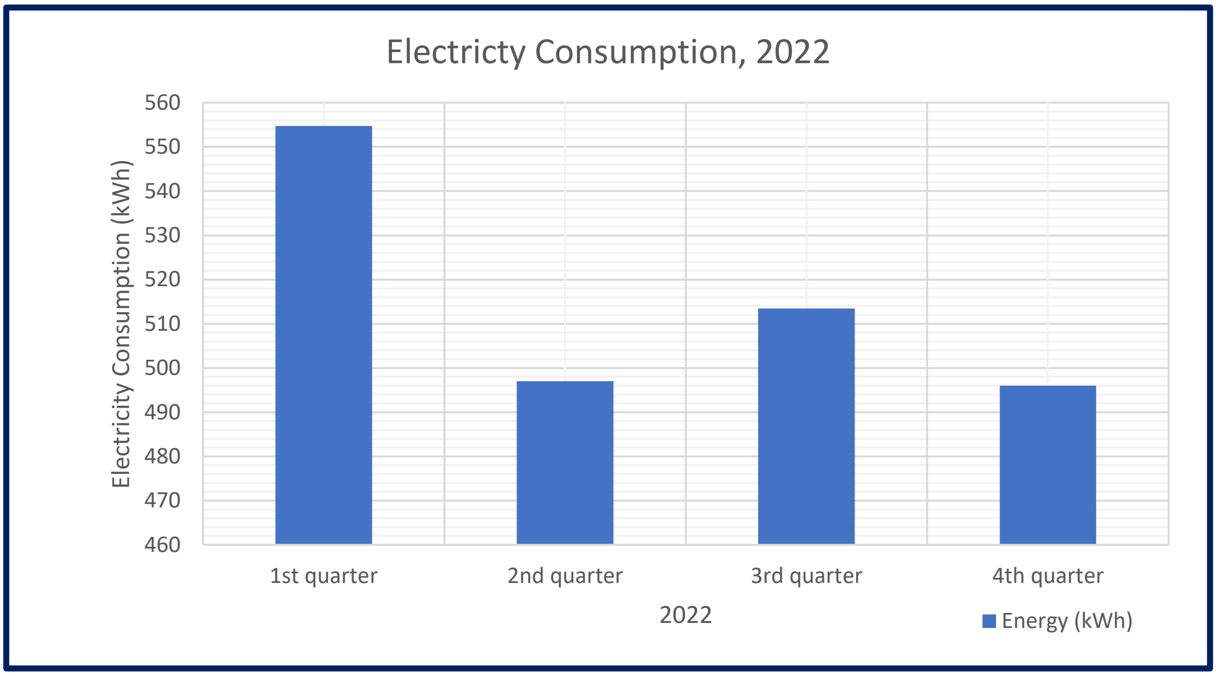

Figure 3.2: Bunessan Village Hall Electricity Consumption, 2022

Energy Generation

Table 3.2 presents an overview of the generation potential from rooftop solar PV and energy storage impact. It is estimated that 15kWp of solar PV capacity can be installed on the property's south-western facing roof, producing ~8,639 kWh per year. However, this generation is substantially higher than current consumption (four-fold) and so a smaller sizing of 8kW has been modelled to produce a more optimal payback time.

The anticipated payback period for the site is 15 years for solar PV without storage. With electrical storage included (8kWh), financial savings from usage and income from export total £954 per year, with a 19-year payback period.

Most of this energy is anticipated to be exported (3,225 kWh), with anticipated energy savings of 1,382 kWh with electrical storage. This means there is a high availability of self-produced energy for other electrical demands at the site.

The recommended option is solar PV with battery storage.

In terms of suitability as a ChargePoint location, there are approximately 30 parking spaces in the adjacent car park. The local primary school regularly use the venue, so it can be expected that on average up to 5 vehicles may

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visit the venue daily. On occasion, dances, plays and other events can also see the venue's car park reach maximum capacity. Therefore, an EV charging facility could be well placed at this property and potentially help in the transition to EVs in the local area.

Whilst not modelled here, there may also be opportunities for wind power development in concert with the neighbouring landowner.

Table 3.2: Bunessan Village Hall Generation Potential

	Rooftop Solar PV Electricity Generation Potential	
Solar PV Power capacity	8kWp (Single Phase)	
Yearly Generation Potential	4,607 kWh	
Available Roof Space	90m^2, 35° pitch, south-western facing	
Battery Storage Capacity	8 kWh	
	Solar PV only	**Solar PV with Storage**
Capital Cost (£)	12,000	18,000
Energy Utilisation (kWh/yr)	691	1,382
Energy Export (kWh/yr)	3,916	3,225
Financial Savings (usage per year)	235	470
Financial Income (export per year)	587	484
Payback Period (yr)	**15**	**19**
Carbon Saving (kg CO_2e/yr)	147	293

Energy Efficiency

Table 3.3 presents an overview of potential energy efficiency savings.

The building currently uses electricity for its heating, and we propose that this is retained due to the daily intermittent use of the building.

There are three thermal efficiency options recommended for the church hall – Draught Proofing, LED Lighting and Smart Thermostatic Controls. Forms of insulation are also explored. Each one of these measures represent a cost-effective and adaptable measures to improve energy efficiency and heat retention throughout the property. Each measure is explained in full in section A.3.

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Table 3.3: Bunessan Village Hall Energy Efficiency Opportunities

Efficiency Opportunities	Capital Cost (£)	Energy Saving (kWh)/yr)	Carbon Saving ($kgCO_2e/yr$)	Financial Saving (£/yr)	Payback Period (years)
Draught Proofing	225	18	3.8	6	36.7
LED Lighting	300	536	114	182	1.6
Smart Thermostatic Controls	200	163	34.7	56	3.6
Solar PV and Battery Storage	18,000	1,382	293	954	18.9
Solar PV	12,000	691	147	822	14.6
Floor Insulation	13,960	138	29.3	47	296.9
Roof Insulation	13,460	171	36.2	58	232.0
Wall Insulation	17,500	249	52.9	85	206.4
Double Glazing	19,000	121	25.7	41	461.3

Full Recommendations and Results

Main Church Hall Building

Draught Proofing:

The entire property currently has no draught-proofing measures. It is estimated that around 18 kWh could be saved if forms of draught proofing were fitted throughout the property. At an average installation cost of just £225, draught-proofing is a cost-effective and low risk measure for large, multi-use properties. Approximate savings of £6 and 3.8 kg CO_2e per year could be expected from this measure.

LED Lighting:

The property currently has around 25 individual non-LED lights. Converting these non-LED lights to LED equivalents could significantly improve the energy efficiency of lighting in the property.

The Energy Saving Trust states that you can save between 6kg and 5kg of CO_2e for every 50 W halogen bulb replaced with an equivalent LED bulb per year. It is estimated the property could save 536 kWh of electricity a year by switching to LED lighting. This could save the property around £182 from electricity bills and 536 kg CO_2e per.

Smart Thermostatic Controls:

The entire property currently has no form of smart thermostatic controls. It is estimated that approximately 163 kWh could be saved by implementing smart thermostatic heating controls across the property. This is a low-risk intervention, as it is relatively low cost and adaptable across existing and new heating systems for future

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operability. It is expected that up to 34.7 kg CO_2e and £56 could be saved if thermostatic controls were fitted alongside the existing heating system.

Solar PV and Battery Storage:

The building is not listed nor is it in a conservation area, meaning solar PV is likely to be considered a permitted development and therefore will not require planning permission.

There is a total feasible roof area of around 90 m^2 which provides space for solar PV capacity of 15 kW. This is based on the property having a roof angle of roughly 35° and a suitable south-western facing roof area. However, this generation is substantially higher than current consumption (four-fold) and so a smaller sizing of 8kW has been modelled to produce a more optimal payback time. If there is a substantial increase in local demand (even after energy efficiency improvements), the larger capacity installation may be viable.

An 8-kW array could produce 4,607 kWh of electricity per year. With this potential generation far outstripping current consumption, we assume that only 1382 kWh can be used on site, a resulting 3,225 kWh would be available for grid export. This exported electricity has the potential to generate revenue of £484 / year, based on an optimal smart export guarantee rate of £0.15 per kWh. Smart export guarantee rates differ between energy suppliers. The rate specified in this report is offered by Octopus. To maximise the income generated from solar PV arrays, preferential export rates should be obtained from an alternative energy provider to that currently provided.

The total cost of implementation is estimated to be £12,000 for rooftop solar PV without battery storage (14.6 years payback period) with an annual carbon saving of 147 kg CO_2e. For a solar PV system with battery storage, the total cost is estimated to be £18,000 and the payback period would be 18.9 years. Associated annual carbon savings would be 293 kg CO_2e. The latter of these options is recommended due to the increased income, greater carbon savings and scope for additional electrical loads.

As the property has single phase electrical capacity, solar PV export could be used for “slower” EV charging at the property using the existing system or “fast” charging, if the electricity connection was upgraded.

Floor Insulation:

The total floor insulation of the village hall is around 216 m^2. Insulating this floor space to 2023 U-value standards could potentially save the client 138 kWh of electricity a year. Financial savings of up to £47 per year, and carbon emissions reduction of 293 kg CO_2e per year are also expected.

