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Evaluation of a Solar PV Scheme

Final report prepared for the Northern Ireland Housing Executive

June 2021

Housing Executive

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Glossary of terms

The following paragraphs outline a number of key terms used in the main body of the report which require additional explanation.

Solar Photovoltaic

Solar electricity panels, also known as photovoltaics (PV), capture the sun's energy and convert it into electricity that can be used in the home. Solar PV cells are made from layers of semi-conducting material, usually silicon. When light shines on the material, electrons are knocked loose, creating a flow of electricity. Most PV systems are made up of panels that fit on top of a roof, but can also be installed on the ground, or as solar tiles. The electricity generated is direct current (DC), whereas the electricity used for household appliances is alternating current (AC). An inverter is therefore installed along with the system to convert DC electricity to AC.[1]

Kilowatts peak (kWp)

kWp is the peak power of a solar PV system or panel. Solar panel systems are given a rating in kilowatts peak (kWp) which is the rate at which they generate energy at peak performance, such as on a sunny day in the afternoon.

Monocrystalline, polycrystalline and hybrid solar panels

Solar panels come in three basic types, which differ in efficiency, appearance and cost:
1) Monocrystalline: made of thin slices of silicon, cut from a single crystal;
2) Polycrystalline: made from thin slices of silicon, cut from a block of crystals; and
3) Hybrid: combining crystalline cells with a thin layer of silicon on a glass or metal base. These tend to be the most efficient.[2]

Renewables obligation certificates (ROC) scheme

The Northern Ireland Renewables Obligation (NIRO) has been the main support mechanism for encouraging increased renewable electricity generation in Northern Ireland. It operates in tandem with the Renewables Obligations in Great Britain - the 'ROS' in Scotland and the 'RO' in England & Wales - in a UK-wide market for Renewables Obligation Certificates (ROCs) issued to renewables generators under the Obligations. The NIRO, like the Obligations in Great Britain, obliges electricity suppliers to produce a certain number of these ROCs for each Megawatt-hour (MWh) of electricity which they supply to their customers in Northern Ireland or to pay a Buy-Out fee that is proportionate to any shortfall in the number of ROCs being presented. The scheme closed to all new applications on 31st March 2017.[3]

[1] Energy Saving Trust, 'Solar panels', https://energysavingtrust.org.uk/advice/solar-panels/
[2] Centre for Sustainable Energy, 'Solar PV', https://www.cse.org.uk/advice/renewable-energy/solar-pv
[3] Department for the Economy, 'Northern Ireland Renewables Obligation', https://www.economy-ni.gov.uk/articles/northern-ireland-renewables-obligation

Rent-a-roof model

This was a third-party ownership arrangement used to facilitate installation of solar PV panels on domestic households in combination with the Northern Ireland Renewables Obligation. The most common arrangement was that the third party covered the upfront costs of installing solar PV panels on the property. The homeowner then receives the electricity generated (lowering their electricity bills) and the third-party owner of the installation receives any associated subsidies, in this instance, Renewables Obligation Certificates and export payments. Where an installation is owned by a rent-a-roof company, there is usually a signed 'agreement' between the relevant parties, i.e. the homeowner and the rent-a-roof company, such as a lease agreement, with the homeowner agreeing to rent their roof to the company for the purposes of installing solar PV panels. However, in this instance, the NIHE developed a bespoke agreement which equated to a license rather than a lease. [4]

Import, export and generation meter reading

Import/ export readings are taken from the meter installed by NIE Networks. The 'import' reading is the number of electricity units a household has imported/ used from the electricity network. The 'export' reading is the number of units generated through renewable sources that a household has been unable to use and therefore exports to the electricity grid to be used elsewhere. Generation readings are taken from the generation meter installed with the solar PV panels themselves. These recording the number of renewable electricity units generated by the panels.

Standard Assessment Procedure (SAP) ratings

The Standard Assessment Procedure (SAP) is the methodology used by the Government to assess and compare the energy and environmental performance of dwellings. Its purpose is to provide accurate and reliable assessments of dwelling energy performances that are needed to underpin energy and environmental policy initiatives. SAP was developed by the Building Research Establishment (BRE) for the former Department of the Environment in 1992, as a tool to help deliver its energy efficiency policies.[5]

Energy Performance Certificates (EPC) bands

Energy Performance Certificates (EPCs) show potential home buyers or tenants how energy efficient the building is. The EPC contains information on potential energy costs and carbon dioxide emissions. A coloured chart, similar to those used on household electrical appliances, shows how energy efficient the building is or could be. Buildings are rated from 'A' to 'G'. 'A' means the building is very efficient and is coloured green on the chart. 'G' means it is inefficient and is coloured red on the chart. Properties with a higher rating are likely to have lower fuel bills.[6]

Northern Ireland House Condition Survey

The Northern Ireland House Condition Survey is commissioned by the NIHE to provide a comprehensive overview of Northern Ireland's dwelling stock and its

[4] Ofgem, 'Third Party Ownership under the FIT scheme', https://www.ofgem.gov.uk/system/files/docs/2018/10/third_party_ownership_under_the_fit_scheme.pdf
[5] Gov.UK, 'Guidance: Standard Assessment Procedure', https://www.gov.uk/guidance/standard-assessment-procedure
[6] nidirect, 'Energy Performance Certificates,' https://www.nidirect.gov.uk/articles/energy-performance-certificates

occupants, including information about fuel poverty, disrepair, Decent Homes, the Standard Assessment Procedure (SAP), the Housing Health and Safety Rating System (HHSRS), unfitness, and household profiles. It was last conducted in 2016 and was due to be conducted again in 2021 but has been postponed until 2022 due to Covid-19 safety restrictions.

Executive summary

The following paragraphs summarise the background and approach taken to the present evaluation of a Northern Ireland Housing Executive Solar Photovoltaic (PV) Scheme. This is followed by a brief outline of the key findings under the main themes of the survey and areas for further consideration.

Background

In summer 2016 the Housing Executive (NIHE) completed a solar PV scheme in partnership with Saliis Ltd, to install solar panels into approximately 1,000 Housing Executive homes using private finance based on the "rent a roof" model. The scheme was the first solar PV project for residential properties in Northern Ireland. To evaluate the performance of the contract, the NIHE required research to be conducted to measure delivery against the following objectives:

Primary objectives

- To evaluate the 2016 Solar PV Panels pilot to assess the impact of Solar PV panels in relation to energy efficiency and ultimately whether or not they were effective in tackling fuel poverty and providing tenants with a way of saving money;
- To estimate the household savings on annual energy bills; and
- To investigate the benefits of using Solar PV Panels as a means of renewable electricity and the influence this may have on any future new build/adaptation schemes that the Housing Executive may wish to carry out.

Secondary objectives

- Ascertain the impacts of the Solar PV panels scheme and the overall effects it had on tenants' way of life; and
- Explore both wider economic benefits (i.e. savings to public purse) and non-monetary benefits resulting from the use of Solar PV Panels in future social housing design for new build schemes.

Methodology

Initially desk-based research in the form of a literature review was carried out to inform design of the research instruments. This was followed by qualitative research involving 10 depth interviews with key stakeholders. A survey was then conducted with NIHE households participating in the scheme. In total, 306 interviews were completed. A telephone interviewing methodology was used to conduct the survey. Interviewing took place between January and February 2021 with each interview taking, on average, 10 to 15 minutes to complete. In addition, 15 respondents were recontacted for a follow up interview to provide additional insight to the survey findings. Interviewing was carried out in compliance with the GDPR 2018 and the Market Research Society Code of Conduct. Generation and export meter reading

data obtained from Saliis Renewables was used to calculate estimated annual bill savings to tenants.

Conclusions and recommendations

Consultation and installation process

While the majority of those surveyed (55%) felt that the Housing Executive had sought their views fairly or very well about the scheme prior to installation and two thirds (65%) said that the Housing Executive had kept them fairly or very well informed about the installation process, the depth interviews indicated that consultation prior to installation had been minimal and that a letter sent to short-listed households had caused confusion in some cases. It was acknowledged by the Housing Executive, that if a future scheme should be commissioned, efforts would be made to better manage the expectations of households in respect of their selection for the scheme. It is suggested that improved face-to-face consultation by NIHE staff with short-listed households at the outset of the process would be beneficial to ensure tenant buy-in and allow tenants to raise any concerns or queries at an early stage.

Conversely, 97% of respondents were fairly or very satisfied with the installation process with only isolated reports of leaks. This finding aligns with the view widely stated in the literature and held by sector stakeholders that solar PV installation involves minimal disruption to householders.

Information provided about the panels

Just under half (46%) of respondents reported not having received any information or guidance from the Housing Executive about the solar panels, however this rose to 79% of respondents who had taken up their tenancy after the panels had already been installed. Overall, 46% said they would welcome further information with almost all of these (96%) wanting additional guidance on how to make the most of the panels to maximise their savings. This is consistent with the finding that under half (46%) of respondents feel fairly or very knowledgeable about how to make the most of the solar PV panels.

While the NIHE did provide an A5 leaflet and fridge magnet with useful “dos and don’ts” in respect of the panels to tenants at the time of install, it is again suggested that face-to-face instruction may be more impactful. Of those participants in the follow-up interviews who spoke about information received, it was usually in reference to a visit and demonstration from Saliis personnel rather than the Housing Executive. It is also suggested that follow-up reminders at intervals may be useful to support tenants to make money saving changes. There appears to be a particular shortfall in information and explanation provided to new tenants. It is suggested that additional checks are put in place to ensure that information and guidance on how best to use the panels are provided as standard at the beginning of any new tenancy in a property involved in the scheme.

Understanding of the panels and energy usage behaviours

Only 29% of respondents who were living at the property prior to installation reported having changed the way they use electricity since the panels were installed, while

over two thirds (70%) had not changed their energy usage behaviour. However, 76% of all respondents reported using large appliances during daylight hours rather than during the evening or at night which reflects positively on levels of understanding of how to benefit from the panels. At the same time, over a quarter (26%) still reported using the washing machine in the evening or at night. Despite evidence of energy usage behaviours which are consistent with best practice in respect of solar PV panels, analysis of generation and export data indicated that households are only utilising on average 29% of the solar PV electricity generated. This is somewhat below the 50% anticipated and indicates that improvement could be made, particularly in light of the finding that prior to the pandemic, 80% of survey respondents' households had at least one person at home during the day (8am to 4pm).

It is therefore suggested that any future solar PV installations should include a device to provide a visual prompt as to when the panels are generating electricity and, as such, when appliances should be used or turned off. These devices would assist householders to feel more informed and in control of their energy use and bill savings. It is further suggested that participating householders could be provided with information about how much electricity the panels are producing and how much of this they are utilising, again to reassure householders of the effectiveness of the panels and allow them to adjust their behaviours to maximise benefits.

Perceived savings and general satisfaction

Over two thirds (68%) of respondents felt that they are saving money on their electricity bill as a result of the solar panels. While 41% of those who felt they were saving were unable to estimate by how much, one quarter (24%) thought they were saving over £100 and 23% estimated the figure at between £51 and £100. Almost all (95%) of those that reported savings on their bill were satisfied with these savings. Over three quarters (78%) of all respondents were satisfied or very satisfied with their solar PV panels, compared to 8% who said they were dissatisfied or very dissatisfied. Again, a higher proportion of new tenants were dissatisfied or very dissatisfied with the panels than original tenants (13% compared to 6% respectively).

It is positive that the majority of those surveyed felt they were saving money on their energy bills, however it is concerning that almost a fifth (18%) of all respondents and almost a third (30%) of new tenants felt they were not making any savings. This perception could in part be due to the way in which solar panels function, as highlighted by the stakeholder interviews, in that the panels are generating electricity most effectively in the summer when financial stress due to fuel bills is lowest, and not producing in the winter when fuel costs are highest. It is noteworthy that interviewing for the study took place in January and February. However, as noted earlier in this section, it also appears that tenants, especially new tenants, could be better supported to improve their savings through behavioural change.

Effectiveness in tackling fuel poverty

An assessment of generation and export data for a sample of 655 properties, where the same tenant had lived in the property since installation, indicated that the following bill savings could be attributed to the panels:

Average estimated annual bill saving
£134.95

Median estimated annual bill saving
£123.54

The calculation did not account for changes in supplier or tariff pre- and post-installation or an overall increase in energy consumption due to a household change or misunderstanding of how the panels function; therefore these savings may not totally align with those actually experienced by householders before and after installation. It is suggested that the median value may be a more accurate indication of the saving actually experienced by most tenants when considering the distribution of savings across households (see figure 8.5.). It should also be noted that there was a considerable range in the savings calculated, with the minimum saving being £11.41 per year and the maximum saving being £362.05 per year. 16 households produced savings of under £50. Therefore, the effectiveness of the panels to address fuel poverty will vary significantly depending on householder behaviour and lifestyle. It was strongly suggested in the stakeholder interviews that any future scheme should include the installation of a hot water diverter to increase the savings to tenants through thermal storage, in a manner which does not require any specific action from individuals.

Considerations of equity and fairness

The scheme has been effective in targeting householders within the profile more likely to be impacted by fuel poverty as identified by the House Condition Survey (HCS) 2016, namely: those aged 65 and over (49% of survey respondents); households which include an individual with a long-term disability (63% of survey respondents); those not in work due to retirement, disability or unemployment (86% of survey respondents); and those with oil heating (54% of survey respondents). Of the 1007 addresses included in the scheme, 34% were located in the most deprived quintile of NI. However, it should be noted that, depending on the load-bearing capacity of the rafters, solar PV panels may not be suitable for older properties, and may not provide a viable solution for householders in energy inefficient older buildings. In addition, solar PV panels are only effective for particular roof orientations and issues of network capacity will limit the number of feasible installations in a locality. This gives rise to considerations of equity and fairness for social housing landlords and it is suggested that the NIHE give consideration to how any future business model for a scheme of this nature might include a method for redistributing the benefits; for example, a revenue stream that can be reinvested in other fuel poverty initiatives.

Going forward, the NIHE should also consider the installation of smaller solar PV systems on a greater number of roofs. The size of the arrays installed under the

scheme was largely dictated by the Renewables Obligation Certificates (ROCs) revenue stream and, as such, single-storey properties were generally chosen for participation in the scheme to accommodate PV systems of up to 4kWp. Such systems are substantially larger than required to deliver maximum bill savings to householders as they are unable to utilise a large portion of the units generated. Therefore, 2kWp or 2.5kWp systems could be used instead to reduce the strain on the electricity network and benefit more households.

Challenges for future solar PV deployment within NIHE dwellings

In the absence of a government support scheme, as was in place at the time of installation of the scheme under review, the NIHE will have to identify an alternative and viable business model for the financing of any future installations. This may include covering the initial outlay through existing capital budgets or borrowing at a low rate of interest. It may still be possible to attract third party investor interest through export revenues, however it was beyond the scope of this study to determine the feasibility of this approach. There is, however, an inherent conflict between monetisation of solar panels through exports, and the aim of addressing fuel poverty, as installing diverters or other technologies to enable storage of the solar generated electricity will reduce the amount exported to the network and therefore reduce the potential revenue stream from export payments. Another possible revenue model might include the NIHE's involvement in the energy market through demand side response should a sufficient number of panels be installed. However, it was beyond the scope of the present evaluation to determine if, at present, the infrastructure exists in respect of network capacity, to enable connections of domestic PV installations to the grid at the scale required. It is suggested instead that the installation of zero export installations is a more viable option.

Additional considerations for the NIHE

Given the resource implications for the current installer in terms of accessing export meter readings, it should be considered how this would be managed within any future scheme in the absence of a smart meter roll out in Northern Ireland.

Introduction

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Report structure

The report is structured as follows:

- Methodology;
- Literature review;
- Findings from stakeholder depth interviews;
- Findings from tenant survey and follow up interviews, to include
  - Experience of consultation and installation;
  - Information provided about the Solar PV panels;
  - Understanding of the Solar PV panels;
  - General experience of Solar PV panels; and
  - Impact of Covid-19;
- Estimated annual bill savings; and
- Conclusions and recommendations.

Throughout the report relevant findings from the follow up interviews with stakeholders and tenants will be used to supplement the findings of the survey.

Methodology

This section provides an overview of the approach taken in the design and implementation of the evaluation.

Desk-based research

Perceptive Insight carried out a detailed **review of existing literature** on the potential benefits and challenges of Solar PV Panels as a means of renewable energy. This included evaluations of similar schemes elsewhere in the UK and Europe as well as academic and policy literature. Findings from this phase of the research provided context for the development of topic guides to be used in the later qualitative consultations with stakeholders and design of the householder survey.

Case studies

The desk-based research was supplemented by write ups of comparable schemes to enable the NIHE to identify instances of best practice and opportunities for learning. Four case studies are included.

Qualitative research with stakeholders

Depth interviews of approximately 60 minutes in length were conducted with a range of **stakeholders** including representatives from NIHE, Housing Associations, DfE, Saliis Ltd, Action Renewables, and Renewable NI. These were conducted via video conferencing and telephone.