Roof Insulation:

The property already has rood insulation in place, dating from around 1988. It is estimated that upgrading this to 2023 building standards could potentially save the property 171 kWh per year. This would come at a cost of £13,460, saving the property 36 kg CO_2e per year.

Wall Insulation:

Walls throughout the property are currently insulated to 1986 regulations. Insulating these to 2023 standards would save the property 249 kWh of energy and around £85 per year. This would come at a cost of £17,500, reducing the carbon footprint of the property by 53 kg CO_2e per year.

Double Glazing:

The property currently has around 27 windows, all of which are double glazed to 1988 standards. Upgrading these to 2023 U-value standards would save up to 121 kWh and 26 kg CO2e per year could be saved for the property. This recommendation would also save the property approximately £41 from electrical bills each year.

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Conclusions

Implementing all recommendations, as set out in this report, will save **2,779 kWh** of energy / year, resulting in a saving of **£945** and **0.6 tonnes CO_2e** per year.

The property also has the potential to operate as an EV hub for slow EV charging via its current electricity connection. Consideration of solar PV and EV charging, as well as upgrading to a three-phase system, should be considered to increase the sites value as an EV hub.

It should be noted that these calculations are high level and specialist installers should be consulted to provide a better understanding of the property and its energy efficiency and electricity generation potential. They would also be able to provide a quote for installation, helping to better understand initial investment costs and potential payback periods.

There are also many funding opportunities for Scottish and UK businesses, charities, and community buildings, for example the Business Energy Scotland SME loan scheme, the Community and Renewable Energy Scheme (CARES), which can help with implementation costs for both energy efficiency and renewable heat strategies. Full detail on available funding streams can be found in the full feasibility report.

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4. Craignure Village Hall

Context and Site Description

Craignure Village Hall was built in 1998 to serve the local area as a community facility and events space. The property is a focus-point of the Craignure community, funded by public subscription from local charitable trusts and governmental bodies. The hall is primarily used a space to hold community events, meetings, and theatrical productions.

The hall is composed of a large main hall area, suitable for hosting theatrical productions and indoor market events. The property also has two smaller meeting room facilities, which are regularly used for local committee meetings. The property also contains modern kitchen facilities, public toilets, and outdoor car parking space. Heating is currently supplied by infrared heaters, which are coin fed when in use. Floor, roof, and wall insulation throughout the property dates from 1988, when the building was constructed. There are around 20 windows in total, half of which are only single glazed.

The hall is not a listed building, nor does it lie within a conservation area. Therefore, any energy efficiency recommendations are less likely to require planning permission. For recommendations those that do require permission, the process should be relatively straight forward to gain necessary consents.

Figure 4.1: External Appearance

Figure 4.2: Internal Appearance

Summary Findings

This section presents the key findings of current energy consumption, and the potential for solar PV, energy storage, and energy efficiency improvements. Further detail and analysis in relation to these technologies may be found in Section 3.3.

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Energy Consumption

Table 4.1 displays the buildings' current electricity consumption, which averages 8,828 kWh per year, with an estimated 61% of this used for electric heating. Figure 4.3 shows the variation in electricity consumption for the hall over the two-year period between throughout the year period between December 2021 and December 2022. Electricity usage increases notably in January and February 2022. Consumption decreases during summer 2022 but steadily increases from September 2022. Another large spike in electricity consumption is observed in January 2023.

Table 4.1: Craignure Village Hall Average Energy Consumption

Average Energy Consumption	Annual	Monthly	Daily
Total Electricity Consumption (kWh)	8,828	735.7	24.2
Of which for electric heating (kWh)	5,385	448.8	14.8

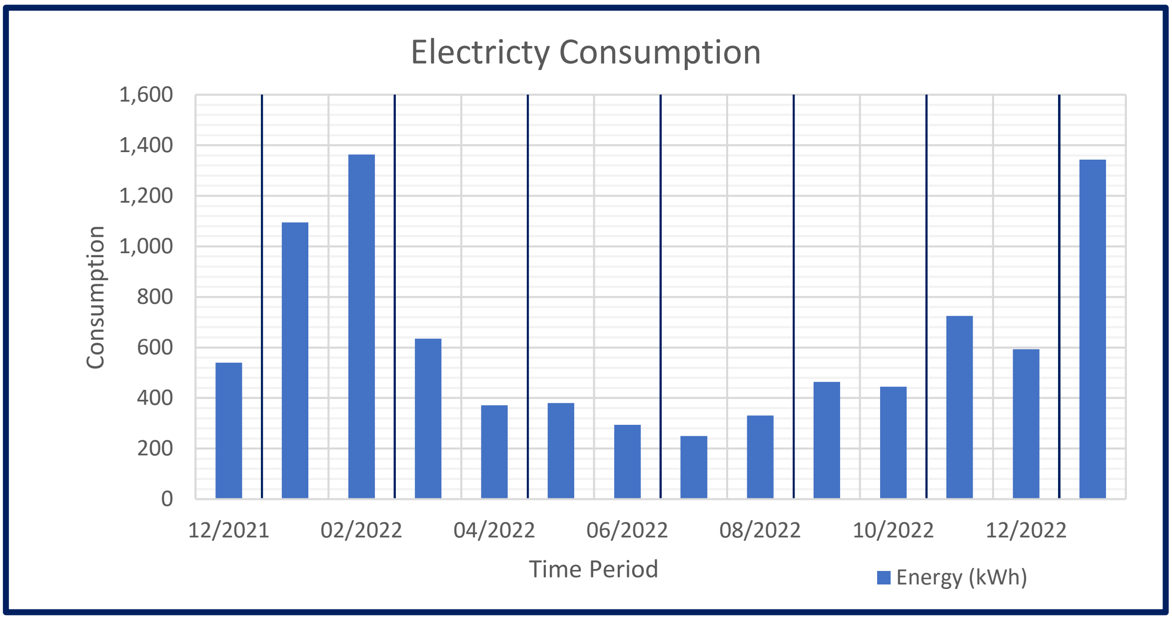

Figure 4.3: Craignure Village Hall Electricity Consumption, 2020-2022

Energy Generation

Table 4.2 presents an overview of the generation potential from rooftop solar PV and energy storage impact. It is estimated that 11 kWp of solar PV capacity can be installed on the property's south-facing roof, producing ~10,122 kWh per year.

For a solar PV system of this size with no storage, anticipated implementation cost is £14,000, annual combined financial savings and income from export total £1,902, and the payback period is anticipated to be 7.4 years.

For a solar PV system of this size with battery storage, initial implementation cost is estimated to be £22,000, combined financial savings and income from export total £2,288, and the payback period is anticipated to be 9.6 years.

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Due to the greater resource and energy savings, the solar PV system with battery system is recommended.

In this scenario with 10kWh storage, most of this energy is anticipated to be exported to the grid, with only 4,049 kWh utilised directly by the hall. This means there is a high availability of self-produced energy for a chargepoint at the site, or other forms of new electrical demand.

In terms of suitability as a ChargePoint location, there is one parking space (with potential for two if reorientated) and on-road parking. With an average of 5 cars frequenting the location per day, an EV charging facility would be well suited at this property and potentially help in the transition to EVs in the local area.

Table 4.2: Craignure Village Hall Generation Potential

	Rooftop Solar PV Electricity Generation Potential	
Solar PV Power capacity	11 kWp (Single Phase)	
Yearly Generation Potential	10,122 kWh	
Available Roof Space	90m^2, 35^o pitch, south facing	
Battery Storage Capacity	10 kWh	
	Solar PV only	**Solar PV with Storage**
Capital Cost (£)	14,000	22,000
Energy Utilisation (kWh/yr)	2,024	4,049
Energy Export (kWh/yr)	8,097	6,073
Financial Savings (£ usage per year)	688	1,377
Financial Income (£ export per year)	1,214	911
Payback Period (yr)	**7.4**	**9.6**
Carbon Saving (kg CO_2e/yr)	430	860

Energy Efficiency

Table 4.3 presents an overview of potential energy efficiency savings.

The building currently uses electricity for its heating, and we propose that this is retained due to the limited and inconsistent use of the building. However, the case for installing an air-source heat pump (ASHP) as an alternative means of heating is explored.

Several efficiency measures are suggested for the village hall – draught proofing, double glazing, smart thermostats, and LED lighting. These measures have low visible impact, ensuring that improved thermal efficiency does not come at the cost of the building's appearance.

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Two energy efficiency recommendations are also suggested. Solar PV and an air-source heat pump may provide alternative solutions to the village hall's current electrical and heating issues.

Table 4.3: Craignure Village Hall Energy Efficiency Opportunities

Efficiency Opportunities	Capital Cost (£)	Energy Saving (kWh)/yr)	Carbon Saving ($kgCO_2e/yr$)	Financial Saving (£/yr)	Payback Period (years)
Draught Proofing	£225	77	16	26	8.6
Double Glazing	£1,125	519	110	176	6.4
Smart Thermostatic Heating Controls	£200	700	149	238	0.8
LED Lighting	£480	858	182	292	1.6
Solar PV	£14,000	2,024	430	688	7.4
Solar PV with Battery Storage	£22,000	4,049	860	1,377	9.6
Air Source Heat Pump (Air-Air)	£9,310	3,231	686	1,099	8.5
Floor Insulation	£10,840	476	101	162	66.9
Wall Insulation	£17,500	942	942	320	54.6

Full Recommendations and Results

Draught Proofing:

The entire property currently has no draught-proofing measures. It is estimated that up to 77 kWh could be saved If forms of draught-proofing were fitted throughout the property. At an installation cost of only around £225, draught proofing is a cost-effective, low risk and adaptable measure throughout large, multi-use properties. We project that savings of £26 and 16 kg CO_2e per year can be expected from this measure.

Double Glazing:

The property currently has approximately 20 windows, half of which are only single glazed. With sufficient double glazing of the property's windows, up to 519 kWh and 110 kg CO_2e per year could be saved. Financial savings of £176 could also be expected from this recommendation. Double glazing 10 windows would come at a capital cost of £1,125, with a payback period of approximately 6.4 years.

Smart Thermostatic Heating Controls:

Based on the current number of heating units in the property, it is estimated that 700 kWh could be saved by implementing smart thermostatic heating controls across the entire property. This is a low-risk energy intervention, as it is relatively low cost and is adaptable across existing and new heating systems for future operability.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Energy Efficient Lighting:

The total amount of lights in the property is currently unknown. However, it is known that 40 currently have non-LED bulbs. These include fluorescent tube and some halogen bulb lighting units. Converting all non-LED lights to LED equivalents could significantly improve the energy efficiency of lighting in the property.

The Energy Saving Trust states that you can save £6 and 5kg of CO_2e for every 50 W halogen bulb replaced with an equivalent LED bulb per year. It is estimated the property could save 858 kWh of electricity a year by switching to LED lighting. This could save the property around £292 from electricity bills and 182 kg CO_2e per year.

Solar PV and Battery Storage:

The building is not listed nor is it in a conservation area, meaning solar PV is likely to be considered a permitted development and therefore will not require planning permission.

There is a total feasible roof area of around 90m^2 which provides space for solar PV capacity of 11 kW. This is based on the property having a roof angle of roughly 35^o and a suitable south facing roof area.

An 11-kW array with battery could produce 10,122kWh of electricity per year. If 40% of this could be used on site, i.e., 4,048.7 kWh, a resulting 6,073.05 kWh would be available for grid export. This exported electricity has the potential to generate revenue of £389 / year, based on a preferential smart export guarantee rate of £0.15 per kWh. Smart export guarantee rates differ depending on energy suppliers. The rate specified in this report is offered by Octopus Energy (£0.15 per kWh) and represents a preferential export rate. Other energy providers offer reduced smart export rates.

For a solar PV system without battery, the total cost of implementation is estimated to be £14,000 (11.6-year payback period) with annual carbon savings of 430 kgCO_2e. For a solar PV system with battery, the total cost of implementation is estimated to be £22,000 (12.5-year payback period) with annual carbon savings of 860 kg CO_2e per year. The latter of these options is recommended.

As the property has single phase electrical capacity, solar PV export could be used for "slower" EV charging at the property using the existing system or "fast" charging, if the electricity connection was upgraded.

Air Source Heat Pump (ASHP):

This measure is suggested as a means of addressing the property's insufficient heating supply. This renewable heat strategy is also dependent on insulating the Village Hall to current insulation standards. ASHPs require sufficient insulation to work optimally as they function on a basis of lower operating temperatures (60^{o}C / 40^{o}C flow temperatures). Implementing an ASHP could save 3,231 kWh per year and provide a £1,099 energy bill reduction, based on an energy price cap of £0.34 per kWh of electricity.

This measure would offer a carbon saving of approximately 686 kg CO_2e / year. This strategy will come at a cost of around £9,310, with an anticipated payback of 8.5 years.

Floor Insulation

Floor insulation currently 1988 building regulations. Insulating the approximate 164 m^2 area of floor space to 2023 standards could save 476 kWh and £162 per year. This recommendation would come at an approximate cost of £10,840, with a payback period of 66.9 years.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Wall Insulation

Walls in the village hall area are insulated to 1988 regulations. Upgrading these to 2023 u-value standards could save the property 942 kWh of energy and around £320 per year. This will come at a cost of £17,500 providing a payback of around 54.6 years. It could also reduce the carbon footprint of the property by 200 kg CO_{2e} per year.

Conclusions

Implementing all recommendations, as set out in this report, will save **10,852 kWh** of energy / year, resulting in a saving of **£3,690** and **2.3 tonnes CO_{2e}** per year.

The property also has the potential to operate as an EV hub for slow EV charging via its current electricity connection. Consideration of solar PV and EV charging, as well as upgrading to a three-phase system, should be considered to increase the sites value as an EV hub.

It should be noted that these calculations are high level and specialist installers should be consulted to provide a better understanding of the property and its energy efficiency and electricity generation potential. They would also be able to provide a quote for installation, helping to better understand initial investment costs and potential payback periods.

There are also many funding opportunities for Scottish and UK businesses, charities, and community buildings, for example the Business Energy Scotland SME loan scheme, the Community and Renewable Energy Scheme (CARES), which can help with implementation costs for both energy efficiency and renewable heat strategies. Full detail on available funding streams can be found in the full feasibility report.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

5. Creich Hall and Bunkhouse

Context and Site Description

Creich Hall was originally built around 1870 as a primary school. In 1996, it was extensively refurbished and repurposed as bunkhouse accommodation for small groups. The hall has two dormitories with a capacity for sleeping eleven guests. Situated within the Ross of Mull, close to popular outdoor pursuit destinations – the hall is in regular use, with up to 20 people using the hall weekly. Downstairs, the hall also has two public meeting rooms, modern kitchen facilities and public toilets. The local Fionnphort community also utilise the facilities - regular sports and arts clubs use the property's two hall spaces for events and classes.

Heating is currently supplied by infrared heaters. Due to the intermittent use of the property, these are coin fed, and are only in operation when the bunkhouse or hall areas are in use. Fibreglass loft insulation and double glazing throughout the property date from the last refurbishment, in 1996. It is understood no floor insulation and minimal wall insulation exists throughout the building. No renewable energy or energy efficiency measures such as smart thermostats, currently exist. The property is currently owned by Argyll and Bute council, and due to recent financial constraints – the feasibility of future energy recommendations may largely depend on external financial support.

The hall is not a listed building nor lies within a conservation area. However, due to the age of the building care should be taken that recommendations do not greatly alter the external appearance of the property. The hall is of great value to the local Fionnphort community and preserving it and its original features should be a primary aim of any future developments to the site.

Also of note is the community interest in buying nearby St. Ernans Church which needs urgent repair. A solar array has been identified as in important part of the restoration work and St. Ernans could be a future possible location for a community owned warm space and energy resource.


Figure 5.1: External and Internal Appearance

Summary Findings

This section presents the key findings of current energy consumption, and the potential for solar PV, energy storage, and energy efficiency improvements. Further detail and analysis in relation to these technologies may be found in Section 4.3.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Energy Consumption

Table 5.1 displays the buildings' current electricity consumption, which averages 4,383 kWh per year, with an estimated 61% of this used for electric heating. As seen in Figure 5.2, throughout the 10-month period examined, electricity usage has highest usage in spring/summer 2022. It should be noted that gaps in electrical usage data in September and November have resulted in an incomplete record of electrical usage across this period.

Table 5.1: Creich Hall Average Energy Consumption

Average Energy Consumption	Annual	Monthly	Daily
Total Electricity Consumption (kWh)	4,383	365.2	12.0
Of which for electric heating (kWh)	2,674	22.8	7.3