Topic guide and moderation

Perceptive Insight developed a topic guide for the interviews in collaboration with the NIHE project team. This document was used to guide the discussion and prompt key thought areas. The topic guide was based on the NIHE's terms of reference for the project and findings from the desk-based research. Interviews were audio-recorded with the full and informed consent of the participant.

Qualitative analysis

Upon completion of the in-depth interviews, thematic analysis was undertaken of the interview transcripts. This involved identification of key findings and common themes within the interview responses.

Estimating energy bill savings

At the outset of the research, Perceptive Insight intended to obtain pre- and post-installation import meter readings from householder energy suppliers and/ or the network operator (e.g. Power NI, SSE, NIE Networks) in order to estimate potential savings to tenants. However, it became apparent that this approach introduced a number of possible issues:

- Changes in consumption pre- and post- installation may have been due to changes in circumstances/ numbers living in household rather than the solar PV panels. To minimise the potential impact of this on the accuracies of

savings estimates, it was suggested that the sample should be limited to only those households with the same tenants pre- and post- installation;
- Concerns around securing a data sharing agreement between NIHE and NIE Networks or otherwise obtaining the consent of individual householders to access data in light of GDPR 2018 considerations. It was expected that these requirements could have considerable implications for the timeframe of the project and possibly a reduction in sample size given the historic nature of the data (i.e. pre 2015 in some cases); and
- Where NIE Networks were not able to access the property, readings would be estimated. Estimated readings cannot be included in analysis which may have impacted on sample size.

After initial enquiries with NIE Networks, it became apparent that it would not be possible to obtain sufficient import meter data during the timeframe of the project due to consent requirements. However, generation and export meter reading data could be obtained from Saliis for a significant proportion of the households included in the scheme. Export meters are not always installed in domestic properties and, as such, at the outset of the project it was not known that this data would be available. These readings were covered by a pre-existing data sharing agreement between the NIHE and Saliis. This data enabled a precise estimation of annual savings to tenants directly resulting from the solar PV panels themselves, by subtracting export figures from generation figures and converting to costs using an average electricity price per kWh for the time period covered.

Quantitative survey and interviews with householders

A quantitative survey was conducted with householders who had panels installed through the scheme.

Sample design

The NIHE project team initially provided Perceptive Insight with 1007 addresses of households which had participated in the scheme. Of these, 10 properties were not tenanted at the time of the survey and 3 had been sold, leaving 994 eligible contacts. In total, 764 of those eligible households included contact telephone numbers. Of these, 586 were for households where the tenant at the time of installation still resided, while for 178 the tenant had moved in since the installation was completed. Overall, 306 interviews were achieved.

Questionnaire design

The questionnaire was designed in collaboration with the NIHE project team. A short pilot was conducted prior to the main fieldwork commencing.

Follow-up interviews

As part of the quantitative tenant survey, respondents were asked if they would be willing to be re-contacted to participate in a follow-up interview to explore their survey responses in greater depth. **15 telephone depth interviews** were conducted with householders of approximately 20 minutes in length. Participants were selected with the aim of interviewing tenants from a range of demographic backgrounds (i.e.

family, pensioner, single person). Quotes from these interviews have been used to further illustrate the findings of the quantitative research.

Literature review

Background to the Northern Ireland Housing Executive

The NIHE is a public authority and independent body corporate under the Housing (Northern Ireland) Order 1981 and is Northern Ireland's single comprehensive regional housing authority.[7] As a public authority, the NIHE is also subject to Section 75 of the Northern Ireland Act 1998 which obliges it to carry out its functions having due regard to the need to promote equality of opportunity between certain specified groups of people.[8] The NIHE's statutory functions include;

- the regular examination of housing conditions and housing requirements;
- drawing up wide ranging programmes to meet housing needs; and
- administering Housing Benefit to the public and private rented sectors.

The NIHE also fulfils the role of Home Energy Conservation Authority (HECA) for Northern Ireland under the Home Energy Conservation Act 1995. Within this role, the NIHE has responsibility for supporting improvements in the energy efficiency of residential accommodation in the region, assessing the cost-effectiveness of possible energy conservation measures and the extent to which carbon dioxide emissions into the atmosphere would be decreased as a result of those measures.[9] These functions align with the NIHE's property purpose statement set out in its Corporate Plan 2017/18 – 2020/21, which is:[10]

'To ensure everyone has access to a quality home which is safe, affordable, warm and appropriate to their needs.'

The HECA functions are also related to outcomes 8 and 13 in the Northern Ireland Executive's Draft Programme for Government Framework 2016 – 2021 which are 'We care for others and help those in need' and 'We connect people and opportunities through our infrastructure' respectively.[11]

The NIHE's current energy strategy was designed in response to a number of key findings of the 2016 House Condition Survey (HCS) (published in 2018).[12] The HCS presented a comprehensive overview of Northern Ireland's dwelling stock and its occupants in 2016, including information about fuel poverty, disrepair, the Standard Assessment Procedure (SAP), the Housing Health and Safety Rating System

[7] Northern Ireland Housing Executive, NIHE, https://www.communities-ni.gov.uk/topics/housing/northern-ireland-housing-executive-nihe
[8] Northern Ireland Housing Executive, NIHE, 'Governing Legislation', https://www.nihe.gov.uk/About-Us/Corporate-Governance/Governing-Legislation
[9] Home Energy Conservation Act 1995, Section 2, https://www.legislation.gov.uk/ukpga/1995/10/section/2
[10] Northern Ireland Housing Executive, NIHE, 'Corporate Plan 2017/18 – 2020/21' https://www.nihe.gov.uk/Documents/Other-Key-Documents/corporate-plan-2017-2021.aspx
[11] Northern Ireland Executive, 'Draft Programme for Government Framework 2016 – 2021', https://www.northernireland.gov.uk/sites/default/files/consultations/newnigov/draft-pfg-framework-2016-21.pdf
[12] Northern Ireland Housing Executive, 'House Condition Survey Main Report' (2016) https://www.nihe.gov.uk/Documents/Research/HCS-2016-Main-Reports/HCS-Main-Report-2016.aspx

(HHSRS), unfitness, and household profiles. The main objectives of the NIHE Energy Strategy include:[13]

- To achieve substantial progress towards a 34% improvement in the energy efficiency of the housing stock in Northern Ireland over a ten-year period;
- To substantially improve the energy rating (SAP rating)[14] of the Northern Ireland dwelling stock;
- To ensure that energy conservation measures are included in all refurbishment work carried out, as far as is practical;
- To take the needs of vulnerable groups into account when developing financial incentives, promotions and advice campaigns; and
- To develop a co-ordinated approach to the promotion of energy efficiency of the housing stock.

These objectives align with those of the Department for Communities' Warmer Healthier Homes: Fuel Poverty Strategy under the key activities of improving the energy efficiency of vulnerable households and facilitating the achievement of affordable energy for households in Northern Ireland.[15] Activities under the Strategy include the testing of renewable and innovative technologies in Housing Executive homes, as well as administering programmes such as the Affordable Warmth Scheme which offers a grant aid to eligible low-income households to install a range of energy efficiency measures.[16]

The current solar PV scheme under evaluation also aligns with the objectives of the strategy. An initial in-house assessment, measuring the outcomes of the scheme, was carried out by the Sustainable Development Unit. However, the results from this exercise identified the need for a more robust evaluation process to investigate the impact of the scheme on tenants, estimated savings on annual household energy bills and better understand the wider benefits of using solar PV panels in future NIHE new build or adaption schemes.

Wider policy context

Transition to net zero carbon emissions

In 2019, the UK became the first major economy to set a target of 'net zero' carbon emissions by 2050.[17] Renewable energy and low-carbon technologies will play a vital role in the response. In November 2020, the UK Government set out its 'Ten Point Plan for a Green Industrial Revolution'.[18] Point 7 of the plan referred to creating

[13] Northern Ireland Housing Executive, NIHE, 'Energy', 'https://nihe.gov.uk/About-Us/Corporate-Strategies/Energy'
[14] SAP (Standard Assessment Procedure) is a way of reliably estimating the energy efficiency of a home. It has been adopted by the UK government as part of the national standard for calculating the energy performance of buildings. It is calculated by a procedure, specified in Building Regulations which predicts heating and hot water costs.
[15] Department for Communities, 'Warmer healthier homes: A new fuel poverty strategy for Northern Ireland' (March 2011) p.19, https://www.communities-ni.gov.uk/sites/default/files/publications/dsd/warmer-healthier-homes.pdf
[16]Northern Ireland Housing Executive, NIHE, 'Energy efficiency and sustainability', https://www.nihe.gov.uk/Working-With-Us/Research/Energy-efficiency-and-sustainability
[17]Gov.UK, 'UK becomes first major economy to pass net xero emissions law' (27 June 2019) https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law
[18]HM Government, 'The Ten Point Plan for a Green Industrial Revolution' (November 2020) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

'greener buildings'[19] which set out plans for the electrification of heating and the timely implementation of the Future Homes Standard which will require new build homes in England to be future proofed with low carbon heating and world-leading levels of energy efficiency by 2025.[20] The Plan also included the expansion of the UK Green Homes Grant under which homeowners and residential landlords in England (including local authorities and housing associations) could apply for a voucher toward the cost of installation of a range of energy efficiency and low carbon heating measures (notably solar PV is not covered by the scheme).[21] The scheme has subsequently been withdrawn.[22] The UK Government also recommitted to the Social Housing Decarbonisation Fund under which local authorities across the UK can bid for funding to use innovative approaches to retrofitting social housing at scale. The scheme encourages a fabric-first approach although other solutions will also be considered.[23] The UK Government supplemented its 'Ten Point Plan' with an energy white paper[24] in December 2020 which stated a number of key commitments including:

- consulting on whether it is appropriate to end gas grid connections to new homes being built from 2025, in favour of clean energy alternatives; and
- growing the installation of electric heat pumps, from 30,000 per year to 600,000 per year by 2028.

As energy policy and the independent regulation of energy companies are devolved matters, the Department for the Economy is currently developing a new energy strategy for Northern Ireland which will set out the path to decarbonise the energy sector by 2050. It is due to be published at the end of 2021.[25]

The social housing sector accounts for around 17% of all homes in the UK and therefore represents a sizeable opportunity to contribute towards this emissions goal.[26] However recent findings have suggested that the sector is not responding at the pace required to make 2050 targets a reality. A study by Sustainable Homes found that 'homes continue to be built to standard building regulations and there is insufficient upgrading to reduce the risks of fuel poverty or CO2 emissions to safe levels by 2050' and 'long-term strategies that pave the way to making homes

[19] Ibid. pg. 20.
[20] Ministry of Housing, Communities & Local Government, 'Consultation Outcome The Future Homes Standard: changes to Part L and Part F of the Building Regulations for new dwellings' (January 2021) https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings
[21] Gov.UK, 'Green Homes Grant: make energy improvements to your home' (28 August 2020) https://www.gov.uk/guidance/apply-for-the-green-homes-grant-scheme#what-the-voucher-can-be-used-for
[22] The Guardian, 'UK government scraps green homes grant after six months' (27 March 2021) https://www.theguardian.com/environment/2021/mar/27/uk-government-scraps-green-homes-grant-after-six-months
[23] Department for Busines, Energy & Industrial Strategy, BEIS, 'Social Housing Decarbonisation Fund Demonstrator Questions and Answers' (October 2020) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/929239/shdf-demonstrator-q-a-version-2.pdf
[24] Gov.UK, 'Energy white paper: Powering our net zero future' (accessible HTML version)' (18 December 2020) https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future/energy-white-paper-powering-our-net-zero-future-accessible-html-version#overview-of-key-commitments
[25] Department for Economy, 'Northern Ireland Energy Strategy 2050', Northern Ireland Energy Strategy 2050 | Department for the Economy (economy-ni.gov.uk)
[26] Sustainable Homes, 'Housing 2050: How UK social housing can meet the challenge of climate change' (2018) pg. 2, https://omghcontent.affino.com/AcuCustom/Sitename/DAM/114/Housing_2050.pdf

prepared for 2050 do not exist, despite being within the reach of most landlords' financial planning cycle.'[27]

For a number of reasons, Solar PV technology may be an attractive element for social landlords to include in long term strategies alongside deep retrofit schemes focused on fabric first and low-carbon heating. A typical domestic Solar PV installation (3.5kWp) will save approximately 1 tonne of carbon dioxide per year in the South of England or 0.8 tonnes per year in Scotland.[28] Panels can be added to existing housing stock with minimal disruption to the tenant[29] and while it may still be considered expensive (a typical domestic PV 4kWp system costs approximately £4,000), the capital costs have reduced significantly over the past decade. In addition, the annual output from a solar PV system is reasonably predictable, therefore providing an easily measurable contribution to carbon reduction efforts.[30] Furthermore, solar PV systems require little maintenance with a system lifetime of 25 years and a 0.50% decrease in efficiency each year. It is expected that the inverter, which converts DC current to AC, will be replaced twice during this period at a cost of around £800 each time.[31] Yet, only around 3% of Northern Ireland's housing stock are currently fitted with solar PV panels.[32]

Given the above, Solar PV may present an opportunity to meet minimum Standard Assessment Procedure (SAP) ratings targets for existing housing stock in Northern Ireland. The SAP is the Government's standard method for rating the energy efficiency of a dwelling. Recent research has stated that housing stock will have to meet an average SAP rating of 86 (EPC Band B) by 2050 if government carbon targets are to be met.[33] The overall SAP rating for Northern Ireland in 2016 was 65.83.[34] The NIHE has modelled how a range of typical fabric first and low carbon heating measures would impact on the general SAP rating, as outlined in the table below. If all of the suggested measures were to be adopted, this would increase the SAP rating to 73.8 or EPC Band C.[35] Solar PV installation may therefore be vital to provide the necessary points to improve suitable properties to a Band B level.
Mean SAP reading base 65.8

Scenario Heating 1
Dwellings with central heating are given a condensing boiler, if one is not already installed.
Mean SAP rating 71.3.

[27] Ibid. pg. 3.
[28] Energy Saving Trust, 'Generating renewable energy, Solar panels, https://energysavingtrust.org.uk/advice/solar-panels/
[29] Changeworks and Eaga Charitable Trust, 'Using solar PV to Tackle Fuel Poverty: Final Report' (February 2014) pg. 22, Executive Summary (changeworks.org.uk)
[30] Changeworks and Eaga Charitable Trust, 'Using solar PV to Tackle Fuel Poverty: Final Report' (February 2014) pg.22, Executive Summary (changeworks.org.uk)
[31] Energy Saving Trust, 'Generating renewable energy, Solar panels', https://energysavingtrust.org.uk/advice/solar-panels/
[32] Sean MacIntyre, 'Examining the Utility and User Experience of Solar PV at 55 Degrees North - unpublished presentation (Ulster University 2020) https://pure.ulster.ac.uk/en/publications/the-utility-of-solar-photovoltaic-panels-at-55-degrees-north-sola
[33] Sustainable Homes, 'Housing 2050: How UK social housing can meet the challenge of climate change' (2018) pg. 8, https://omghcontent.affino.com/AcuCustom/Sitename/DAM/114/Housing_2050.pdf
[34] Housing Executive, 'House Condition Survey Summary Report' (2016) https://www.nihe.gov.uk/Documents/Research/HCS-2016-Main-Reports/HCS-Main-Report-2016.aspx
[35] Home Energy Conservation Authority, 'Annual Progress Report' (2019) https://www.nihe.gov.uk/Documents/News/Home-Energy-Conservation-Authority-Annual-Progress.aspx?ext=

Scenario Heating 2
Dwellings with non-central heating are given central heating with a condensing boiler.
Mean SAP rating 66.4

Scenario Heating 3
Combines heating scenarios 1 and 2.
Mean SAP rating 71.9.

Scenario Insulation 1
Dwellings with unfilled cavity walls (partial or full) with a U-value of > 0.6 W/m2K are given cavity wall insulation.
Mean SAP rating 66.3.

Scenario Insulation 2
Dwellings with lofts and <= 150mm of loft insulation are given 270mm of loft insulation.
Mean SAP rating 66.5.

Scenario Insulation 3
Combines insulation scenario 1 and 2.
Mean SAP rating 67.0.

Scenario Double glazing
Dwellings with single glazing, or pre-2006 double glazing, are improved to modern double glazing, with a U-value of 1.6 W/m2K.
Mean SAP rating 67.2.

Scenario All
Combines heating scenario 3 with insulation scenario 3 and double glazing, to give dwellings all appropriate heating and insulation measures.
Mean SAP rating 73.8.

Sourced: Home Energy Conservation Authority Annual Progress Report 2019

Tackling fuel poverty

A further policy objective behind the deployment of solar PV technology in social housing is to reduce incidence of fuel poverty. In Northern Ireland, a household in fuel poverty is defined as one which spends in excess of 10% of its household income on all heating and electric bills. The three factors which determine fuel poverty are:[36]

- Fuel prices;
- Energy consumption (based on energy efficiency); and
- Household income.

[36] Ibid.