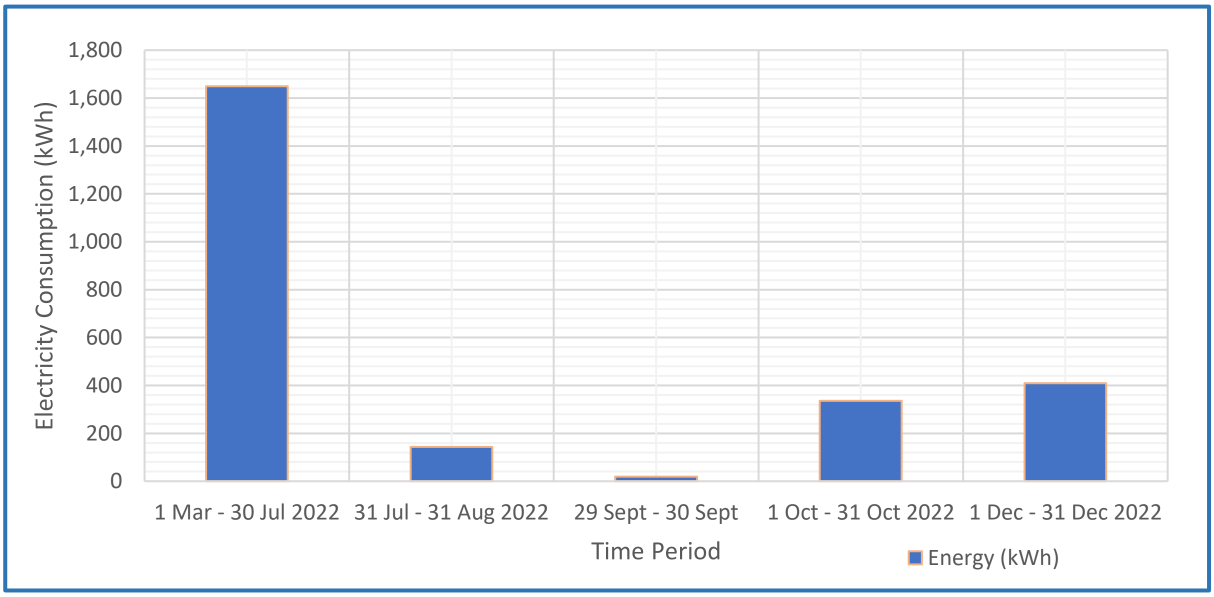

Figure 5.2: Creich Hall Electricity Consumption, 2020-2022

Energy Generation

Table 5.2 presents an overview of the generation potential from rooftop solar PV and energy storage impact. It is estimated that 10kWp of solar PV capacity can be installed on the property's south-facing roof, producing ~8,727 kWh per year.

The anticipated payback period for the site is 14.1 years for solar PV without storage. With electrical storage included, financial savings from usage and income from export total £3,264 per year, with a 4.1-year payback period.

In terms of suitability as a ChargePoint location, the property has an adjoining car park area – with room for around 5 cars. Due to the property's footfall during tourist season, an EV charging facility would be well suited at this property and potentially help in the transition to EVs in the local area.

Whilst not modelled here, there may also be opportunities for wind power development in concert with the neighbouring crofting community.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Table 5.2: Creich Hall Generation Potential

	Rooftop Solar PV Electricity Generation Potential	
Solar PV Power capacity	10 kWp (Single Phase)	
Yearly Generation Potential	8,727 kWh	
Available Roof Space	50m^2, 35^o pitch, south facing	
Battery Storage Capacity	10 kWh	
	Solar PV only	**Solar PV with Storage**
Capital Cost (£)	14,000	22,000
Energy Utilisation (kWh/yr)	1,745	3,491
Energy Export (kWh/yr)	6,982	5,236
Financial Savings (£ usage per year)	593	1,187
Financial Income (£ export per year)	1,047	785
Payback Period (yr)	**8.5**	**11.2**
Carbon Saving (kg CO_2e/yr)	371	1,110

Energy Efficiency

Table 5.3 presents an overview of potential energy efficiency savings.

The building currently uses electricity for its heating, and we propose that this is retained due to the limited and inconsistent use of the building. However, the feasibility for an air-source heat pump is modelled.

There are multiple thermal efficiency options recommended– insulating the floors, walls and upgrading window glazing are put forward. These measures have low visible impact, ensuring that improved thermal efficiency does not come at the cost of the building's original 19th century appearance.

The village hall could also benefit from implementing multiple low-risk measures, if operating on a limited budget. Measures such as draught proofing or smart thermostats could be easily implemented in this case.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Table 5.3: Creich Hall Energy Efficiency Opportunities

Efficiency Opportunities	Capital Cost (£)	Energy Saving (kWh)/yr)	Carbon Saving (kgCO₂e/yr)	Financial Saving (£/yr)	Payback Period (years)
Draught Proofing	225	38	8	13	17.3
LED Lighting	528	944	200	321	1.6
Smart Thermostatic Controls	200	348	74	118	1.7
Solar PV	14,000	1,745	371	593	8.5
Solar PV and Battery Storage	22,000	5,236	1,110	1,187	11.2
Air-Source Heat Pump (Air-Air)	6,000	1,604	340	545	20.2
Floor Insulation	22,000	270	57	92	239.9
Wall Insulation	17,500	820	174	279	62.8
Roof Insulation	11,000	325	69	110	99.7
Double Glazing	16,000	156	33	53	301.8

Full Recommendations and Results

Village Hall building

Draught Proofing:

The entire property currently has no draught-proofing measures. It is estimated that around 38 kWh could be saved If forms of draught-proofing were fitted throughout the property. Draught proofing is an adaptable, low-cost, and low risk measure which could be implemented. In a property of this size, installation would cost only around £225. We project that savings of £13 and 8 kg CO_2e per year can be expected from this measure.

LED Lighting:

The property currently has around 44 non-LED lights. Converting these lights to LED equivalents could significantly improve the energy efficiency of lighting in the property.

The Energy Saving Trust states that you can save 6 kg and 5 kg of CO_2e for every 50 W halogen bulb replaced with an equivalent LED bulb per year. The property could save approximately 944 kWh of electricity a year by switching to LED lighting. In turn, this will save the property around £321 from electricity bills and 200 kg CO_2e per year.

Smart Thermostatic Controls:

Based on the current number of heating units in the property, it is estimated that 348 kWh could be saved by implementing smart thermostatic heating controls across the entire property. Smart thermostats are a low-cost intervention, costing around £200 on average. They are particularly adaptable, working alongside existing and new heating systems for future operability.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Solar PV and Battery Storage:

The building is not listed nor is it in a conservation area, meaning solar PV is likely to be considered a permitted development and therefore will not require planning permission. However, due to the building's age – care should be taken to preserve original architectural features as best as possible.

There is a total feasible roof area of around 50 m^2 which provides space for solar PV capacity of 10 kW. This is based on the property having a roof angle of roughly 35° and a suitable south facing roof area.

A 10-kW array could produce 8,727 kWh of electricity per year. If 3,491 kWh can be used on site, a resulting 5,236 kWh would be available for grid export. This exported electricity has the potential to generate revenue of £785 / year, based on a preferential smart export guarantee rate of £0.15 per kWh. Smart export guarantee rates differ depending on energy suppliers. The rate specified in this report is offered by Octopus Energy (£0.15 per kWh) and represents a preferential export rate. Other energy providers offer reduced smart export rates.

For a solar PV system of this size without battery, the estimated implementation cost is £14,000 (8.5-year payback period) with 371 kg CO_2e annual savings. For a solar PV system of this size with battery, the estimated implementation cost is £22,000 (11.2-year payback period) with annual carbon savings of 1,110 kg CO_2e.

Air-Source Heat Pump (Air-Air):

This renewable heat strategy is dependent on insulating the Church Centre to current insulation standards. ASHPs require sufficient insulation to work optimally as they function on a basis of lower operating temperatures (60°C / 40°C flow temperatures). Implementing an ASHP could save 1,604 kWh per year and provide a £545 energy bill reduction, based on an energy price cap of £0.34 per kWh of electricity. This strategy will come at a cost of around £11,000, with an anticipated payback of 20.2 years.

Floor Insulation:

The total floor area for the property is around 175 m^2, and insulating this floor space could potentially save the client 270 kWh of electricity a year.

This will come at an estimated cost of £22,000. Although with a grant or loan, for example from the Business Energy Scotland (BES) SME loan scheme, the client can spread the cost and ensure a shorter duration payback. At the current energy price cap rate of £ 0.34 per kWh, it is estimated the payback period for this recommendation would be around 239.9 years. With the SME loan scheme, payback could be reached in around 60 years. The strategy could save 57 kg/CO_2e per year.

Wall Insulation:

The property has little to no form of wall insulation. The main walls are constructed from granite, and due to their age have no capacity for internal cavity insulation. As a result, interior wall insulation is recommended to preserve the property's 19th century stone exterior. Although the property is not listed or in a conservation zone, preservation of the building's appearance and inherent features is deemed of great value and importance to the local community. Appropriate insulation of the interior's walls to 2023 U-value standards could save the property 820 kWh of energy and around £279 per year. This will come at a cost of roughly £17,500 providing a payback of around 62.8 years. It could also reduce the carbon footprint of the property by 174 kg CO_{2e} per year.

Roof Insulation:

The roof already has some insulation in place, installed at some point during the 1990's. Our modelling is based on increasing this insulation to 2023 U-value standards for a roof space. This can usually be satisfied by putting 250 mm quilted wool layers in the roof / loft space.

This project has received funding from the European Union's Horizon 2020
research and innovation program under grant agreement N° 864266.

Upgrading roof insulation to 2023 regulations could potentially save the property 325 kWh per year. This would come at a cost of roughly £11,000 and anticipated payback of 99.7 years. It could save the property 69 kg CO_{2e} / year. It is recommended that financial support and advice from loan or grant schemes should be pursued if this recommendation is to be implemented.

Double Glazing:

The property currently has approximately 20 windows. It is understood that approximately 16 windows are older, dated double-glazed windows, dating from at least the 1990’s. Upgrading the windows to modern 2023 U-value standards could save up to 156 kWh and 33 kg CO_2e per year. Financial savings of £53 could also be expected from this recommendation. Double glazing around 16 windows would come at a capital cost of £16,000, with a payback period of approximately 301.8 years. As previously mentioned, financial support and advice is available for high-cost and high-payback period efficiency recommendations.