Using this definition, the 2016 HCS estimated that approximately 22% of households (160,000) were living in fuel poverty.[37] This marked a 20% reduction from 2011 levels. In light of an ongoing programme of work to improve the energy efficiency of the NI housing stock, the NIHE commissioned the Building Research Establishment (BRE) to undertake a further evaluation in 2018 of the factors outlined above. This evaluation concluded that there had been a further reduction in the number of households in fuel poverty, to 18% (131,000 households.)[38] While the proportion of households in Northern Ireland experiencing fuel poverty has been steadily decreasing over the past decade, addressing this area remains a strategic priority for the NIHE. The HCS 2016 included the following findings:[39]

- low income is a significant cause of fuel poverty in Northern Ireland (55% of households with an annual income of less than £10,399 were in fuel poverty);
- 78% of all households in fuel poverty had incomes of £15,599 per annum or less;
- more than half (52%) of households living in older dwellings (pre 1919) were in fuel poverty;
- one-third (34%) of households living in small villages, hamlets or open country areas were in fuel poverty;
- almost two-fifths (38%) of households headed by an older person (75 plus) were in fuel poverty and one-third (34%) of older household types were fuel poor;
- fuel poverty was higher in households with reference persons who were unemployed (32%) or retired (31%);
- rates of fuel poverty were highest in households living in bungalows (28%) , followed by detached (26%) and then terraced and semi-detached houses (both 19%); and
- a quarter (25%) of households with oil central heating were in fuel poverty compared to 9% of those with mains gas central heating.

Solar PV converts sunlight into electricity. When installed onto a domestic property, this electricity can either be a) used by the household, or b) exported to the national grid. Unless additional technology is added to the system, generated electricity cannot be stored and therefore must be used immediately. The electricity generated from a Solar PV system is free to use for the household while imports from the national grid will be charged at the normal rate. Therefore, a household can lower its electricity costs by using that generated by the panels and reducing its reliance on imports from the grid. In this way, Solar PV can be an effective tool in reducing incidence of fuel poverty. Previous studies have observed that social housing tenants tend to under-heat their homes in order to avoid high heating bills. The effect of solar PV in lowering electricity costs may also enable households to devote more income to heating their homes adequately.[40]

[37]Housing Executive, 'House Condition Survey Summary Report' (2016) pg. 57, https://www.nihe.gov.uk/Documents/Research/HCS-2016-Main-Reports/HCS-Main-Report-2016.aspx

[38] BRE, 'Estimates of fuel poverty in Northern Ireland in 2017 and 2018' (May 2019) https://www.nihe.gov.uk/getmedia/1f9e55a1-66c2-46b7-bf92-9ee192ce355f/estimates-of-fuel-poverty-northern-ireland-2017-and-2018-revised.pdf.aspx?ext=.pdf

[39] Housing Executive, 'House Condition Survey Summary Report' (2016) p.58, https://www.nihe.gov.uk/Documents/Research/HCS-2016-Main-Reports/HCS-Main-Report-2016.aspx

[40] Joseph Rowntree Foundation, 'Renewable energy: getting the benefits right for social housing' (October 2012) https://www.jrf.org.uk/report/renewable-energy-getting-benefits-right-social-housing

Potential limitations

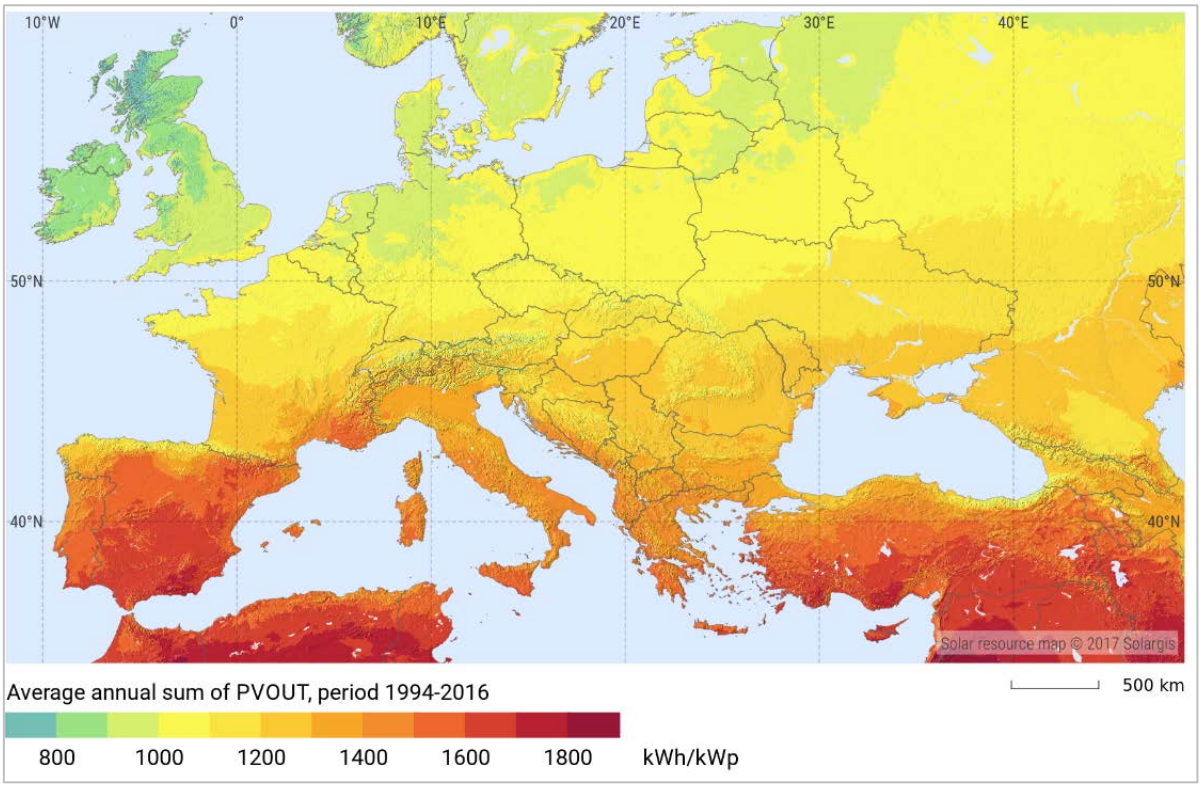
There are, however, a number of possible drawbacks or limitations to the usefulness of Solar PV installations in relation to fuel poverty and the green energy transition.

Factors affecting PV output

Firstly, the size of the system will have a significant impact on the level of generation. This will largely depend on the size of available roof space and, depending on the funding model, capital costs. A roof area of 10 to 20 m^2 is generally sufficient to deliver between 20% and 45% of the typical household's electricity needs, with the average size of domestic solar PV system being 3.5kWp.[41] The average size for the scheme under review was 3.75kWp.

Secondly, the energy output of PV is dependent on the amount of sunlight[42] striking the panels, which varies daily and seasonally, and can be impacted negatively by nearby buildings, trees or chimneys shading a roof. Ideally panels should be installed on a south facing roof at a pitch angle of 30 – 40 degrees.[43] The geographical location of a solar panel will also have a significant impact on its electricity production due to varying amounts of solar radiation at different latitudes. For example, the Energy Saving Trust estimates that a 3.5kWp in the south of England will generate around 3,700 kWh of electricity a year, with the same system in Scotland generating around 2,850 kWh annually.

Figure 1.1. Photovoltaic power potential Europe



Sourced: Solargis

[41] Energy Saving Trust, 'Generating renewable energy, Solar panels', https://energysavingtrust.org.uk/advice/solar-panels/

[42] Solar PV panels operate at maximum production when absorbing direct sunlight, but can harness both sunlight ('direct light') and daylight ('diffuse light'). In diffuse light on a cloudy day, however, they will not operate at maximum production. (https://solarshare.ie/articles/do-solar-panels-work-on-a-cloudy-day/)

[43] Ibid.

Proportion of solar PV-generated electricity used within the home

The potential savings for a household in fuel poverty will depend on maximizing the proportion of solar generated electricity utilised by the household and minimizing the proportion imported from the electricity network. As the solar PV panels themselves cannot store electricity, this will largely depend on the demand for electricity when it is being generated, i.e. during daylight hours. Published savings estimates are often based on the assumption that a household will typically consume 50% of the PV output,[44] however this is likely to vary considerably depending on the size of the panels, profile of the householder and their understanding of how the panels function.

Where a householder is not at home during the day, this will considerably limit their opportunity to use the electricity as it is generated. The table below demonstrates the considerable variation in potential savings depending on the lifestyle of an occupant.

Figure 1.2. Variation in percentage utilised and potential savings from 4kWp domestic Solar PV installation in Belfast (based on 30 degree angle and 16.36 p/kWh)

Scenario	% Used	Potential annual fuel bill saving
Home all day	42%	£234
Home in the mornings	33%	£186
Home in the afternoons	30%	£168
Out all day until 4pm	21%	£116
Out all day until 6pm	17%	£97

Sourced: Energy Saving Trust Solar Energy Calculator

The proportion of solar generated electricity used by the households can be increased through behavioural changes based on an understanding of how the panels work, or through the addition of storage technologies such as batteries or a hot water diverter.

Behavioural changes

The most straightforward way to increase household energy savings from solar generated electricity is through encouraging the use of larger appliances during daylight hours, rather than in the evening or at night. This may be facilitated through the use of timers for those who are not at home during the day. At the same time, householders should avoid using larger appliances simultaneously as consumption can exceed that being generated and, likewise, avoid increasing overall electricity consumption.[45]

In the context of social housing, there is therefore an education piece for social landlords to ensure tenants receive the greatest benefit from a solar panel scheme. However, in a review of social housing energy efficiency schemes in 2012 by the

[44] Savings estimates for the pilot scheme under evaluation were based on 50% utilization.
[45] Energy Saving Trust, 'Generating renewable energy, Solar panels', https://energysavingtrust.org.uk/advice/solar-panels/

Joseph Rowntree Foundation (JRF), it was found that many social landlords did not have the time or resources to educate tenants adequately about how to maximize benefits.[46] Subsequent research has shown that beneficiaries of solar PV schemes are often not aware of best practice to maximize savings.[47] In this instance, Changeworks responded by creating an information leaflet for tenants giving clear and simple advice on how to get the most out of solar PV panels.

Particularly in respect of retrofit programmes, JRF has suggested that tenant consultation at the outset of planning is also important to ensure a positive response to such schemes. Tenants may have different priorities to those of the social landlord, including concerns around more 'noticeable' issues that require improvement within their homes.[48] Wider consultation to include community groups may be appropriate depending on the scale of the project and conflicting interests. There are a considerable range of engagement activities available which can be tailored to the circumstances.[49]

Sharing information with people

- Emails and newsletters
- Letters
- Phone calls
- Print and online announcements
- Existing events or meetings

Bringing people together

- One-on-one meetings
- Small or large group meetings
- Public meetings
- Webinars

Structured stakeholder gatherings

- Facilitated discussion
- Focus groups
- Workshops
- Negotiation
- Mediation
- Consensus building

Storage and additional technologies

Studies have shown an increasing interest in emerging technologies such as battery storage and smart appliances to combine with solar PV. However, markets are still immature and as such not financially viable for many social landlords.[50] For example, a 4kWh battery costs approximately £5,000 and will likely have to be replaced at

[46] Joseph Rowntree Foundation, 'Monitoring poverty and social exclusion 2012' (26 Nov 2012), p.35, https://www.jrf.org.uk/report/monitoring-poverty-and-social-exclusion-2012

[47] https://www.changeworks.org.uk/sites/default/files/Using_Solar_PV_to_Tackle_Fuel_poverty_case_study.pdf

[48] Joseph Rowntree Foundation, 'Monitoring poverty and social exclusion 2012' (26 Nov 2012), p.46, https://www.jrf.org.uk/report/monitoring-poverty-and-social-exclusion-2012

[49] Sol Smart, 'Solar energy: Solsmart's toolkit for local governments' https://solsmart.org/solar-energy-a-toolkit-for-local-governments/stakeholder-engagement/

[50] Sustainable Homes, 'Housing 2050: How UK social housing can meet the challenge of climate change' (2018) p.12, https://omghcontent.affino.com/AcuCustom/Sitename/DAM/114/Housing_2050.pdf

least once during the 20-year lifespan of the panels. Batteries are largely still at trial stage with the example of the Girona Project in Northern Ireland.[51] Through the project, a Sonnen SB10 battery will be installed alongside wind or solar generation in Northern Ireland homes. The SB10 is supported by an app that will allow the household to monitor its electricity generation and consumption and see how much is being saved on bills. In nearly all cases, the battery will be mounted outside the property inside a protective cabinet. The Project estimates a saving of 40% on current electricity bills.

A fully-charged medium-sized system could store sufficient energy to power lights and lower-powered items like the fridge-freezer, TV and laptop during the evenings. Over four or five hours, all of these together will use very few kWh of electricity. However, the battery will quickly run out if heavy energy users like the washing-machine or tumble-dryer are put on. These can consume 2 - 3kWh in a single use. And in winter, the battery might not store enough to provide for even the lower-powered items for many hours.[52]

Trials have also been conducted for Solar PV ready radiators. Two Solar PV Ready Radiators operating in conjunction with a smart control device that can divert excess electricity generated from Solar PV were installed in 27 households. The trial found that adding the radiators increased self-consumption by 42% although notably the sample was small.[53] Hot water diverters are a much more affordable and established technology and will be discussed later in the case study section.

Financing

Northern Ireland Renewables Obligation

Like many other renewables, solar PV is very capital intensive with low operating costs. The high up-front cost is one of the barriers to investing in solar. In addition to this, the benefits or revenues are spread out over 20 years or more. Over the last ten years European solar markets have been largely policy driven – determined not by the solar irradiation resource but by the regulatory frameworks and support schemes available.[54] Business models have been dictated by the support schemes, with revenues being guaranteed by the state and therefore generally considered low risk.[55] Within UK social housing, investment in renewable electricity has plateaued or declined in the absence of funding.[56]

The Solar PV programme under evaluation benefitted from the Northern Ireland Renewables Obligation (NIRO) which ran from 2005 and closed to new applicants in March 2017. All projects already accredited under the scheme will continue to benefit

[51] Girona, 'What is project Girona?', https://gironaenergy.com/what-is-project-girona/
[52] BRE, 'Batteries and Solar Power: Guidance for domestic and small commercial consumers' (2016) p.4 https://www.bre.co.uk/filelibrary/nsc/Documents%20Library/NSC%20Publications/88166-BRE_Solar-Consumer-Guide-A4-12pp-JAN16.pdf
[53] Delta-ee, 'EHC Solar PV Ready Radiator Trials- Final Report on final results' (2017) https://www.delta-ee.com/downloads/30-consultancy-downloads/1521-ehc-solar-pv-ready-radiator-trials.html
[54] SolarPowerEurope, 'EU-wide Solar PV Business Models: Guidelines for Implementation' (November 2016) p.10, https://www.solar-trade.org.uk/wp-content/uploads/2017/01/EU_Implementation_Guidelines_PVF_D4.4_LOW_RES.pdf,
[55] Ibid.
[56] Sustainable Homes, 'Housing 2050: How UK social housing can meet the challenge of climate change' (2018) p.12, https://omghcontent.affino.com/AcuCustom/Sitename/DAM/114/Housing_2050.pdf

for 20 years from accreditation or until March 2037. The NIRO placed a legal requirement on all Northern Ireland licensed electricity suppliers to provide Ofgem (on behalf of the Northern Ireland Authority for Utility Regulation (NIAUR)) with evidence that a specified quantity of electricity supplied to final consumers was accounted for by generation from renewable sources.[57] Compliance with the Obligation is evidenced by Northern Ireland Renewables Obligation Certificates (NIROCs) which are issued free of charge by Ofgem to electricity generators for each MWh of eligible renewables generation.

The scheme created a financial incentive for developers to invest in renewables as accredited generators can sell ROCs directly to electricity suppliers or via an agent. ROCs are issued for every MWh generated regardless of whether the electricity is used on site, exported to the grid or a combination of both.[58] ROCs are tradeable commodities that have no fixed price, but value is linked to a 'buy-out' penalty that must be paid by any supplier who fails to meet their renewables obligation.[59] The number of ROCs issued to each generator is determined by the type of technology it uses and the amount of electricity it generates. Each renewable technology falls under a 'banding level' indicating the number of ROCs issued for each MWh generated by that technology. These bands were reviewed by Government at intervals to reflect market conditions and sector innovation. When banding levels changed, existing accredited generators remained on the previous banding level. At the time when the NIHE scheme was accredited, a generator received 3 ROCs per MWh.[60] Any new NIHE solar PV scheme would not benefit from the NIRO and no equivalent revenue stream is currently in place.