Conclusions

Implementing all recommendations, as set out in this report, will save **7,995 kWh** of energy / year, resulting in a saving of **£2,718** and **1.7 tonnes CO_{2e}** per year.

The property also has the potential to operate as an EV hub for slow EV charging via its current electricity connection. Consideration of solar PV and EV charging, with use of the current three-phase connection should be considered to increase the sites value as an EV hub.

It should be noted that these calculations are high level and specialist installers should be consulted to provide a better understanding of the property and its energy efficiency and electricity generation potential. They would also be able to provide a quote for installation, helping to better understand initial investment costs and potential payback periods.

There are also many funding opportunities for Scottish and UK businesses, charities, and community buildings, for example the Business Energy Scotland SME loan scheme, the Community and Renewable Energy Scheme (CARES), which can help with implementation costs for both energy efficiency and renewable heat strategies. Full detail on available funding streams can be found in the full feasibility report.

This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement N° 864266.

6. Dervaig Village Hall

Context and Site Description

Dervaig Village Hall was built between 1998 and 2000 to serve the Dervaig community as a public events hub and community space. The property consists of two main spaces; a village hall area and seasonal bunkhouse accommodation, able to accommodate up to 6 people during summer tourist seasons. The property also contains a community library, meeting rooms, foyer space and kitchen facilities.

Currently, the property is heated via two sources. An air-source heat pump was recently installed in 2021 and the main hall area is supplied by infrared heaters. It is understood that all windows at the property are double-glazed up to modern building regulation standards. Loft, floor, and wall insulation across both areas date from the year of their construction – 1998 and 2009 respectively. Lighting across the property is a mixture of LED and non-LED bulb, it is estimated that around half the number of current lights is non-LED bulbs and are anticipated to be replaced.

The site is currently used by roughly 20 occupants per day, with occasional use by the local primary school and sports teams The property is not a listed building; however, it lies within the Dervaig Conservation Area. As a result, some future energy recommendations will require some form of planning permission. This is particularly appropriate if energy recommendations impact the physical external appearance or condition of the property.

Figure 6.1: External and Internal Appearance

Summary Findings

This section presents the key findings of current energy consumption, and the potential for solar PV, energy storage and energy efficiency improvements. Further detail and analysis in relation to these technologies may be found in Section 5.3.

Energy Consumption

The building's current electricity consumption is shown in Table 6.1, averaging 11,525 kWh per year. From assumed energy usage patterns and using typical energy demand profiling for non-domestic buildings, it is estimated that approximately 61% of the energy consumption is used for electric heating. Figure 6.2 shows the variation in electricity consumption for the hall over the two-year period between September 2020 and September

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

2022. Low energy usage is observed during 2020, attributed to limited usage of the venue during the Covid-19 pandemic. Electricity usage spikes in April 2021, with another notable peak in December 2021.

Table 6.1: Dervaig Village Hall Average Energy Consumption

Average Energy Consumption	Annual	Monthly	Daily
Total Electricity Consumption (kWh)	11,525	960.4	31.6
Of which for electric heating (kWh)	7,030	585.9	19.3

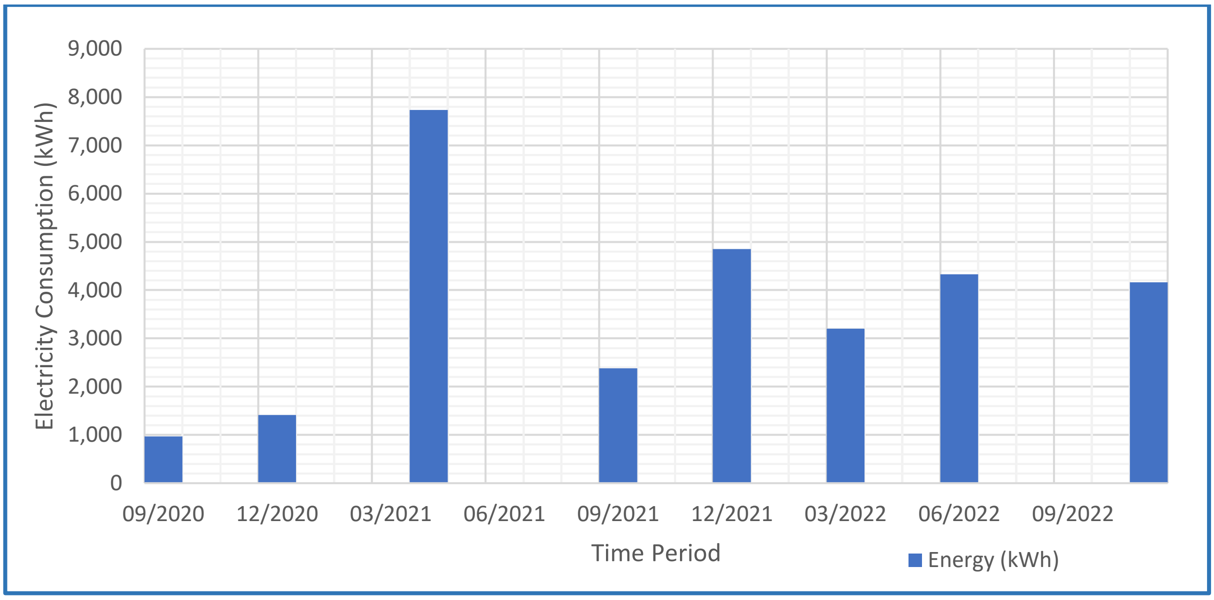

Figure 6.2: Dervaig Village Hall Electricity Consumption, 2020-2022

Energy Generation

Table 6.2 presents an overview of the generation potential from rooftop solar PV and the impact of any energy storage. It is estimated that 19 kWp of solar PV capacity can be installed on the property's south-eastern facing roof, producing ~11,587 kWh per year.

For solar PV without storage, annual savings from usage and income from export total £2,178 and the anticipated payback period is 11 years.

For solar PV with battery storage, annual savings from usage and income from export total £3,059 and the anticipated payback period is 11 years. In this scenario, 6,952 kWh of electricity generated is predicted to be utilised directly by the hall. This means there is a high availability of self-produced energy for a chargepoint at the site, or other forms of new electrical demand.

For this reason, the system with battery storage is recommended.

The hall's car park has been assessed as "well-suited" as an EV charging facility. Currently there are 30 car spaces with an average of at least five cars per day. The installation of EV charging points here would encourage increased use of EVs in the local area.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Table 6.2: Dervaig Village Hall Generation Potential

	Rooftop Solar PV Electricity Generation Potential	
Solar PV Power capacity	19 kWp (Single Phase)	
Yearly Generation Potential	11,587 kWh	
Available Roof Space	100m^2, 35^o pitch, south-eastern facing	
Battery Storage Capacity	20 kWh	
	Solar PV only	**Solar PV with Storage**
Capital Cost (£)	24,000	35,000
Energy Utilisation (kWh/yr)	2,317	6,952
Energy Export (kWh/yr)	9,269	4,635
Financial Savings (usage per year)	788	2,364
Financial Income (export per year)	1390	695
Payback Period (yr)	**11**	**11.4**
Carbon Saving (kg CO_2e/yr)	491	1,476

Energy Efficiency

Table 6.3 presents an overview of potential energy efficiency savings.

The village hall space currently uses electricity for its heating, and we propose that this is retained due to the intermittent use of the building. However, we propose that a smart thermostatic control system is installed to regulate and control the existing infrared heating system when in use.

The village hall would benefit from several other energy efficiency improvements, including draught proofing and LED lighting, which would provide financial savings and result in payback periods. These are summarised in Table 6.3.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Table 6.3: Dervaig Village Hall Energy Efficiency Opportunities

Efficiency Opportunities	Capital Cost (£)	Energy Saving (kWh)/yr)	Carbon Saving ($kgCO_2e/yr$)	Financial Saving (£/yr)	Payback Period (years)
Draught Proofing (Entire property)	£225	101	21.4	£34	6.6
LED Lighting (Hall)	£360	643	136	£219	1.6
Smart Thermostatic Heating Controls (Hall)	£200	914	194	£311	0.6
Solar PV with Battery Storage (Hall)	£35,000	6,952	1,474	£2,364	11
Solar PV	£24,000	2,317	491	£788	11
Floor Insulation	£13,000	914	914	£311	41.8
Roof Insulation	£7,500	1,055	224	£359	20.9
Wall Insulation	£17,500	1,394	296	£474	36.9

Full Recommendations and Results

Village Hall

Solar PV and Battery Storage:

The building is not listed, however lies within a conservation area, meaning solar PV will require planning permission prior to any works. The building's age and position at the vicinity of the conservation area means that efforts to acquire planning permission can be regarded as promising.

There is a total feasible roof area of around 100m^2 which provides space for solar PV capacity of 19 kW. This is based on the property having a roof angle of approximately 35^o and a suitable south-eastern facing roof area.

A 19-kW array could produce 11,587 kWh of electricity per year. If 60% of this could be used on site, i.e., 6,953 kWh, a resulting 4,635 kWh would be available for grid export. This exported electricity has the potential to generate revenue of £695 / year, based on a preferential smart export guarantee rate of £0.15 per kWh. Smart export guarantee rates differ depending on energy suppliers. The rate specified in this report is offered by Octopus Energy (£0.15 per kWh) and represents a preferential export rate. Other energy providers offer reduced smart export rates.

For a solar PV system without battery storage, the total cost of implementation is estimated to be £24,000 (11 years payback period). For a solar PV system with battery storage, the total cost of implementation is estimated to be £35,000 (11.4-year payback period). This relates to an annual carbon saving of 1,476 kg CO_2e per year. For this reason, the latter system is recommended.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Smart Thermostatic Heating Controls:

Based on the current number of heating units in the property, it is estimated that 914 kWh could be saved by implementing smart thermostatic heating controls across the entire property. This is a low-risk energy intervention, as it is relatively low cost and is adaptable across existing and new heating systems for future operability.

Entire property (Village Hall and Bunkhouse)

The entire property is sufficiently insulated to 1998 building regulations, and the adjacent bunkhouse contains an air-source heat pump system. The bunkhouse's ASHP enables this part of the building to be much more energy efficient, thus removing the need for larger-scale energy recommendations.

Energy Efficient Lighting (LED's)

The total amount of individual lights throughout the property is unknown. However, lights currently used include both LED and non-LED blub lighting units, and the client is gradually phasing out older, inefficient non-LED bulbs. Converting all non-LED lights to LED equivalents could significantly improve the energy efficiency of lighting in the property.

The Energy Saving Trust states that you can save 6kg and 5kg of CO_2e for every 50 W halogen bulb replaced with an equivalent LED bulb per year. It is estimated that the property could save 643 kWh of electricity per year by switching to LED lighting. This could save the property approximately £219 from electricity bills and 136 kg of CO_2e per year.

Draught Proofing

The entire property currently has no draught-proofing measures. It is estimated that up to 101 kWh could be saved if forms of draught-proofing were fitted throughout the property. At an installation cost of only around £225, draught-proofing is a cost-effective, low risk and adaptable measure throughout large, multi-use properties. We project that savings of £34 and 21.4 kg of CO_2e per year can be expected from this measure.

Floor Insulation

Floor insulation currently complies with 1998 (hall) and 2009 (bunkhouse) building regulations. Insulating the approximate 200m^2 area of floor space to 2023 standards could save 914 kWh and £311 per year. This recommendation would come at a cost of £13,000, with a payback period of 41.8 years.

Roof Insulation

Roof insulation in both buildings complies to 1998 (hall) and 2009 (bunkhouse) regulations. Upgrading both roof areas to 2023 U-value standards could save the property 1,055 kWh per year. This would come at a cost of £7,500 and an anticipated payback period of 20.9 years. It could save the property 224 kg CO_{2e} per year.

Wall Insulation

Walls in the village hall area are insulated to 1998 regulations, and in the bunkhouse to 2009 regulations. Insulating these further to 2023 u-value standards could save the property 1,394 kWh of energy and around £474 per year. This will come at a cost of £17,500 providing a payback of around 36.9 years. It could also reduce the carbon footprint of the property by 296 kg CO_{2e} per year.

Conclusions

Implementing all recommendations, as set out in this report, will save **11,973 kWh** of energy / year, resulting in a saving of **£4,071** and **2.5 tonnes CO_2e** per year.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

The property also has the potential to operate as an EV hub for fast EV charging via its current electricity connection. Consideration of solar PV and EV charging, using the current three-phase connection should be promoted to increase the site's value as an EV hub.

It should be noted that these calculations are high level and specialist installers should be consulted to provide a better understanding of the property and its energy efficiency and electricity generation potential. They would also be able to provide a quote for installation, helping to better understand initial investment costs and potential payback periods.

There are also many funding opportunities for Scottish and UK businesses, charities, and community buildings, for example the Business Energy Scotland SME loan scheme, the Community and Renewable Energy Scheme (CARES), which can help with implementation costs for both energy efficiency and renewable heat strategies. Full detail on available funding streams can be found in the full feasibility report.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

7. Salen and Ulva Parish Church

Context and Site Description

Salen & Ulva Parish church was opened in 1899 to serve the communities' Christian population. In 1990 it was adapted into a multi-purpose hall to help with financial constraints and difficulties the hall was facing at the time. In 2009, the church centre extension was built to include a vestry and two meeting rooms and a modern kitchen and toilet facilities, enabling it to better facilitate the community and events.

The main church building is a mid-Gothic style church hall with well-preserved historic detail, although the hall is not a listed building, nor is it in a conservation area. This means that energy recommendations are less likely to require planning permission and, for those that do require permission, will be relatively straight forward to gain necessary consents. Whilst not designated, the appearance of the building does have value to those who use the building regularly and changes to its unique architecture and place in the community should be consulted on before activities are undertaken. The building can be considered in two parts, the church hall dated 1899 and the church centre extension built in 2009.

Figure 7.1: External and Internal Appearance

Summary Findings

This section presents the key findings of current energy consumption, and the potential for solar PV, energy storage, and energy efficiency improvements. Further detail and analysis in relation to these technologies may be found in Section 6.3.

Energy Consumption

Table 7.1 displays the buildings' current electricity consumption, which averages 27,900 kWh per year, with an estimated 61% of this used for electric heating. As seen in Figure 7.2, throughout the two-year period examined, electricity usage has several spikes, most notably in May 2022 when monthly usage was four times the average, with notable increases in June and December 2021.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Average Energy Consumption	Annual	Monthly	Daily
Total Electricity Consumption (kWh)	26,941	2,245	73.1
Of which for electric heating (kWh)	16,434	1,370	45.0

Table 7.1: Salen Church Hall Average Energy Consumption

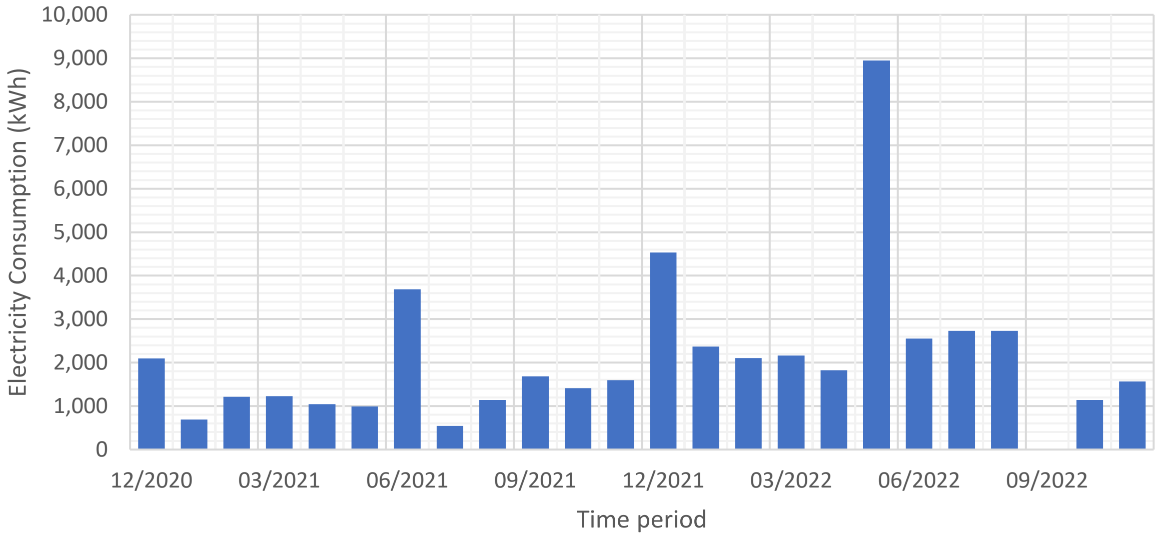

Figure 7.2: Salen Church Hall Electricity Consumption, 2020-2022

Energy Generation

Table 7.2 presents an overview of the generation potential from rooftop solar PV and energy storage impact. It is estimated that 19kWp of solar PV capacity can be installed on the property's south-facing roof, producing ~14,000 kWh per year.

The anticipated payback period for the site is 7.1 years for solar PV without storage. With electrical storage included, financial savings from usage and income from export total £3,000 per year, with a 9.5-year payback period.

Even in the scenario with 20kWh storage, most of this energy is anticipated to be exported, with only 4,300 kWh utilised directly by the hall. This means there is a high availability of self-produced energy for a ChargePoint at the site, or other forms of new electrical demand.