Export revenue

Any electricity generated which is not used by the householder is exported to the national grid which provides another possible source of revenue. As wholesale electricity prices are considerably lower than retail prices and subject to market forces, the value to an individual householder of using the electricity generated far exceeds that of revenue from exports. However, at scale, this provides an additional revenue stream for investors. To illustrate, a 4kWp system would typically produce approximately 3,500 kWh per annum. If it is assumed that a household uses approximately 50% of the electricity generated and the wholesale electricity price is 5 pence per unit (approximate current rate), this would come to £87.50 for each household annually. A deemed export regime was introduced by NIE Networks in 2015 as a way of paying micro-generators for generated power not consumed on site in the absence of readily available export data. The deemed rate was set at 45%. This changed in 2017/18 requiring generators to submit actual metering data. In the absence of smart meters, these readings must be physically collected creating

[57] DfE, 'Northern Ireland Renewables Obligation – How it works' (2017) https://www.economy-ni.gov.uk/sites/default/files/publications/economy/NIRO-how-it-works.pdf
[58] Ibid.
[59] Department of Energy & Climate Change, 'Policy Paper 2010 to 2015 government policy: low carbon technologies (2015) https://www.gov.uk/government/publications/2010-to-2015-government-policy-low-carbon-technologies/2010-to-2015-government-policy-low-carbon-technologies#appendix-5-the-renewables-obligation-ro
[60] Ofgem, 'Renewables Obligation Guidance for Generators', p.71, https://www.ofgem.gov.uk/system/files/docs/2019/04/ro_generator_guidance_apr19.pdf

a substantial burden on stakeholders with a sizeable portfolio of domestic properties.[61]

Approaches elsewhere

In Great Britain, the Feed-in Tariffs scheme replaced the Renewables Obligation for Solar PV small-scale renewable generation in 2010. The scheme was not extended to Northern Ireland. Under the scheme, licensed electricity suppliers were required to make payments on both generation and export from eligible installations. Payment levels were set and guaranteed by government for a period of up to 25 years, paid for by a levy on all consumer electricity bills. Tariff rates were adjusted annually for new applicants in line with the Retail Prices Index.[62]

The scheme closed to new applications in March 2019 and was replaced by the Smart Export Guarantee, which came into force in January 2020. In this instance, payments are only required for electricity exported to the grid by small-scale renewable generators. Licensed suppliers determine the rate they will pay, the contract length and other terms, however whilst wholesale electricity prices can sometimes fall below zero, licensees must always offer a tariff that remains above zero. Payments must be calculated by reference to actual Export Meter Readings.[63] Again, the scheme does not apply to Northern Ireland, given the administration difficulties created by the absence of smart meter roll-out in the region.[64]

In the absence of any current statutory funding schemes for solar PV installation in Northern Ireland, an alternative financing or business model would be required for a future NIHE scheme of this scale. It is unclear at time of writing whether any new governmental support schemes are envisaged to incentivise the adoption of small-scale renewable generation. As an alternative to schemes which guarantee payment for energy generated and/or exported, grants for solar PV installation are another possible option. In the Republic of Ireland, a Solar Electricity Grant is currently available for small-scale generators. At present a €900 per kWp rebate is currently available for systems up to 2kWp or, if a battery is included, an additional €300 per kWp up to 4kWp with an additional €600 available towards the battery cost.[65]

Case studies

This section sets out a number of case studies involving similar schemes or housing types at similar latitude which have been undertaken or are currently underway elsewhere. It should be noted that there was very limited publicly available information about comparable schemes, with most savings estimates being projected rather than actual. There appear to be few published evaluations of the type undertaken for this project.

[61] Pinsent Masons, 'Northern Ilrenad to end micro-generation 'deemed export' regime' (March 2018) https://www.pinsentmasons.com/out-law/news/northern-ireland-micro-generation-deemed-export-regime
[62] Ofgem, 'About the FIT scheme', https://www.ofgem.gov.uk/environmental-programmes/fit/about-fit-scheme
[63] Ofgem, 'About the Smart Export Guarantee (SEG)' https://www.ofgem.gov.uk/environmental-programmes/smart-export-guarantee-seg/about-smart-export-guarantee-seg
[64] Northern Ireland Electricity Networks, 'Meter Replacement Programme', https://www.nienetworks.co.uk/meterupdate
[65] Sustainable Energy Authority Of Ireland, 'Solar Electricity Grant', https://www.seai.ie/grants/home-energy-grants/solar-electricity-grant/

Case study 1[66]
Location Denmark
Panel size 0.9 - 6 kWp (Total 750 kWp)
Project description
Solar PV panels were mounted on the roofs of 264 privately-owned single-family properties at eight geographical locations around Denmark as part of the SOL-300 retrofit project (2000 – 2001). The project was mostly government funded with homeowners covering 25% of the upfront costs. The panels were positioned for optimal orientation, that is, to face due south at an angle of 45 degrees. The scheme used a mix of monocrystalline and polycrystalline solar panels. The SOL-300 houses were equipped with a PV meter which showed the system's electricity production and the household's purchase and sale of power. The PV meter provided had coloured diodes to indicate when appliances should be used or turned off in order to produce savings benefits and was located centrally within the household. It was found that the panel installation had an indirect impact on the consumption behaviour of the households involved, leading to an average reduction in total electricity consumption of 11-12 % per household. The table below compares the performance of the mono- and polycrystalline modules from generation data collected from panels at various locations indicated by the area code.

Figure 1.3. Generation per kWp for a selection of solar PV system (Denmark)

Area	Capacity (kWp)	Module type	Specific production 2001 (kWh/kWp)	Specific production 2002 (kWh/kWp)	Specific production 2003 (kWh/kWp)	Specific production average (kWh/kWp)
1	3.00	Poly	651	723	414	596
1	2.25	Poly	708	683	692	694
2	1.80	Poly	803	842	624	756
2	2.70	Poly	863	859	800	841
2	0.90	Poly	776	834	733	781
6	2.16	Poly	795	785	864	815
6	1.92	Poly	883	961	1,007	950
6	2.88	Poly	840	911	923	891
4	2.04	Mono	715	760	817	764
4	3.06	Mono	827	868	961	885

Sourced: EnergiMidt Ltd., 'Optimisation of Design of Grid-Connected PV Systems under Danish Conditions' (2009)

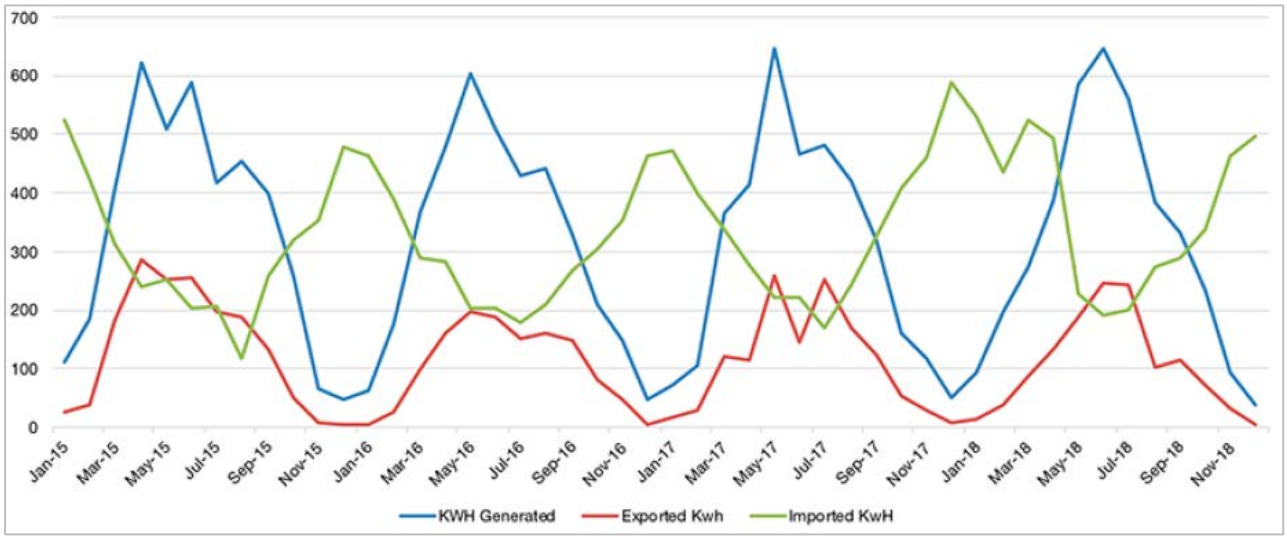
Case study 2[67]
Location Scotland and Wiltshire, England
Panel size 2.4kWp average
Project description
In 2014, Changeworks conducted an evaluation of solar PV installation by a number of social landlords. The evaluation included a survey with 122 tenants. As export meters had not been installed in the properties included in the scheme, bill saving

[66] PV Database, 'BI PV Urban Scale Project Details', http://www.pvdatabase.org/urban_view_detailsmore.php?ID=27
[67] https://www.changeworks.org.uk/sites/default/files/Using_Solar_PV_to_Tackle_Fuel_poverty_case_study.pdf

estimates were calculated according to pre- and post- installation import meter data sourced from energy suppliers. Changeworks encountered significant challenges in obtaining sufficient data by this method, and as such a sample of only 72 households was included in the final data analysis in respect of savings. It was assumed that any reduction in energy consumption pre- and post-installation was due to the PV system, however this could instead have been due to reduced consumption brought about by changes in household occupancy or in response to income changes. On average, the panels produced 805 kWh per installed kWp but this ranged considerably: from 353kWh to 1037kWh. In carrying out estimated savings calculations, any households that appeared to have utilised more than 75% of the electricity generated were excluded from the sample. It was concluded that the average annual bill saving was £90 per year or £38 per year per installed kWp, which constituted an average bill reduction of 8%. The average proportion of PV generated electricity utilised was 32%.

Case study 3[68]
Location Northern Ireland
Panel size 5kWp
Project description
It has been shown that a 5kWp system in Northern Ireland will generate sufficient electricity to meet household needs typically between the months of March and September. Households are still reliant on the electricity network during this period because generated electricity cannot at present be stored without the introduction of energy storage technologies, therefore electricity requirements when the sun is not shining will be met by imports from the grid. However, the study is helpful in illustrating the utility of solar PV installation at Northern Ireland's latitude.

Figure 1.4. Solar PV 5.3 kWp System Household Electricity Generation and Import

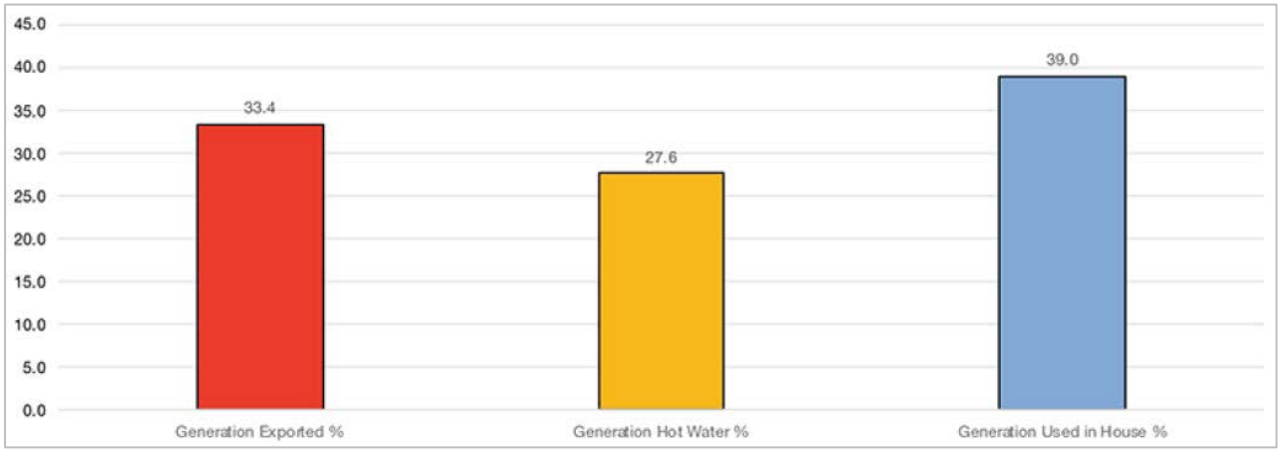


Sourced: Sean MacIntyre, University of Ulster, Energy Report – The Utility of Solar Photovoltaic Panels at 55 Degrees North (2018)

[68] Sean MacIntyre, University of Ulster, Energy Report – The Utility of Solar Photovoltaic Panels at 55 Degrees North (2018) https://pure.ulster.ac.uk/en/publications/the-utility-of-solar-photovoltaic-panels-at-55-degrees-north-sola

In this example it can be shown that a hot water diverter added to the installation will covert 28% of PV produced energy into hot water that would have otherwise been exported to the grid.

Figure 1.5. Percentage Electricity Generation and Usage 2018 5.3kWp PV system 2018



Sourced: Sean MacIntyre, University of Ulster, Energy Report – The Utility of Solar Photovoltaic Panels at 55 Degrees North (2018)

Case study 4[69]

Location East Lancashire

Panel size Total installed capacity of generation 749.7kWp with Total installed useable capacity of storage 1.4MWh

Project description

The social landlord Together Housing Association undertook a solar-plus-storage demonstration project, partly funded by the European Regional Development Fund, involving 250 households. The project combined battery storage and rooftop PV, with installation completed by December 2019. The £2 million pilot was designed to identify alternative commercial models for renewables deployment in social housing following the decline of feed-in tariff rates. The technology offers Together Housing the possibility of selling excess energy generated by the systems back to energy suppliers, exploring options for sale of power on site, or via peer-to-peer networks, as well as interaction with other energy markets for demand-side response. Avonside Renewables won the tender for the pilot project. Within the tender, Avonside Renewables were required to carry out a visit to explain the benefits of the system and the process of installation.

There was a positive initial uptake of the project with around 90% of tenants agreeing to take part. In return for free installation of the system and free electricity, tenants had a device fitted to their homes which captures data remotely to help assess the pilot's feasibility, with each device showing generation, import, export, load, frequency, voltage per dwelling. The project covered a variety of different property types, with installations largely split between one-bed bungalows and three-bedroom houses. Together Housing anticipated that the project would save the

[69] Avonside, 'Avonside Renewables Contractor in Together Housing's Innovative Solar PV & Storage Pilot Project' (14 October 2020) https://www.avonsidegroup.co.uk/news/together-housing-solar-project/

tenants 60% on their electricity bills. It found that by the end of June 2020, tenants involved in the project consumed a total of 196.778 kWh of solar energy. When compared to average electricity prices for the North West, this equates to £31,878 of direct savings to tenants by the end of June alone, with total savings in all of 2020 projected to hit £63,253 or approximately £253 per household. With an approximate carbon emissions reduction per annum of 311,400kgs.

Findings from stakeholder interviews

Implementation of the solar PV pilot scheme

This section provides additional background to the scheme as set out in stakeholder interviews.

Business model

The Solar PV pilot scheme was in large part made possible by the NI Renewables Obligation which created an attractive revenue stream for third party funders. Under this business model, a third party funder would cover the up-front capital investment in exchange for the ROCs and export payments which would deliver approximately 2.5 times return on investment over the 20 year contract term.

"The main driver from a financial point of view would have been NIRO. We had roughly about half a dozen funding providers asking us 'You have 88,000 houses, we want to put PV in the houses and we will pay for it and your tenants will get some savings, what do you think?' That would have been pushed from 2012 onwards. We had a procurement exercise. We had done our own exercise before that where we basically said that if the landlord had the money, they could basically do this themselves and reap the benefits themselves so that tenants get benefit and roughly 2/2.5 times the return on investment could have been used for future fuel poverty schemes. That would have meant writing a cheque for between 4 to 5 million pounds, which the landlords were not prepared to do in 2015."
[Sustainable Development Manager, NIHE]

"The essential basis behind ROCs is that certain renewable generation attracts ROCs – if you install a renewable generating system you can measure the amount of generation it is delivering and that attracts ROCs. Solar PV was added to that in NI around 2012, and 1MW of generation attracted 4 ROCs…It was up for review at the end of 2014 to change it back to 1.2 ROCs which made it unsustainable from an individual and funder perspective. There was some objection in the marketplace – they changed it to 3 ROCs from September 2015 to September 2016, then on to 2 ROCs for a shorter period then completely went in March 2017. There are no ROCs applicable now for Solar PV. At the time of the HE solar contract there were 3 ROCs for all of it. There are no such schemes in existence at the moment."
[Saliis]

Procurement process

Award of the contract was based on the level of rental income that a potential contractor could guarantee for the NIHE. Issues arose at this stage of the process as a result of the complexity of the contractual arrangement because, while the funding model was so-called 'rent-a-roof,' the NIHE had instead developed a bespoke licensing arrangement to avoid complications at time of property sale.

"Under English solar PV schemes, they have a 3rd party property charge on the houses which means that if you go to sell the house, the funder has got a charge on that roof. We did not allow that to happen over here. We changed it from being a lease system to a license system which involved a lot of pre-work with legal people outside the organisation to make sure the tender document stated that it was not a lease like the model in GB but it was going to be a licensed arrangement."
[Sustainable Development Manager, NIHE]

The contract had been initially awarded a year earlier, but the original contractor had not taken notice of this licensing arrangement and therefore could not deliver on the contract. The consequence of this was that the ROCs scheme had diminished in value in this time, meaning that it was a less attractive proposition and potential rental income for the Housing Executive was lost.