In terms of suitability as a ChargePoint location, there is one parking space (with potential for two if reorientated) and on-road parking. With an average of 5 cars frequenting the location per day, an EV charging facility would be well suited at this property and potentially help in the transition to EVs in the local area.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

	Rooftop Solar PV Electricity Generation Potential	
Solar PV Power capacity	19 kWp (Single Phase)	
Yearly Generation Potential	14,264 kWh	
Available Roof Space	140m^2, 75° pitch, south facing	
Battery Storage Capacity	20 kWh	
	Solar PV only	**Solar PV with Storage**
Capital Cost (£)	19,000	27,991
Energy Utilisation (kWh/yr)	2,853	4,279
Energy Export (kWh/yr)	11,411	9,985
Financial Savings (usage per year)	970	1,455
Financial Income (export per year)	1,712	1,498
Payback Period (yr)	**7.1**	**9.5**
Carbon Saving (kg CO_2e/yr)	606	908

Table 7.2: Salen Church Hall Generation Potential

Energy Efficiency

Table 7.3 presents an overview of potential energy efficiency savings. The building's walls are well-preserved solid brick, with curved wooden joists and rafters, which make up the roof space. Insulating these areas will remove these important architectural details and therefore is not advisable.

The building currently uses electricity for its heating, and we propose that this is retained due to the limited and inconsistent use of the building.

There are two thermal efficiency options recommended for the church hall – insulating the floors and implementing secondary glazing for the windows. These measures have low visible impact, ensuring that improved thermal efficiency does not come at the cost of the building's appearance.

The church centre expansion would benefit from several efficiency improvements, including roof and wall insulation, which would provide sizable savings and result in payback periods.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Efficiency Opportunities	Capital Cost (£)	Energy Saving (kWh)/yr)	Carbon Saving ($kgCO_2e/yr$)	Financial Saving (£/yr)	Payback Period (years)
Draught Proofing	£225	329	70	112	2.0
Underfloor Insulation (Hall)	£19,755	3,240	700	1,102	17.9
Energy Efficient Lighting (Hall)	£740	794	200	270	2.7
Smart Thermostatic Heating Controls (Hall)	£795	2,136	454	726	1.0
Roof Insulation (Church Centre)	£1,500	1,479	300	503	3.0
Wall Insulation (Church Centre)	£4,226	1,693	400	575	7.3
Double Glazing	£10,000	1,431	303	487	20.5
Air Source Heat Pump (Church Centre)	£20,620	9,860	2,100	3,353	6.1

Table 7.3: Salen Church Hall Energy Efficiency Opportunities

Full Recommendations and Results

Main Church Hall Building

Draught Proofing:

The entire property currently has no draught-proofing measures. It is estimated that around 38 kWh could be saved If forms of draught-proofing were fitted throughout the property. Draught proofing is an adaptable, low-cost, and low risk measure which could be implemented. In a property of this size, installation would cost only around £225. We project that savings of £112 and 70 kg CO_2e per year can be expected from this measure.

Solar PV and Battery Storage:

The building is not listed nor is it in a conservation area, meaning solar PV is likely to be considered a permitted development and therefore will not require planning permission.

There is a total feasible roof area of around 140m^2 which provides space for solar PV capacity of 19 kW. This is based on the property having a roof angle of roughly 75° and a suitable south facing roof area.

A 19-kW array could produce 14,264 kWh of electricity per year. If 2,852.8 kWh is used on site, a resulting 11,411.7 kWh would be available for grid export. This exported electricity has the potential to generate revenue of £1,711.67 / year, based on a preferential smart export guarantee rate of £0.15 per kWh. The rate specified in this report is offered by OPUS Energy (£0.15 per kWh) and represents a preferential export rate. Other energy providers offer reduced smart export rates.

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A 20-kWh battery system would increase self-consumption of generated electricity up to 4,279.2 kWh. This would reduce electricity bills by £1,455.

The total cost of implementation is estimated to be £24,000 for rooftop solar PV (7 years payback period) and £33,000 with the battery storage system (10 years payback period). There would also be a total carbon saving from this strategy of 900 kg CO_{2e} per year.

As the property has single phase electrical capacity, solar PV export could be used for "slower" EV charging at the property using the existing system or "fast" charging, if the electricity connection was upgraded.

Underfloor Insulation:

The total floor area for the church hall is around 329m^2, and insulating this floor space could potentially save the client 3,240 kWh of electricity a year.

This will come at an estimated cost of £19,755. Although with a grant or loan, for example from the Business Energy Scotland (BES) SME loan scheme, the client can spread the cost and ensure a shorter duration payback. At the current energy price cap rate of £ 0.34 per kWh, it is estimated the payback period for this recommendation would be around 18 years. With the SME loan scheme, payback could be reached in around 5 years. The strategy could save 700 kg/CO_2e per year.

Double Glazing:

It is unknown when the property's windows date from. Upgrading the windows to modern 2023 U-value standards could save up to 1,431 kWh and 303 kg CO_2e per year. Financial savings of £487 could also be expected from this recommendation. Double glazing on a property of this size may come at a capital cost of around £10,000, with a payback period of approximately 20.5 years. As previously mentioned, financial support and advice is available for high-cost and high-payback period efficiency recommendations.

Energy Efficient Lighting:

The property currently has around 37 individual lights. These include fluorescent tube and some halogen bulb lighting units. Converting all non-LED lights to LED equivalents could significantly improve the energy efficiency of lighting in the property.

The Energy Saving Trust states that you can save £6 and 5kg of CO_2e for every 50 W halogen bulb replaced with an equivalent LED bulb per year. It is estimated the property could save 794 kWh of electricity a year by switching to LED lighting. This could save the property around £270 from electricity bills and 200 kg CO_2e per.

Smart Thermostatic Heating Controls:

Based on the current number of heating units in the property, it is estimated that 2,136 kWh could be saved by implementing smart thermostatic heating controls across the entire property. This is a low-risk energy intervention, as it is relatively low cost and is adaptable across existing and new heating systems for future operability.

Church Centre

As the church centre extension was built in 2009, it does not have the same constraints relating to historic detail. This enables this part of the building to be much more energy efficient and provides the potential to implement low carbo heating options thanks to improved air tightness and thermal efficiency level.

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 864266.

Roof Insulation:

The roof already has some insulation in place, installed in 2009, when the building was built. Our modelling is based on increasing this insulation to 2023 U-value standards for a roof space. This can usually be satisfied by putting 270 mm quilted wool layers in the roof / loft space.

Further insulating the loft space of the Church Centre using 270 mm quilted wool, could potentially save the property 1,479 kWh per year. This would come at a cost of roughly £1,500 and anticipated payback of 3 years. It could save the property 300 kg CO_{2e} / year.

Wall Insulation:

The cavity walls of the property are insulated to 2009 standards, when the building was built. Insulating these further to 2023 U-value standards could save the property 1,693 kWh of energy and around £575 per year. This will come at a cost of roughly £4,226 providing a payback of around 7 years. It could also reduce the carbon footprint of the property by 400 kg CO_{2e} per year.

Air Source Heat Pump (ASHP):

This renewable heat strategy is dependent on insulating the Church Centre to current insulation standards. ASHPs require sufficient insulation to work optimally as they function on a basis of lower operating temperatures (60^{o}C / 40^{o}C flow temperatures). Implementing an ASHP could save 9,860 kWh per year and provide a £3,353 energy bill reduction, based on an energy price cap of £0.34 per kWh of electricity.

As this measure has the highest energy saving, it also has the highest carbon saving of 2,100 kg CO_2e / year. This strategy will come at a cost of around £20,620, with an anticipated payback of 6.1 years.

Conclusions

Implementing all recommendations, as set out in this report, will save **25,240 kWh** of energy / year, resulting in a saving of **£8,582** and **5.4 tonnes CO_{2e}** per year.

The property also has the potential to operate as an EV hub for slow EV charging via its current electricity connection. Consideration of solar PV and EV charging, as well as upgrading to a three-phase system, should be considered to increase the sites value as an EV hub. It should be noted that these calculations are high level and specialist installers should be consulted to provide a better understanding of the property and its energy efficiency and electricity generation potential. They would also be able to provide a quote for installation, helping to better understand initial investment costs and potential payback periods.

There are also many funding opportunities for Scottish and UK businesses, charities, and community buildings, for example the Business Energy Scotland SME loan scheme, the Community and Renewable Energy Scheme (CARES), which can help with implementation costs for both energy efficiency and renewable heat strategies. Full detail on available funding streams can be found in the full feasibility report.

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8. Ulva Ferry Pontoon

Please note: This audit and report was conducted before construction was completed. As of November 2023, the completed building now has a 4 kW rooftop solar PV installation with 9 kWh battery storage.

Context and Site Description

Ulva Pontoon is situated on the far western coast of the Isle of Mull, around 40 minutes driving distance from Tobermory. It is important in being the only ferry landing for connections to the Isle of Ulva. The Ulva Ferry Pontoon is the subject of a £850,000 development, carried out by the Mull and Iona Community Trust (MICT). As a result, Ulva ferry pontoon has seen considerable development in recent years. New homes, a hybrid minibus service and electric car connections to shops, health services and social activities across Mull have all been created as part of recent developments. A new ferry pontoon, car park and motorhome pitches have recently been installed to accommodate higher volumes of visitors.

The next stage of the Ulva Ferry Pontoon initiative will see the development of a new building to provide facilities to both visitors and residents. It will also act as a community hub, providing much needed space for the growing local community. This proposed Ulva community hub will contain a multifunctional venue space, meeting rooms, offices, a kitchen, and toilet facilities.