"We had to do a procurement exercise. The quality assessment was based on the level of rental income they would give us back. If contractor A gives us X and B gives us Y, if X is more than Y then the first one wins it…Whenever it was first procured, it was a 4 ROC system…The first contractor could not carry it through, and…the point was that we had lost almost a year and during that year the incentive scheme went from 4 ROCs to 3 ROCs which meant that only 75% of the potential for the funder was there and that greatly diminished the opportunity for rental income for us."
[Sustainable Development Manager, NIHE]

Special purpose vehicle

A special purpose vehicle was established for the purpose of the bid, involving Oxford Capital Partners as the fund manager and Saliis as the engineering, procurement and construction partner. Saliis were separately contracted under the SPV to provide maintenance and monitoring services.

"We had partnered with a fund manager who was interested in funding schemes like that. Our role was as the EPC contractor – we partnered with a fund and put together a bid. The bid wasn't in our name, it was in the name of a Special Purpose Vehicle that would be set up to fund and deliver the project, then that Special Purpose Vehicle would subcontract the installation works to Saliis and that's where we came in."
[Saliis]

Selecting households for participation

NIHE selected an initial long list from its portfolio of low-rise properties with modern roofs in good condition. The long-list was then passed on to Saliis to short list based on factors such as orientation. The selection of houses by the contractor was largely influenced by the operation of the NIRO scheme, whereby a larger PV system would generate more electricity and therefore attract more ROCs. As such, mainly bungalows were chosen in order to accommodate the larger systems. This resulted in an average system size of 3.75kWp. The NIHE's working assumption is that these panels deliver £150 annual benefit to householders based on 50% utilization of approximately 3200kWh annual generation.

"We started off with a long list of 21,000 houses, based on going to our programming people and asking them how many houses with modern roofs that do not need any tiles changed in the next 20 years. Out of 55,000 low rise houses – which is one to

two storey – we came back with around 21-22,000. We then let the contractor reduce that down based on primarily orientation."
[Sustainable Development Manager, NIHE]

"The average size of the PV array is 3.75kW (roughly 15 panels) and the maximum is 3.96kW. The funder had carte blanche to pick whatever houses they wanted based on a number of different variables. They generally went for single storey houses because they had a larger roof and they were looking for elderly people who tend to be in the house more which would provide more benefit. …Our working assumption is that there is £150 saving per year for householders."
[Sustainable Development Manager, NIHE]

Informing householder and installation

Initially a letter was sent by the NIHE to the majority of the short-listed properties, of which there were 3,000, to inform tenants that their home was being considered for the scheme. 10% of householders did not want to take part in the scheme. The role of the NIHE was minimal after this stage, with Saliis carrying out property surveys, obtaining householder consent, making necessary building control applications to Councils, speaking with tenants about the installation process and use of the panels, carrying out construction works and providing follow up support. The maintenance contract costs approximately £40 to £50 per property each year.

"Effectively our role was to assess suitable properties that the Housing Executive had given to us. They had given us a portfolio of properties that they thought might be suitable, we did a desk-top study on those. And then to follow through and go survey the properties and discuss what was happening with the tenants, install the system and commission it."
[Saliis]

"When it's done there is a handover pack, a demonstration. Then we provide 24/7 cover so if any customers have issues they can come back to us. If there are any problems, we're monitoring that to see those systems are operating all the time – if they're not we do a call out in the normal manner by notifying the tenant, asking them for permission to call, and apart from those callouts we also have planned visits which are done every 5 years."
[Saliis]

NIHE location offices performed a 100% check on selected properties to ensure the panels had been installed and provided fridge magnets and written instructions on electricity usage to maximise savings benefits.

"We gave them plastic cards like fridge magnets to say use it or lose it, when it is daylight do the following. We did try to manage their expectation in the fact that this is a 3 or 4kW system; do not put on the 9kW shower and expect to get it for free because that is only half the value. So we tried to condition people and it seems to have worked because people are saving money out of it."
[Sustainable Development Manager, NIHE]

Advantages to deployment of solar PV

Main drivers

Stakeholders identified three main objectives behind the NIHE's interest in a solar PV scheme, namely; a) potential energy bill savings for tenants who participated in the scheme, b) the decarbonisation of the housing stock, and c) opportunity to improve the energy efficiency and therefore SAP rating of existing housing stock.

"For the tenants it's straightforward – from an economic view, many of these tenants are in or close to fuel poverty so the amount of saving may not be huge for a private client but for the Housing Executive tenant it is. For the Housing Executive, it is the decarbonisation of their stock to some extent. It certainly has an input into reducing the carbon footprint of their organisation and the decarbonisation of their housing stock, which is part and parcel of both the NI and UK government's short-, medium- and longer-term strategy."
[Saliis]

"Although with energy efficiency people always think of insulation, it is not just that, it is about cutting people's bills out as well. You can put on a certain amount of value for money refurb which can get you up to SAP Band C, but long-term, you have to put existing houses up to a SAP Band B. Insulation will only get you so far and that extra 7 or 8 SAP points will come from PV. The role of PV will definitely, for retrofit, be a key part of housing to increase SAP points and thermal efficiency of the house."
[Sustainable Development Manager, NIHE]

In addition, the deployment of solar PV in domestic dwellings could have a positive effect on the economy if adopted at sufficient scale.

"…through the NIRO scheme, because they were supporting solar installations, we saw growth in the solar installations industry. So there were a lot of companies operating in NI which was creating jobs and generating income."
[DfE]

Ease of installation and use

Stakeholders reported that installation of the panels was generally well received by tenants. Disruption is minimal as the panels can be fitted in under a day with most of the work taking place outside the property. Solar PV is a passive addition as it does not take up space within the household and requires minimal involvement from tenants. While householders can maximise their savings through behavioural changes, they will not be worse off financially than before the installation if they do not alter their energy usage patterns. This is distinct from other low-carbon technology, such as heat pumps, which can cost the householder money if used incorrectly.

"Most wanted the system because it was free and they were going to save money, and it wasn't that intrusive. Internally there's very little – a cable and a merger – but there's no great issue…As a contractor we do other installations for the Housing Executive where you often get refusals because of the disruption and people just don't want to change. With the Solar PV we didn't have any of that."
[Saliis]

"The benefit is, it goes in, the tenants don't need to do anything with it, they don't need to adjust anything. It's not like a heating system where they have to run it a certain way or at a certain temperature or run it for longer hours… Whatever they can generate and use will happen automatically… If it goes wrong it doesn't cost them anything. Other technologies like heat pumps tend to cost the tenants more money to use if they go wrong, whereas if solar PV fails it won't cost them anything. That's what makes it appealing."
[Choice Housing]

Householder profile

It was felt that the scheme had been effective in targeting those households likely to be affected by fuel poverty and that the technology had considerable potential to make a positive impact in this area, as the household profile of NIHE tenants was likely to align with opportunities for day time electricity usage.

"Out of the 1,007 PV installations 40% are actually in the fifth most disadvantaged quintile, and less than 2% is in the fifth most advantaged quintile: that reflects their housing stock. But if you look at that in comparison to the Warm Homes Scheme [superseded by the Affordable Warmth Scheme], which includes more houses outside the Housing Executive stock, it's [Warm Homes Scheme] not so well targeted at the most disadvantaged."
[Sean MacIntyre, Ulster University]

"Thinking of the Housing Executive where people are low income, working different shift patterns, not working, elderly or disabled, traditionally they would have been home more to use it – the profile tended to suit the social housing contacts quite well."
[Action Renewables]

Benefit to the NIHE

While under the 'rent-a-roof' model the financial benefit to the NIHE was very small (in the form of rental payments to cover some staff costs), the arrangement allowed the NIHE to have minimal input to the installation, management and maintenance of the systems while at the same time continuing to benefit in the long term from the decarbonization and increased energy efficiency of the housing stock in line with strategic priorities. Alternative business models may provide opportunities for the Housing Executive to monetize a scheme of this nature. This is discussed later in this section.

"From a simple point of view of getting £4 million capital investment in renewable onto 1,000 Housing Executive property roofs that are all generating renewable electricity – whether that's being used by the tenant or going back to the grid at no cost to the landlord, and at very little hassle or interference with the landlord."
[Saliis]

Role of solar PV in green energy transition

A number of stakeholders noted the important role that solar PV is likely to play in the context of the green energy transition, particularly as demand is increasing through the electrification of transport and heat. Small-scale solar PV deployment in domestic dwellings may be an important tool in democratising the energy transition by allowing householders to play an active role in the shift to low carbon energy

production as well as helping to ensure a 'just' transition, whereby individual citizens as well as developers experience financial benefits. In addition, domestic solar PV may be important in off-setting network demand from electric vehicles as ownership grows into the future.

"The onus and focus is on the power sector to drive the decarbonisation agenda with heat and transport likely to electrify as the best way to meet their climate objectives. PV plays an important part in that from another number of perspectives. Increasing the amount of renewable electricity generation – which currently sits at about 48% for NI. As well as that, the domestic PV sector is important in ensuring the benefits of this are spread out. Whilst the majority of electricity produced will inevitably be from large scale wind farms, solar farms and future offshore developments, to ensure we have a just transition as well as a wider societal buy-in then I do think the PV sector is vital in that."
[Renewable NI]

"If you try to separate the two issues in your mind, source of power and consumption of power: PV, battery and the network and wind turbines are your sources. That battery power can come from your vehicle – it can work in reverse, vehicle to grid, and if you have PV coupled with another technology like a power wall, it does mean during the day when you're out you can charge your battery from the PV and use that electricity that was generated during the day to charge your car rather than taking it off the grid where you're going to be charged the unit cost. It's this ability to be slightly smarter in how you utilise your energy and if you have a resource, even though you don't use it at the time of generation, you can either export it, store it or trade it so it gives you that flexibility."
[NIE Networks]

Challenges and areas for further consideration

Technical issues

A number of stakeholders highlighted technical issues with systems of this kind. These largely referred to obtaining generation and export meter readings. Generation readings, while accessed remotely, were impacted by signal issues from the modem while export readings had to be taken manually and therefore gave rise to access issues. The problems with obtaining export readings are potentially significant for the Housing Executive as payments from exports are likely to play a role in any future funding model. Therefore, consideration should be given to how these readings will be collected and what the resource impact might be.

"…monitoring is sometimes an issue. There's a sim card at the meter and that's picked up by a portal which we're looking at every day, and not monitoring is more signal issues. Often its cured by installing a small aerial at the location."
[Saliis]

"…most of the properties were fitted with a remote modem for reading the generated energy remotely, so someone in a company logs in remotely and takes all the readings related to the ROCs. The difficulty was recording the export as it needs a physical walk in – that's difficult at the best of times but obviously in the last year it's been impossible."
[Action Renewables]

"Monitoring and getting the readings has been an issue and things like communications faults have recently crept in, five years down the line. Longevity around that may be a concern …there are a lot of things that it could be, so diagnosing that could be difficult and it doesn't help that the PV industry has dwindled in NI. Some of our installers from that are now not supplying anymore so we have no one to go back to without going to a brand-new company."
[Choice Housing]

Limitations on benefit to householders

The potential benefit of solar PV to relieve fuel poverty is limited by its seasonal pattern of generation. Solar PV is generating electricity most effectively during the summer months when household heating demands are at their lowest, and generating the least amount of energy in the winter when fuel costs are highest and when households are likely to be under most financial pressure from energy bills. Therefore, the usefulness of PV to offset the costs of fossil fuel heating systems in winter is less than optimal. As such, while a household may be saving a certain amount over the course of a year, these seasonal fluctuations are likely to impact on their perception of the value of solar PV and their actual experience of fuel poverty.

"In the peak summer days, its twice the daylight hours of the depths of the winter and in the summer our electricity use tends to be lower, so the profile is just not ideal, but that's how it is unfortunately."
[Action Renewables]

"It doesn't actually correlate very well with fuel poverty stress, when people are likely to be running out of money in terms of their heating. It could be interesting to determine if householders would be interested in an arrangement where you received some of the benefit of the PV system in winter instead of in summer, because that is relatively easy to set up actually."
[Technical Innovation Manager, NIHE]

It is also possible that householders will not use the technology in the best possible way to maximise benefits and therefore see little or no bill reductions. This might particularly effect those who are not at home during the day and therefore have very little opportunity to use the electricity generated.

"…you have to learn how to use it, and that is where some of the socio-economic differences come in. The technology just isn't quite there – it needs to be fit and forget for people to maximise it. The ultimate solution is you put in solar PV, put one of the Immersuns in and have batteries, and that way they can continue to work the way they normally do and the energy has been generated and stored, but until they have batteries they have to realise 'when the sun's out, I'll make the most of it', and not every household will do that."
[Sean MacIntyre, Ulster University]

Maximising bills savings

A number of stakeholders addressed the area of increasing the savings benefits to householders, either through devices to prompt individuals to use appliances when the panels are generating or through the addition of storage technologies. The scheme under evaluation did not include the use of batteries or hot water diverters to increase the proportion of PV generated energy utilised by the household. While batteries continue to be very expensive and come with some concerns such as increased fire risk, hot water diverters are affordable, of proven utility in this context and would likely be a feature of any future scheme of this kind. In order for this device to be installed, a property must have a water tank of sufficient volume, as such, some properties which have had mains gas installed and their water tanks removed will be unable to benefit. There was some doubt from stakeholders as to the utility of batteries in this context, however it is intended that the ongoing Girona pilot project will provide an evidence base in this area. Other technologies may also become available to maximise the proportion of solar generated electricity that a household can utilise.

"You can get handheld devices which will tell you what is being generated from your solar and how much you're using and use a green or red light to indicate whether you should switch something on or off. You don't want someone to use it unnecessarily but if it was a bright summer day, they could use the tumble dryer – you have energy there so you may as well use it. I think it's just that visibility: being able to see what your usage is and what your generation from the panel is, and being able to see some sort of indicator to tell you when to use it."
[Action Renewables]

"I think there is still work to be done on batteries. They are expensive, and yes you can pair a larger system with a battery and try to get the benefit but I would like to see more empirical data around the actual benefit of batteries, for example in a

Housing Executive property. The theoretical benefit is, if we're not using electricity we're saving it into a battery and using it later, but if, in the case of solar PV your maximum generation is May-September, is the battery going to have the capacity, are you going to use that electricity, or are you going to reach the stage where you generate electricity and you can't do anything with it?"
[Saliis]

"There are a couple of things that you would call solar plus – they are gadgets you fit onto the PV system to improve energy storage. The cheapest is called Immersun – if you have an immersion heater in your house attached to the hot water tank, this gadget costs £350 and the moment you start generating more electricity than you use this switches on your immersion heater…For households that don't have one of those gadgets fitted, they are exporting 60, 70, 80% of what they generate. For those that do, they are only exporting 30%, so by spending that extra £300 you are keeping that electricity off the grid and providing free hot water to the household."
[Sean MacIntyre, Ulster University]

"An immersion heater is usually 3kW. If the panel size is very big, 4 to 6kWh, sometimes it will be producing all of the 3kW. But if the size is smaller you might be better to put in a 2kW system; the PV system therefore only has to be two thirds of the size to be useful for hot water. Another option is to have dual elements – you have one heater but instead of 3kW, it has 1 plus 2kW. Some of the diverters already have two switches so if there's too much solar export happening they switch on the 2kW immersion heater, if there's even more they add the 1kW."
[Technical Innovation Manager, NIHE]

"We have opened a conversation with a manufacturer who can provide a heating element to add to a central heating radiator. You clamp this thing on. It's electric, so your central heating radiator becomes a dual fuel heating appliance. So once the hot water is done you can begin to heat the radiator."
[Technical Innovation Manager, NIHE]

Network capacity

A significant challenge for the scheme under review and for any future scheme of this type is that of network capacity.

"The biggest challenge (and it's the same challenge no matter which country you are in) was related to the grid connection. NIE are a stakeholder in any renewable electricity generation, and the thing to always remember is that the NIE grid is set up for one way transmission of electricity – there's central generation and then that electricity goes to the user. It isn't set up for embedded generation like you have with solar or wind where you are putting electricity back into the grid. That's not to say it can't cope with that, but the grid wasn't designed and set up that way."
[Saliis]

For small scale microgeneration, NIE Networks had a 'fit and inform' approach whereby it was not necessary to obtain permission prior to installing. However, as the pace of installation of solar PV systems increased in light of government incentives, there were concerns that street level infrastructure could fail at times of peak level generation if several properties in close proximity had the panels installed. In response, NIE Networks began to enforce a 'neighbouring clause' whereby an installer had to obtain permission in cases where proposed installations would be

within a specified distance of each other. This led to challenges around the selection of suitable properties for involvement in the scheme for the avoidance of delays inherent with the permission process.

"They were much more specific about what they called neighbouring installation – if you had two installations within 100 – 150 metres of each other you had to get approval from NIE. It wasn't such a big issue when we were doing it in the private sector but with the Housing Executive if you found a suitable property with the right type of roof and orientation, the chances are all the properties on that street would have been equally the right type of orientation. But with the neighbouring notification clause if you were to do that you had to go to NIE to get approval. In a normal course of events, they will either approve or not approve it, but one of the things about the ROCs scheme and these types of project was that time was never on your side, there was always a deadline – the ROCs were ending and the project would become unviable if they did."
[Saliis]

Equitable distribution of benefit

The challenge of network capacity also gives rise to concerns around the equitable distribution of solar PV schemes. Clearly, not all households experiencing fuel poverty will be able to benefit from such a scheme; either due to network capacity, dwelling type (i.e. apartments), or positioning, condition or orientation of their roof. As such, the NIHE should consider both how to manage the expectations of tenants and how to address the 'fairness' issue, when administering any future solar PV scheme.

"We had a long list of 22,000 which was cut down to 3,000. Once the contractor got their long list, they only accepted 15% of what we were giving them so the working assumption had to be that, although we have 80,000 houses, 50,000 low rise properties, potentially only 7,000 houses could actually take solar PV at the very maximum of 3.68Kw. That is a big constraint going forward."
[Sustainable Development Manager, NIHE]

In relation to the present scheme, the process by which tenants were informed about the scheme and sequencing of the selection process did lead to disappointment for a number of tenants. Some individuals who had been initially informed that their property was suitable for the scheme, were then unable to benefit due to the 'neighbouring clause' limitation.

"We… sent out letters ... If you give somebody a letter, you then set up their expectations that they will get something. So although the letter says that you are on a long list of thousands and you may get PV and we may survey your house… but by getting that letter, they immediately jumped past the caveats and thought they would get it."
[Sustainable Development Manager, NIHE]

"We would have had situations where we surveyed properties, then we went and said to the tenant that 'your property has passed the initial filter and looks as if it's suitable, we now have to contact the NIE to get approval.' On some occasions we didn't get approval or get it in time, and those people would have been disappointed.

There was no negative feedback from tenants who did get them but there was from those who didn't get them."
[Saliis]

Possible installation of smaller solar PV systems

One possible response to the issue of network capacity and equitability, is the installation of smaller solar PV systems on a greater number of roofs. The size of the arrays installed under the scheme was largely dictated by the ROCs revenue stream given that every unit generated attracted ROCs. In general, single-storey properties were chosen for participation in the scheme to accommodate PV systems of up to 4kWp – the average size of system installed was 3.75kWp. Such systems are substantially larger than required to deliver maximum bill savings to householders as they are unable to utilise a large portion of the units generated, particularly without additional storage technologies. Therefore, 2kWp or 2.5kWp systems could be used instead to reduce the strain on the network and benefit more households.

"The rent a roof scheme was important in getting more rooftop solar out there. The majority of those benefits were accrued by the installer rather than the householder, so if we're coming at it from a fuel poverty point of view, that was probably a less than optimal way of addressing fuel poverty, but in terms of maximising the level of rooftop solar it was by-and-large a no risk option for the householder."
[Renewable NI]

"The big question mark is around what size of system you put on a roof. If the roof could take it, we would put on the biggest system we could, up to 4kW – 4kW being the maximum size system NIE would allow. That 4kW was not driven by the how much energy or the optimum size for the energy usage of the home occupier, it was simply driven by maximising revenue from ROCs…It doesn't necessarily mean it's the right thing, you would probably find if the systems were 2kW that the amount used and saved by the tenant was probably similar, and you see that when you go through the interface between energy use and energy generated. You'll probably find not too many are using more than 50% of the energy generated. So there is an argument the 2kW system would make more sense. The other advantage of the 2kW system or something along those lines is that it presents less issues for NIE."
[Saliis]

"I think ROCs worked but I don't think it was the best mechanism. I think the best mechanism is to say 'what is the best programme to benefit the tenant and housing stock that allows us to provide the maximum coverage?', and to me that is smaller sized systems where everyone is getting a benefit, most of the electricity is getting used, you are able to cover streets of houses and you provide a significant saving from a fuel poverty and decarbonisation point of view."
[Saliis]

"There is very limited capacity left on the network, in particular the transmission network – the higher voltage stuff. While sometimes people think 'I'm only connecting at my low voltage circuit level how can that impact at transmission level?' - it is the aggregate impact and there is little capacity available. We are seeing a lot more interest in zero export connections which we can still accommodate on the network whereby customers never export to the network and utilise all their

generation through their household demand and there will be a G100 relay fitted to safeguard the network."
[NIE Networks]

Insurance

One stakeholder highlighted possible issues around insurance, particularly if batteries were to be installed with a system.

"Insurance is another thing to bear in mind – yesterday I was talking to our insurance company about the Girona project…they do still have some concerns around PV generally – they don't like that you put the inverter in the attic which is normal practice but what you have there is a source of potential fire, and there are BRE reports showing where there have been incidents across the UK of fire coming from PV systems…The other thing is ventilation – you might have it in a cold roof but in a warm roof is there a chance it will overheat and create a fire risk? So do you need to plan for extra attic ventilation? There's also tenant engagement to make sure they don't tamper with it or throw stuff around it."
[Choice Housing]

Decarbonization

One stakeholder suggested that the installation of solar PV systems may not be as affective an approach for decarbonization as originally hoped.

"As the grid gets greener… then the carbon emissions from electric reduce, so PV offsets electric and therefore the carbon savings you get will reduce over time. For us building new homes, the energy target is actually a carbon target so it's looking at reducing emissions, so actually PV will be a less effective solution going forward. You could put in the exact same system but as the emission factors change for electric over time the same approach in two years' time may not be appropriate."
[Choice Housing]

Financing

Financing of future solar PV schemes of this size was raised by most stakeholders as a significant issue going forward. The ROCs scheme is no longer available, and no other incentive scheme is currently running for solar PV in Northern Ireland. In advance of the Department for the Economy's Energy Strategy 2050, stakeholders discussed other possible funding models or approaches to make a scheme of this type viable.

These included the NIHE covering the capital costs itself and therefore benefitting from the export revenue directly to recoup the initial outlay. Given the recently announced changes to the NIHE's structure with the landlord arm becoming an independent mutual organisation,[70] it may be able to borrow the necessary funds at a very low rate of interest or source the necessary funding from its existing capital works budget where an appropriate strategic policy instrument is created for this type of spending.

[70]BBC, 'Homes to be built by NI Housing Executive again' (3 November 2020) https://www.bbc.co.uk/news/uk-northern-ireland-54795055

However, there is an inherent conflict between the NIHE's ability to monetise solar PV panels and the aim of increasing benefits to tenants, as installing diverters or other technologies to enable storage of the solar generated electricity will reduce the amount exported to the network and therefore reduce the potential revenue stream from export payments.

"We're interested in the export revenues as that could have the possibility of bringing in either some external finance for PV panels or some revenue for the Housing Executive."
[Technical Innovation Manager, NIHE]

"The key determinant is funding, and at this minute in time there is no funding…As an observer and a minor stakeholder I can't see another ROCs system coming back particularly in NI, I can't see a grants system – but I think the more likely source is that there is some methodology or facility for authorities like the Housing Executive to actually get paid for capital works that demonstrate carbon reduction."
[Saliis]

"...it's not an insurmountable amount of money when you consider the budget and the Housing Executive has a huge budget to spend on capital works but it doesn't have a mechanism to spend budget on that type of work. There is a strong argument that's just as good a thing to be putting on a house as a new bathroom or kitchen or heating system. In monetary terms the 2kWp solar system would be a third of the price of a kitchen, half of a bathroom and of a new heating system, so if all of those things get done every 10 years, why wouldn't you do one programme over 15 years?"
[Saliis]

"No industry likes being reliant on incentives – you want it to be mainstream or else you get what we have had for years which is demand goes up when the incentives are there and it disappears afterwards. Saying that, all of the biggest industries are heavily incentivised in one form or another, including oil etc, so it's not like renewables always have the cap out, but it is just a fact unfortunately that at the moment people get used to some kind of incentive."
[Action Renewables]

A second possible revenue stream, if the NIHE owned the panels themselves, could be remuneration for turning exports on or off according to network supply and demand. To facilitate this, it would be necessary to invest in smart controls and more sophisticated data-systems. These in turn could be used to assist households to get the greatest benefit from their panels through identification of household consumption patterns.

"If there was a sufficient amount of Housing Executive-owned houses with solar PV they could potentially participate in our Flex Project through an aggregator where the aggregator could say 'you have X amount of panels, I can turn them down so reducing the output when NIE Networks require that' and in doing so we would then offer up renumeration to that aggregator to be passed to the Housing Executive."
[NIE Networks]

"For a number of reasons, the Housing Executive needs to look at a business case for data systems and linking our houses with the web and cloud. We would be

diagnosing boiler faults remotely, switching systems on and off remotely. For example, we can be paid money for switching electrical systems on and off, the PV system could be diverting to hot water but if there's a requirement for electricity at that time, we can be paid to switch that off. There are revenues available for that… so there's going to be systems in the future with sophisticated smart controls. To even start with that it's important to get data about self-use."
[Technical Innovation Manager, NIHE]

In any case, it was noted that if such a scheme were to represent a credible response to fuel poverty then any funding model or incentive should not be financed by an increase to consumer utility bills.

"If we argue the case for domestic solar on the basis of fuel poverty, there may be a contradiction in the cost of that scheme being put onto utility bills. For example in ROI the grant is paid through government subsidy rather than through consumer bills so the cost arguably is then through taxation on those who can most afford to pay rather than through utility bills which arguably is a regressive way of funding these models by those who can least afford seeing an increase in their bills."
[Renewable NI]

One stakeholder also noted the need to create financial incentives to stimulate investment in large scale renewables in order to progress at the rate needed to meet decarbonization targets.

"But for both wind and solar to develop at the scale we need to meet decarbonisation targets, we need some form of support mechanism – not a subsidy as was the case in the past, but something similar to the CFD [Contracts for Difference] scheme in Great Britain, or the RESS [Renewable Electricity Support Scheme] in ROI which gives generators a guaranteed price over the long term in order to reduce the risk of those investments."
[Renewable NI]

Future role of solar PV

Large scale rather than small-scale solar

Despite the positive qualities of solar PV, stakeholders tended to be of the view that large-scale solar and wind farms will be much more significant in respect of delivering wider environmental benefits and the level of renewable generation needed to meet 2050 targets.

"It is beneficial to the consumer in that it gives them more control and it allows them to become more active in the energy transition and can also be of benefit to Northern Ireland as a whole in that it is generating more renewables so therefore, we are decarbonising the system. There are health benefits from that, cleaner air because you're using less fossil fuels, people are going to be healthier which again, is a benefit to the consumer. But to really see those wider benefits, it would need to be done in a large-scale way."
[DfE]

"Solar has a significant part to play for the simple reason it's renewable, predictable, cost effective, but the question maybe is has small scale rooftop solar got a part to play? Or is it more likely that renewable generation from solar will be large solar farms feeding into the grid and then the grid is better able to take that? I don't know the answer to that…Undoubtedly the decarbonisation of heating in homes, offices and commercial buildings is the biggest challenge for the decarbonisation of the economy. Is that done by changing everyone to electric heating and trying to make sure that is generated from a renewable source? Is that source large scale solar or wind, along with batteries? Is it large scale along with small scale and microgeneration on roofs? Is it hydrogen generation boilers and that hydrogen is being manufactured by large scale solar and wind that would rule out small scale?"
[Saliis]

Citizen engagement

A role for greater engagement with the wider consumer body on the issue of renewable energy generation was identified. This may be required to ensure householders are 'bought in' to the broader use of renewable technologies and their importance in the response to the climate crisis. This may be necessary to implement the EU Electricity Directive in terms of citizen engagement and citizen energy communities.

"As part of the strategy process, we have been looking at a citizen assembly type approach; co-production and co-design techniques for engaging with consumers. We have a consumer working group under the strategy which is looking specifically at consumer issues; at really who are our consumers and trying to identify specific groups and how to engage with each group because they will all require engagement in different ways."
[DfE]

"There is the citizen engagement and citizen energy communities side of things which is coming in through EU law. Under the Electricity Directive, there is a requirement on Member States to ensure they put provisions in place that allow citizens to be self-consumers and self-generators, to be active in the energy transition and to engage in citizen energy community-type schemes…the Electricity Directive has to be transposed because the transposition date for that is the 31st December before the transition ended. So there are elements of the Electricity Directive that we are going to have to put in place."
[DfE]

Greater clarity in policy

While stakeholders recognised that the opportunity and justification for the further roll out of small-scale solar PV existed, several commented that it was unlikely to be realized without a supportive policy framework in place. Such a framework should primarily set out government funding pathways for solar PV deployment as well as providing a more 'joined-up' approach to improving the energy efficiency and decarbonization of NI's housing stock. One stakeholder suggested that it would be important to address housing holistically; that is, not only looking at the opportunities for social housing, but including privately owned and privately rented also. This could include taking an area based rather than individual household based approach to green energy planning.

"Energy efficiency is still the most cost-effective way of reducing fuel poverty. Throughout government the reason it's been ineffectively addressed is because it cuts across a number of departments – Building Regulations are Department of Finance, Housing Executive comes in under the Department for Communities, the Energy Strategy will be developed by the Department for the Economy – and then Councils have a responsibility in terms of Affordable Warmth [Scheme]. You've got four different public bodies responsible for energy efficiency and that led to a piecemeal approach to tackling the issue. I think we need to collate the work of each of those bodies and have some form of an energy efficiency strategy that has one delivery body."
[Renewable NI]

"Something that provides a third of household needs across a year and most of your needs across six months is worth having. And providing you learn to use it, it impacts fuel poverty so why wouldn't you do it? But it's reliant on the policy framework and changes to building regulations and then some financial incentive to encourage the housing stock that is already there to put this in. There are already various green deals that are being talked about in GB in terms of insulation. You do the insulation first because it's cheap and relatively easy but this is the extension of that, this is the natural conclusion. If you want to decarbonise our society this is one of the more valuable and easy ways you can do it."
[Sean MacIntyre, Ulster University]

"The Housing Executive has got economies of scale, so they can say 'this year we want to put 5000 PV systems in'. If they go to any of the suppliers, they can negotiate a good deal on the price and installation. They can sell it on the energy savings, the impact on fuel poverty, the work that would create, the employment – there's a whole range of boxes this ticks, and they have the economy of scale. There can be few landlords in the whole of the UK that have as many properties as the Housing Executive, they just need the policy context and budget to roll it out."
[Sean MacIntyre, Ulster University]

"… they need to look at how they are going to, or at what levels they are going to, incentivise renewable electricity, whether it's a grant, feed-in tariff, or whatever, but until you get that policy direction you just don't know. The technological side of things is, from a grid point of view, will NIE approve things if you put a diverter in or if you put a battery in? From a policy point of view on that, are they going to only provide grant funding if you put a battery or diverter in? For example in ROI, they put in grant funding which connected it to batteries, so you're incentivised to put them in whereas in NI there's maybe more of a barrier as even the process around batteries doesn't seem to be clear…"
[Choice Housing]

However, it is also important that any new incentive scheme is carefully managed and administered to prevent further capacity issues on the network, specifically in terms of the visibility of new small-scale generators and NIE Networks' ability to plan investments in response to this.

"What I would say is around this notification rate and that is essential to us. I know there's a piece of work done in GB and only around 30% of these schemes are actually being notified to the network operator. If we aren't being notified that somebody has retrofitted PV panels, we never know about it, and there could be network problems that individuals or their neighbours are facing – voltage rise problems for example – and we aren't aware of it. With that retrofit piece, there's a greater challenge for us that we aren't being notified of every scheme. We are clear in making this point to the DfE that if there is ever any future incentive scheme for solar panels then one of the criteria is that the customer show evidence that they have notified the DNO before they are eligible."
[NIE Networks]

Building regulations

The issue of policy extends beyond retrofit schemes to new builds and therefore to building regulations. Several stakeholders noted confusion about what was required under current NI building regulation in respect of low carbon technologies, with some housing associations building to a higher specification than currently required in an attempt to avoid having to retrofit at a later date. It was suggested that building regulations in NI should be brought into line with those in ROI which require a specified proportion of a new build's energy requirement to be produced from a renewable source. This, however, again raises considerations of network capacity.

"So Part L of their building regulations looks for so many kWh per square metre. So if someone wants to build a mansion that's okay so long as 8 or 10 kWh per square metre come from renewables. You found then that people actually revised their plans or realised that we don't need such a big house as they were having to pay for additional renewable energies to heat the area, but it also meant somebody that still

wanted a large area simply built it to a much higher standard so they could heat it with the addition of modest renewables. It was also tiered in such a way so that normal houses (3 to 4 bedroom detached or semi detached) could easily meet the equivalent 10% from renewables just by putting in something like solar panels or solar thermal or a wood stove."
[Action Renewables]

"We are also working closely with the Department of Finance who are responsible for building control and building regulation. As part of the EU Energy Performance and Buildings Directive, they are looking at should they bring in a law that says all new homes built in NI should have solar PV, EV charging points etc. We are working with them to determine, if they were to do that, how would that impact on the NIE Networks."
[DfE]

Findings from tenant survey and interviews

Respondent profile and household fuel

In summary, contact information was provided for 764 households. These households were approached by telephone to take part in the research. In total 306 households completed the questionnaire.

Respondent profile

The figures below detail the profile of the respondents surveyed and their households. An individual with a long-term disability resided at 63% of households surveyed. Almost half (47%) of respondents to the survey described themselves as retired, 22% said they were unable to work due to sickness or disability and a further 17% were not working, indicating that a high proportion are likely to spend time at home during the day and are therefore in a position to maximise the usage of solar generated electricity.