As of June 2023, the Ulva community hub has yet to be constructed. Therefore, no statistics for the property's current energy consumption are available. For the purposes of this energy audit, an estimated electricity consumption figure, based on consumption from another similar-sized hall on the Isle of Mull has been used. In terms of the property's energy efficiency measures, again some assumptions have been made to produce this energy audit. As a new-build construction it is assumed that the property will include sufficient insulation, double-glazing and heating requirements that all comply with 2023 building regulations. As a result, the site's potential for Solar PV systems, EV charging and an Air-Source Heat Pump system have been explored.

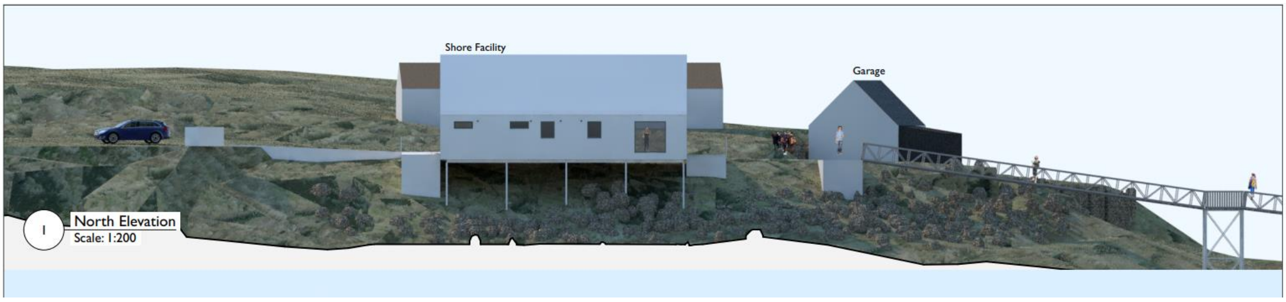

Figure 8.1: Proposed External Appearance

Summary Findings

This section presents the potential for solar PV and energy storage. Further detail and analysis in relation to these technologies may be found in Section 7.3.

Estimated Energy Consumption

The estimated current electricity consumption of the building is shown in Table 8.1, averaging 11,500 kWh per year. This figure has been based on actual electricity consumption of another village hall on the Isle of Mull (Dervaig Village Hall). Data from this property was used due to being similar in size and being the most similarly aged property included in this study. From assumed energy usage patterns and using typical energy demand

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profiling for non-domestic buildings, it is estimated that approximately 61% of the energy consumption is used for electric heating.

Table 8.1: Ulva Pontoon Ferry Estimated Average Energy Consumption

Average Energy Consumption	Annual	Monthly	Daily
Estimated Electricity Consumption (kWh)	11,500	958.3	31.5
Of which for electric heating (kWh)	7,015	584.6	19.2

Energy Generation

Error! Reference source not found. presents an overview of the generation potential from rooftop solar PV and the impact of any energy storage. It is estimated that 8 kW of solar PV capacity can be installed on the property's south-eastern facing roof, producing ~7,670 kWh per year.

For a solar PV system without battery, the anticipated implementation cost is £11,000 with a 21-year payback period. In this system the combined annual savings from usage and income from export total £569. If battery storage is included, the initial cost increases to £16,100. Financial savings from usage and income from export amount to £2,025 per year, with an 8-year payback period.

Table 8.2: Ulva Ferry Pontoon 8 kWh Solar PV Generation Potential

	Rooftop Solar PV Electricity Generation Potential	
Solar PV Power capacity	8 kW (Single Phase)	
Yearly Generation Potential	7,670 kWh	
Available Roof Space	58 m^2, 35° pitch, south facing	
Battery Storage Capacity	8 kWh	
	Solar PV only	**Solar PV with Storage**
Capital Cost (£)	11,000	16,100
Energy Utilisation (kWh/yr)	1,534	4,602
Energy Export (kWh/yr)	6,136	3,068
Financial Savings (usage per year)	522	1,565
Financial Income (export per year)	920	460
Payback Period (yr)	**21.1**	**8.0**
Carbon Saving (kg CO_2e/yr)	325	976

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Whilst not modelled here, there may also be opportunities for wind power development in the nearby area. However, obtaining planning permission may be challenging due to environmental (nearby Site of Special Scientific Interest (SSSI)) and visual constraints.

There is also opportunity for additional ground-mounted solar PV on the surrounding land.

Part of development works at Ulva Ferry Pontoon envisage the upgrade of two car park areas around the facility. The one car park, adjacent to the planned building will be able to accommodate 8 cars, with priority for disabled parking. The other car park, situated across the road, will be able to accommodate up to 16 vehicles. From understanding of the footfall and the aims of the Ulva Ferry Pontoon site – these car parks can be considered as 'well-suited' for EV charging facilities. With increased usage of the ferry pontoon centre by residents and visitors – the installation of EV charging points here would encourage further EV use in the local area.

Energy Efficiency

As a new construction, it is assumed that the property will contain modern standards of energy efficiency measures, and an energy efficient heating system.

Therefore, it is assumed that the property will contain wall, loft and floor insulation that conforms to 2023 building regulation u-values. These are the most energy efficient forms of insulation and will aid in thermal retention and building breathability. Similarly, it is assumed that all windows throughout the property are double-glazed to the same standard. Additionally, the property may benefit from implementing smart thermostatic controls and LED lighting to further maximise the energy efficiency of the property.

In terms of heating system, it is anticipated that an air-source heat pump (or equivalent) is installed. Due to the property's size and requirements, a 10kW pump may be required. Air-source heat pumps offer an efficient answer to heating requirements in medium to large multi-use venues.

As discussed in the previous chapter, the hall would benefit from renewable energy generation, which would provide financial savings and result in payback periods. These have been modelled and are summarised in table 8.4.

Table 8.4: Ulva Ferry Pontoon Energy Efficiency Opportunities

Efficiency Opportunities	Capital Cost (£)	Energy Saving (kWh)/yr)	Carbon Saving ($kgCO_2e/yr$)	Financial Saving (£/yr)	Payback Period (years)
3.16 kW Solar PV	7,000	606	129	206	34.0
3.16 kW Solar PV with Battery Storage	10,500	1,817	386	618	13.1
8 kW Solar PV	11,000	1,534	325	522	21.1
8 kW Solar PV with Battery Storage	16,100	4,602	976	1,565	8.0
10 kW Air-Source Heat Pump	11,000	4,209	894	1,431	7.7

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Full Recommendations and Results

Ulva Ferry Pontoon

Solar PV and Battery Storage:

The proposed location for this building does not lie within any conservation or protected area, therefore implementing solar PV should encounter minimal planning permissibility issues.

There is a total feasible roof area of around 60 m^2, however only around a third of this will be used to house a 3.16 kW solar PV system. This is based on the property having a roof angle of approximately 35° and a suitable south facing roof area.

An 8kW array could generate 7,670 kWh of electricity per year. Assuming 20% (1,533.9 kWh / year) is utilised on-site, then 6,135.6 kWh will be available for export to the grid. At a preferential smart export guarantee rate of £0.15 per kWh, this could generate £460.17 / year.

An 8kW solar PV system would come at a cost of around £11,000 (21.1 years payback) and £16,100 (8.0 years payback) with a battery storage system. If an 8kW array with battery storage were to be installed, there would be a carbon saving of approximately 976 kg CO_2e per year.

10 kW Air-Source Heat Pump (ASHP):

As a new-build construction, it is assumed that some form of air-source heating or cooling system will be implemented. Again, the property's location does not fall within any conservation or heritage area – therefore minimal permissibility issues should be encountered when installing ASHPs.

This heat strategy is dependent on the building complying with modern 2023 insulation requirements. ASHPs require sufficient insulation to work optimally as they function on a basis of lower operating temperatures (60°C / 40°C flow temperatures). Based on estimated electricity consumption, implementing an ASHP could save 4,209 kWh per year and provide a £1,431 energy bill reduction, based on an energy price cap of £0.34 per kWh of electricity. This strategy will come at a cost of approximately £11,000, with an anticipated payback period of 7.7 years.

Conclusions

Energy and cost savings will ultimately depend upon what type of solar system is implemented at the property. Provided architectural plans suggest that an 8 kW Solar PV system with battery storage is most favoured. An 8-kW solar PV array (with storage) and an air-source heat pump system will save **8,811 kWh** of energy / year, resulting in a saving of **£2,996** and **1.9 tonnes CO_2e** per year.

With development of two car park areas around the centre, the property has the potential to operate as an EV hub for slow EV charging via upgrades to electricity connection. Consideration of solar PV and EV charging, as well as upgrading to a three-phase system, should be considered to increase the sites value as an EV hub.

It should be noted that these calculations are high level and specialist installers should be consulted to provide a better understanding of the property and its energy efficiency and electricity generation potential. They would also be able to provide a quote for installation, helping to better understand initial investment costs and potential payback periods.

There are also many funding opportunities for Scottish and UK businesses, charities, and community buildings, for example the Business Energy Scotland SME loan scheme, the Community and Renewable Energy Scheme (CARES), which can help with implementation costs for both energy efficiency and renewable heat strategies. Full detail on available funding streams can be found in the full feasibility report.

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