Figure 2.1. Respondent profile

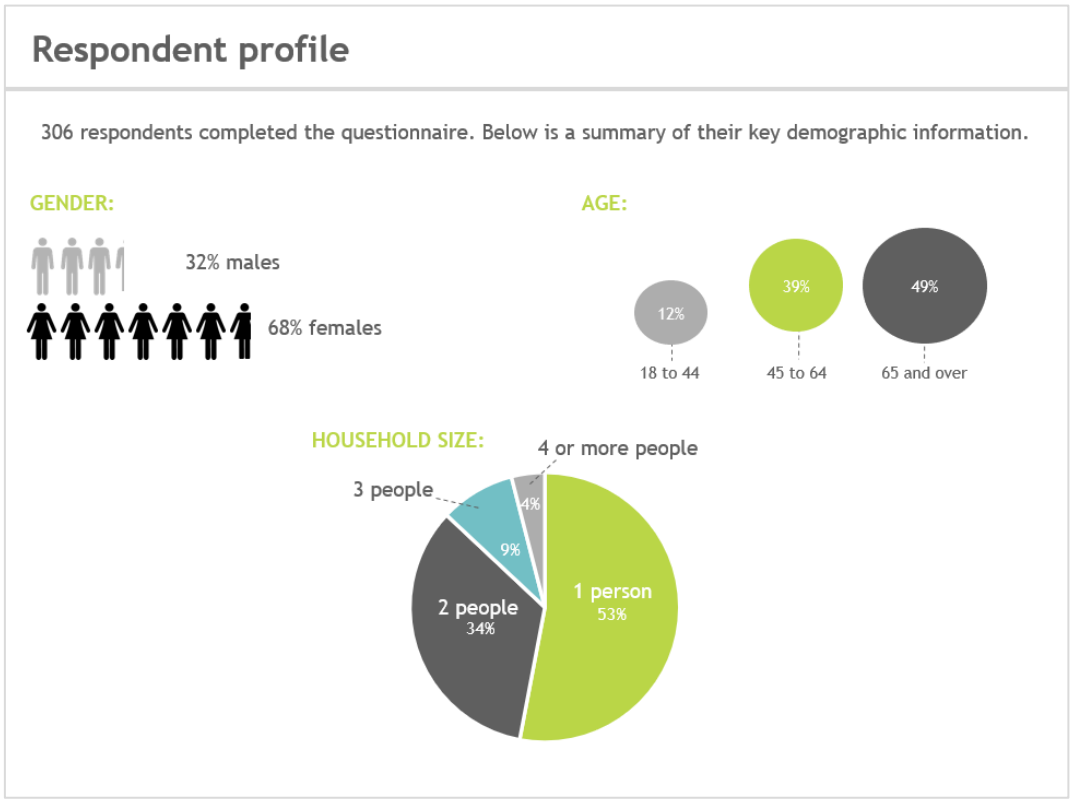


Figure 2.2. Vulnerable households

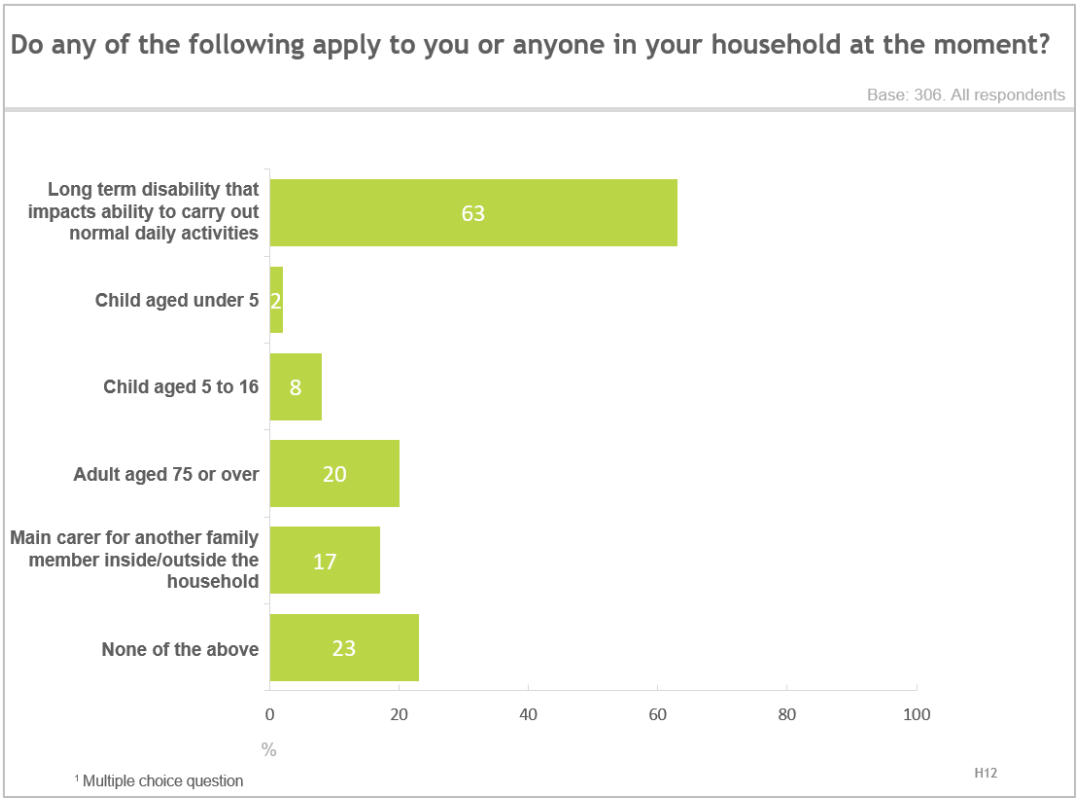
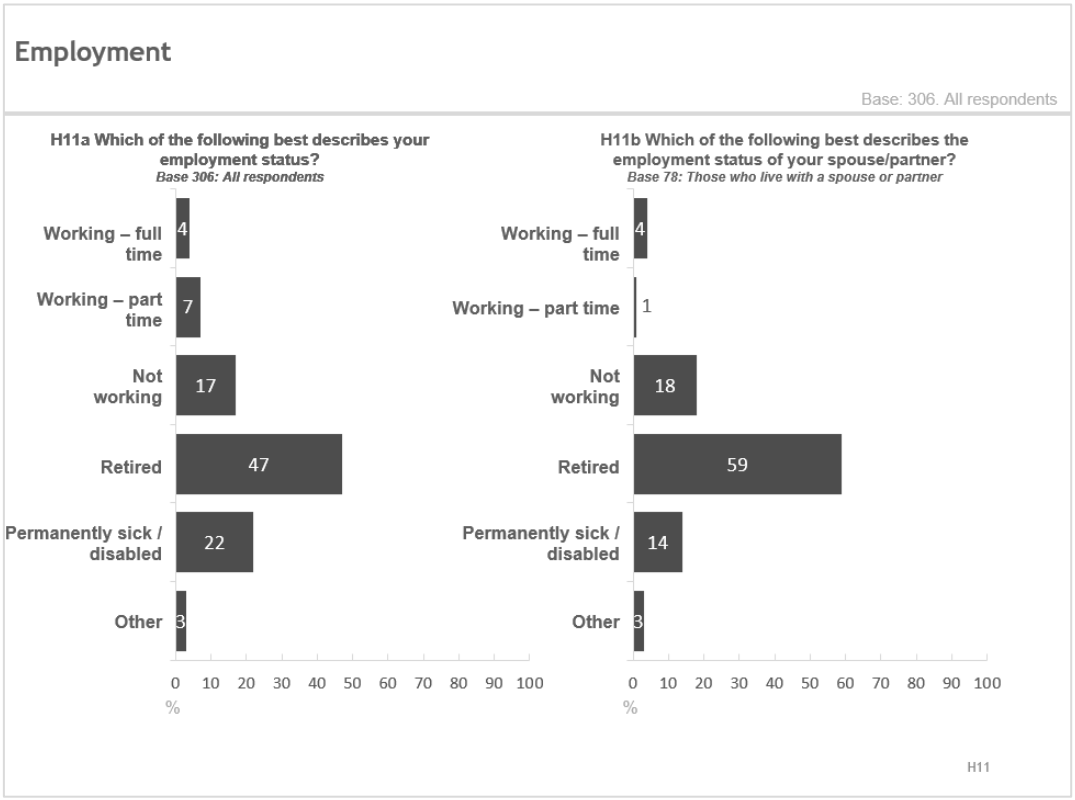
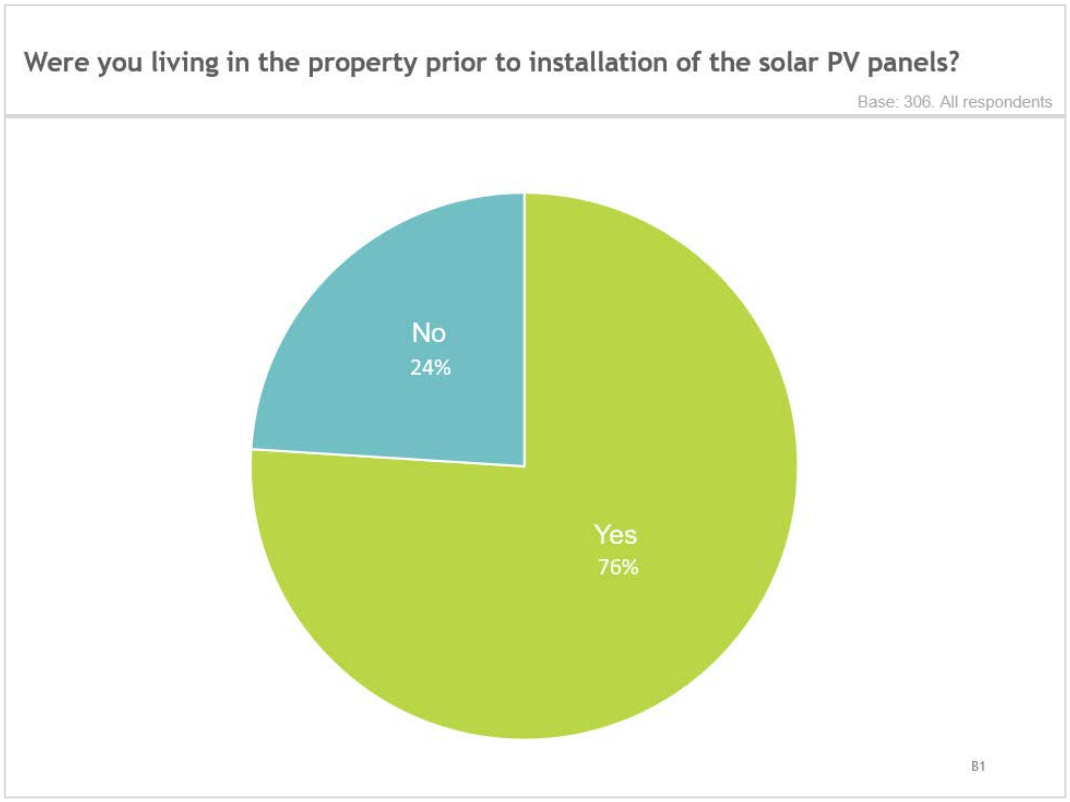


Figure 2.3. Employment status



Three quarters (76%) of the tenants surveyed were already living in their property prior to installation, while 24% moved in after the solar panels had been installed.

Figure 2.4. Tenancies before and after Solar PV installation



Household changes

For most households resident at the time of installation, the number of people living at the property has remained the same since the panels were installed (86%), while occupancy had decreased in 12% and increased in 3 instances. Almost all respondents, 98%, reported no change to the size or structure of their property since the panels were installed. As such, electricity consumption levels pre- and post-installation are unlikely to have been affected by household changes for 303 of the 306 properties surveyed.

Figure 2.5. Household size since the panels were installed

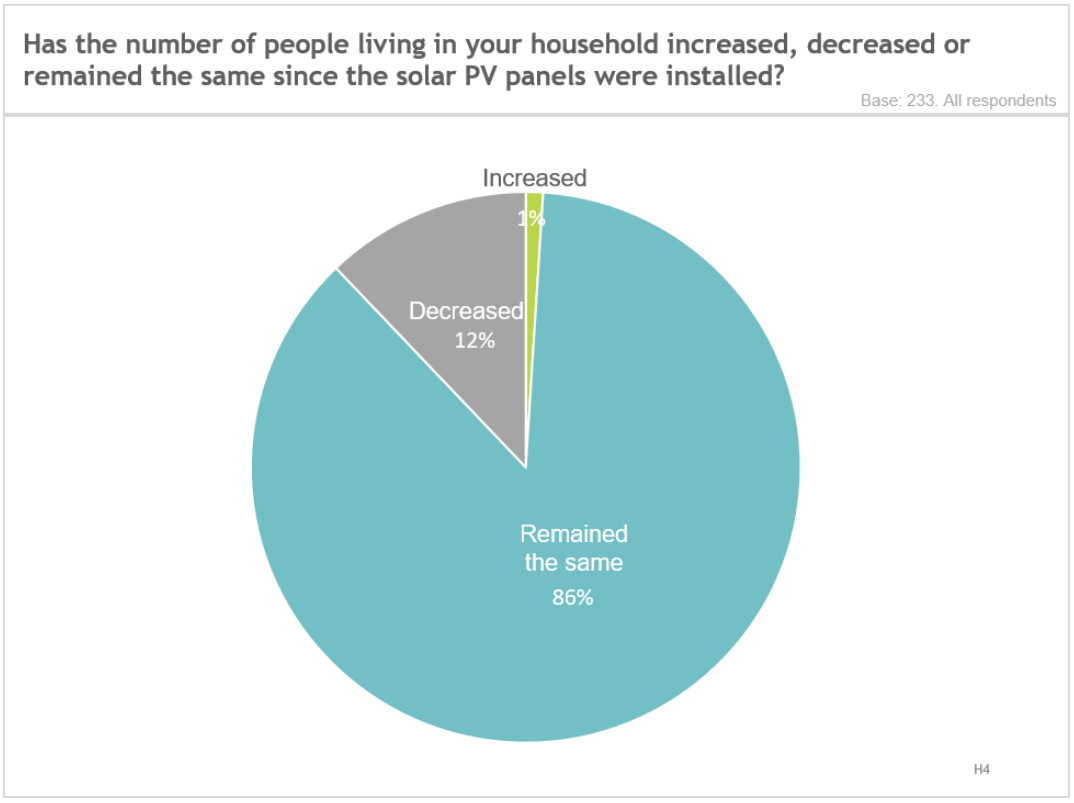
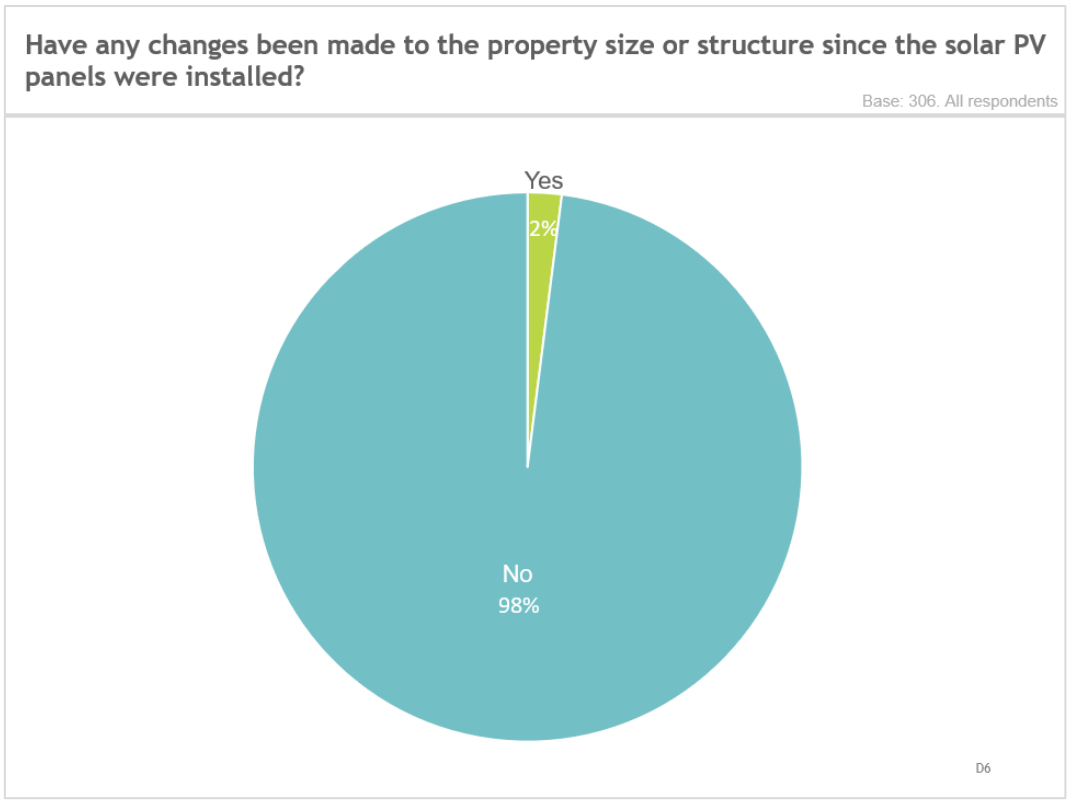


Figure 2.6. Property size or structure since the panels were installed



Fuel type

Over half (54%) of respondents used oil for heating their homes, while 39% used natural gas, 6% had electric heating or Economy 7 and 2% used coal or other solid fuels. This finding has implications for the value-added by the solar PV scheme in terms of both the green energy transition and tackling fuel poverty. Oil heating has both higher carbon emissions and is more expensive to the householder than natural gas, therefore targeting solar PV schemes towards properties with oil as the main fuel source will have a greater impact in terms of carbon offsets and lifting households out of fuel poverty.

Four in five (82%) households had a gas- or oil-fired boiler to heat the water in their home, while 10% used an immersion heater and 6% reported having an instantaneous hot water heater. This finding indicates that there is considerable opportunity to increase savings to tenants by installing a hot water diverter alongside solar PV panels. While water tanks are often removed when natural gas is installed in a home, findings from the current sample indicate that the infrastructure exists within a substantial proportion of the housing stock to benefit from this technology.

Figure 2.7. Energy used to heat home

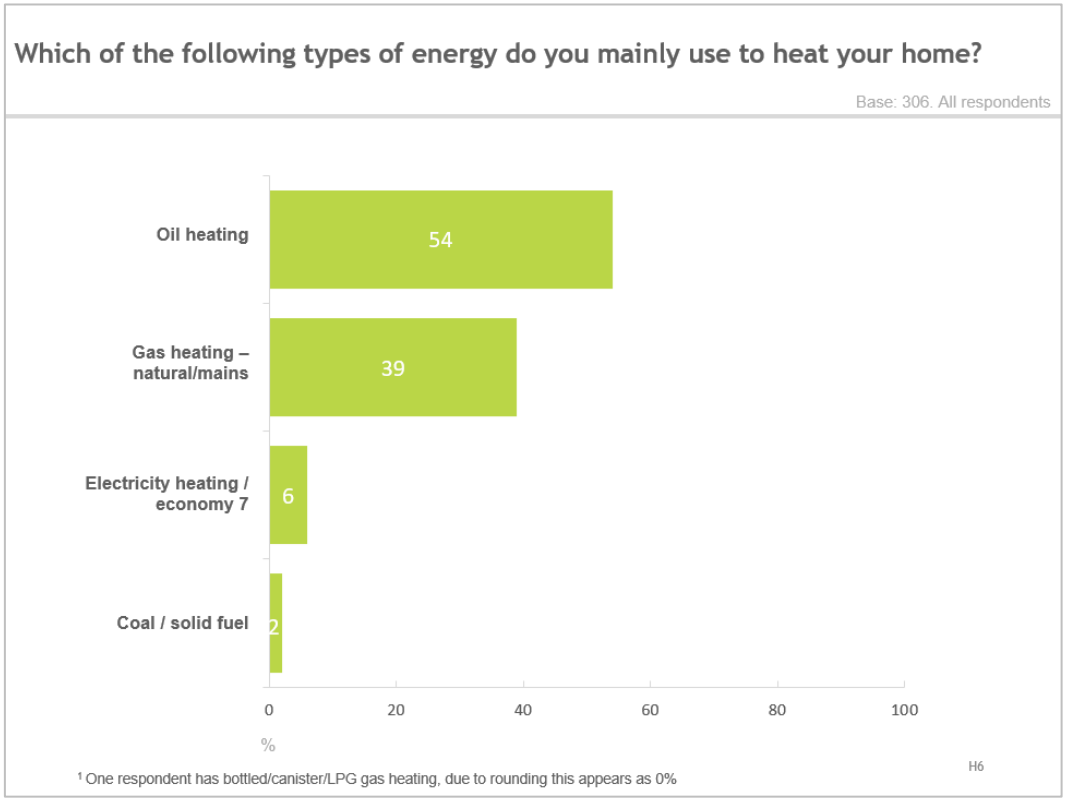
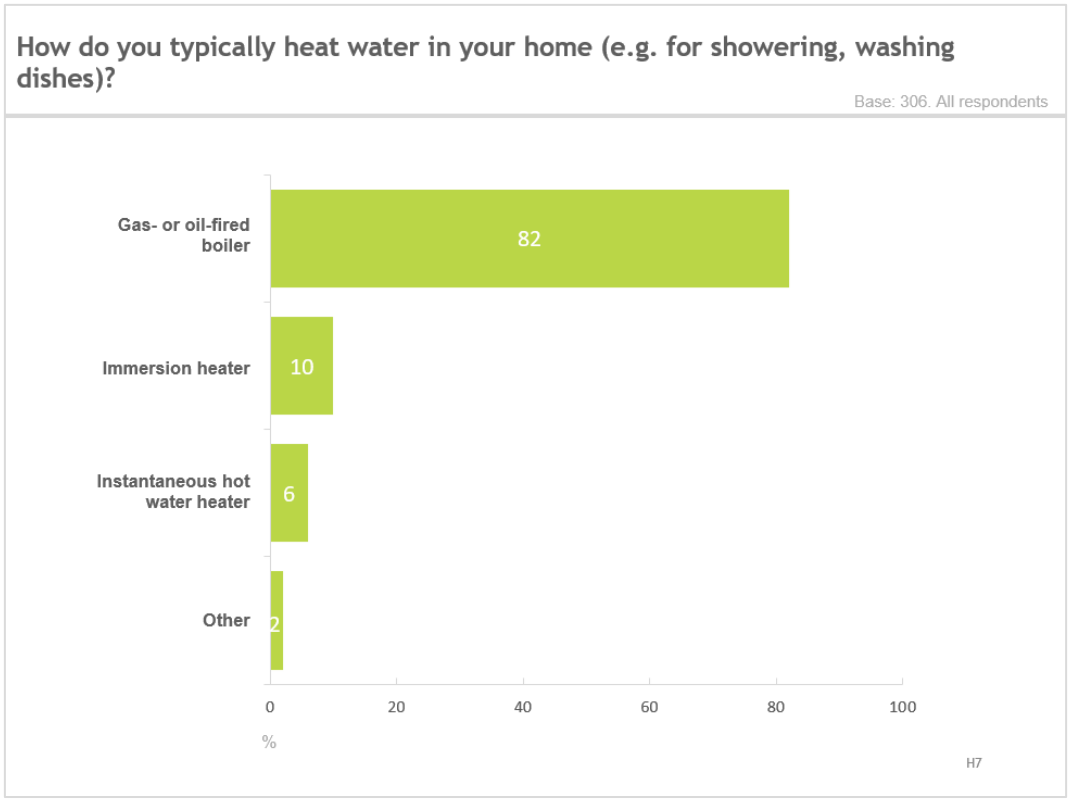


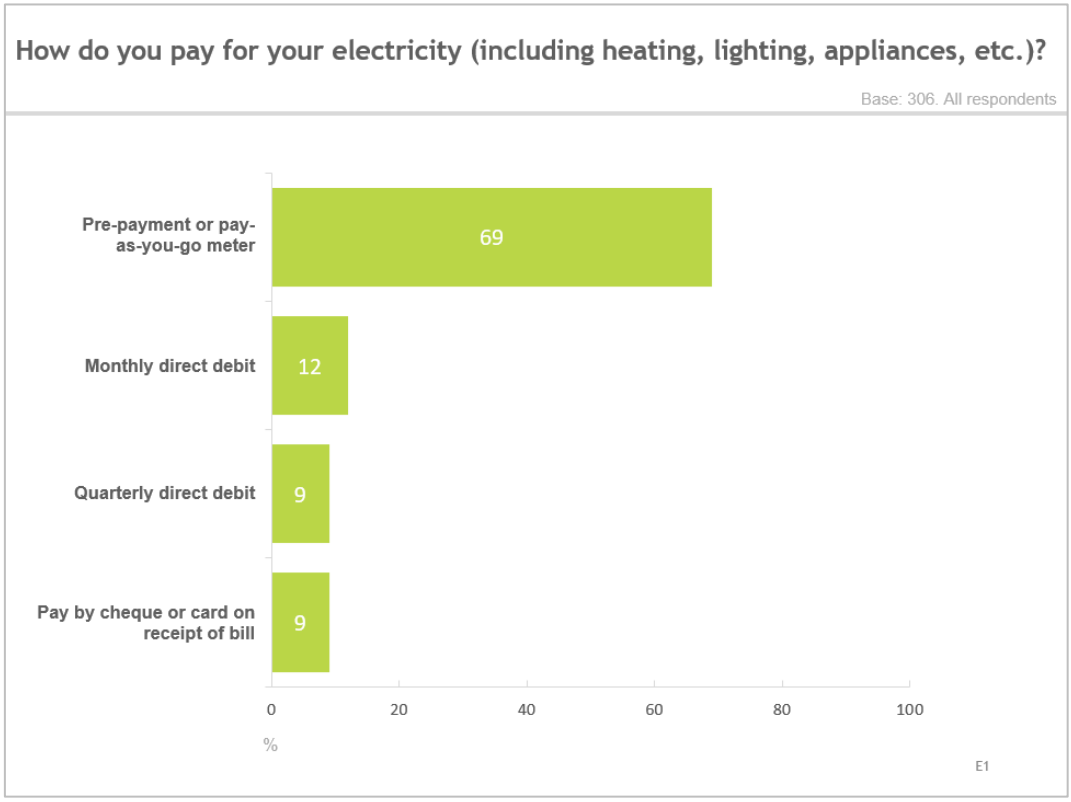
Figure 2.8. Method for heating water



Payment method

Over two thirds (69%) of tenants paid for their electricity through a pre-payment or pay-as-you-go meter, 12% had a monthly direct debit and 9% used a quarterly direct debit, while 9% paid by cheque or card on receipt of their bill.

Figure 2.9. Paying for electricity



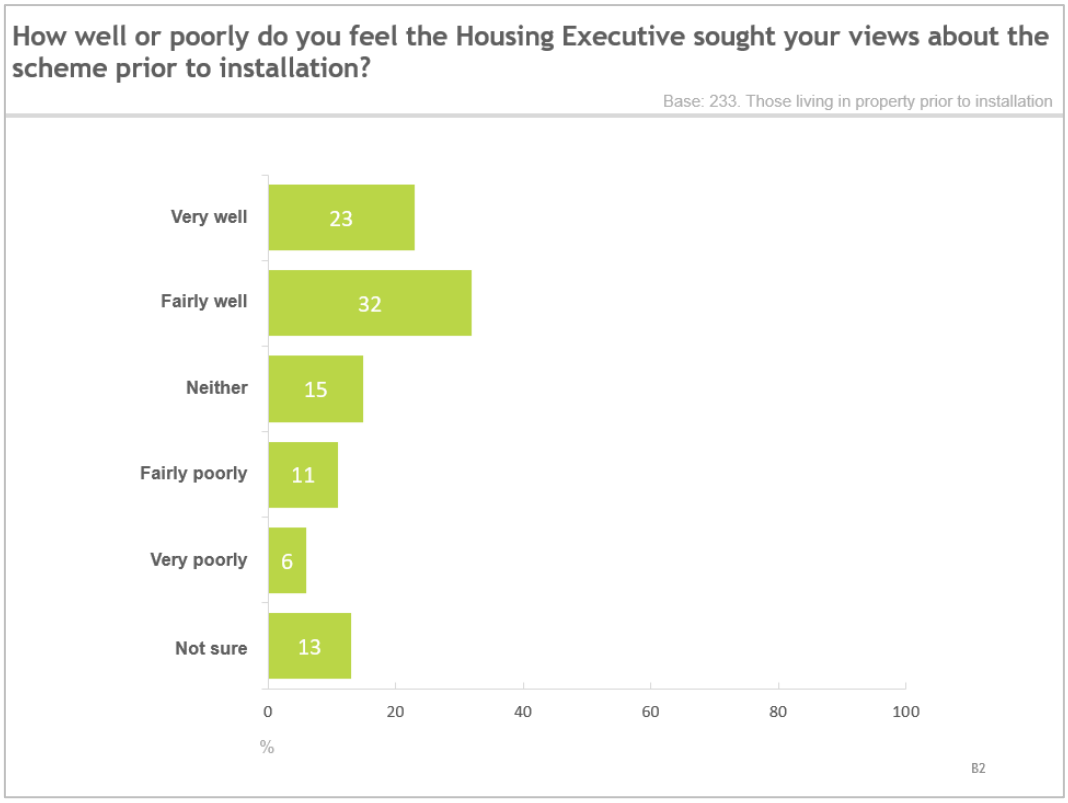
Experience of consultation and installation

In this section, tenants' views and experiences of prior consultation and installation of the panels are explored. The base is lower for this section than elsewhere in the report as only 233 of those interviewed lived in the property at the time of installation.

Experience of consultation

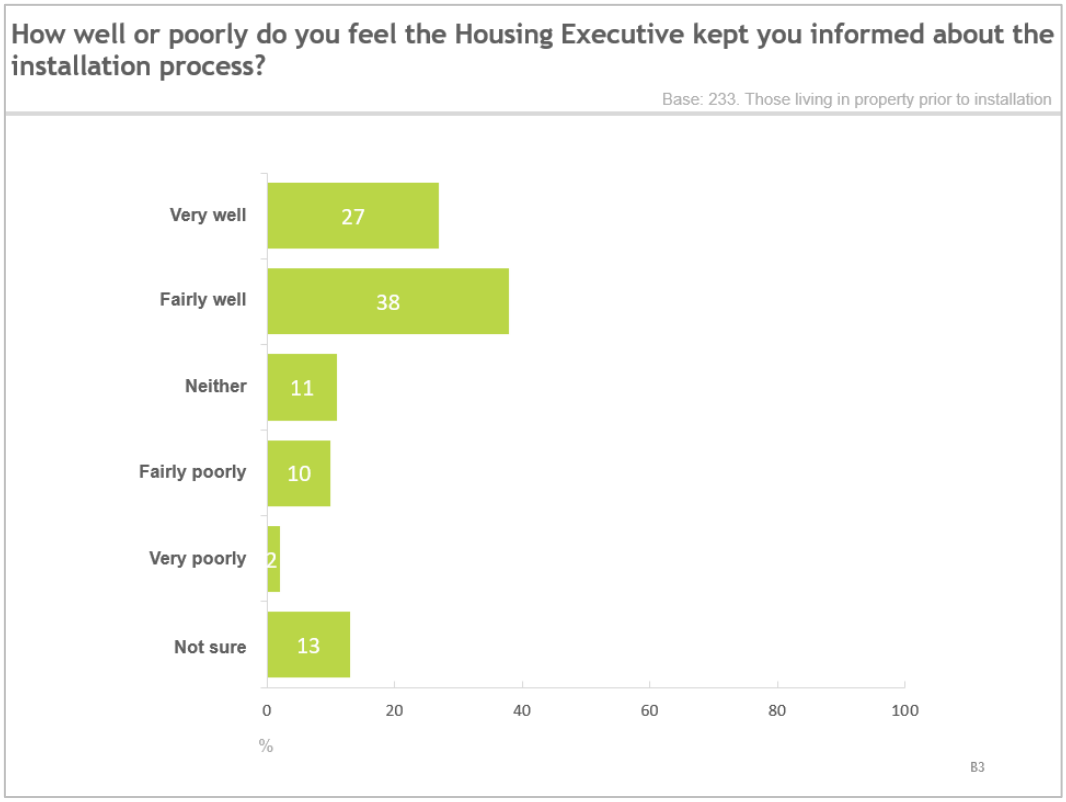
Over half (55%) of the original tenants felt that the Housing Executive had sought their views fairly or very well about the scheme prior to installation, while 17% felt they had been fairly or very poorly consulted. Two thirds (65%) said that the Housing Executive had kept them fairly or very well informed about the installation process compared to 12% who thought they were fairly or very poorly informed.

Figure 3.1. Consultation prior to installation*



*It should be noted that installation took place in 2015-16 and therefore there may be some recall bias.

Figure 3.2. Keeping the tenant informed during the installation process



While the majority of survey respondents reported positive experiences, in the follow up interview, several participants indicated that the consultation prior to installation had been minimal or unsatisfactory:

"They sent a letter to say they would be putting panels on the roof… no one from the NIHE came to tell us any advice."

"There was a letter that came first… then somebody came and told me they would come in so many days' time to start the work."

"There was just a plain letter, no phone call or anything else from the Housing Executive. I had to ring them and ask was it a joke or fraud."

"They sent me out a letter to say you will be notified if you are picked for solar panels and that was it. No one came round to explain why so many houses are being picked. There was nothing from them. It would have been nice if they let us know face-to-face that you could be picked, what this is all about and the process of it all."

"We got a letter asking us were we interested in taking part and I think that was about it. There has been no real contact from the Executive in regard to that. The company that put them in, Saliis, they came out once to check everything."

"They need to let people know how this scheme works and how they will benefit because I just had a man knock on the door one day and say they were coming to measure my roof. I said what for and he said to put the panels up. That was really the first thing I knew about them."

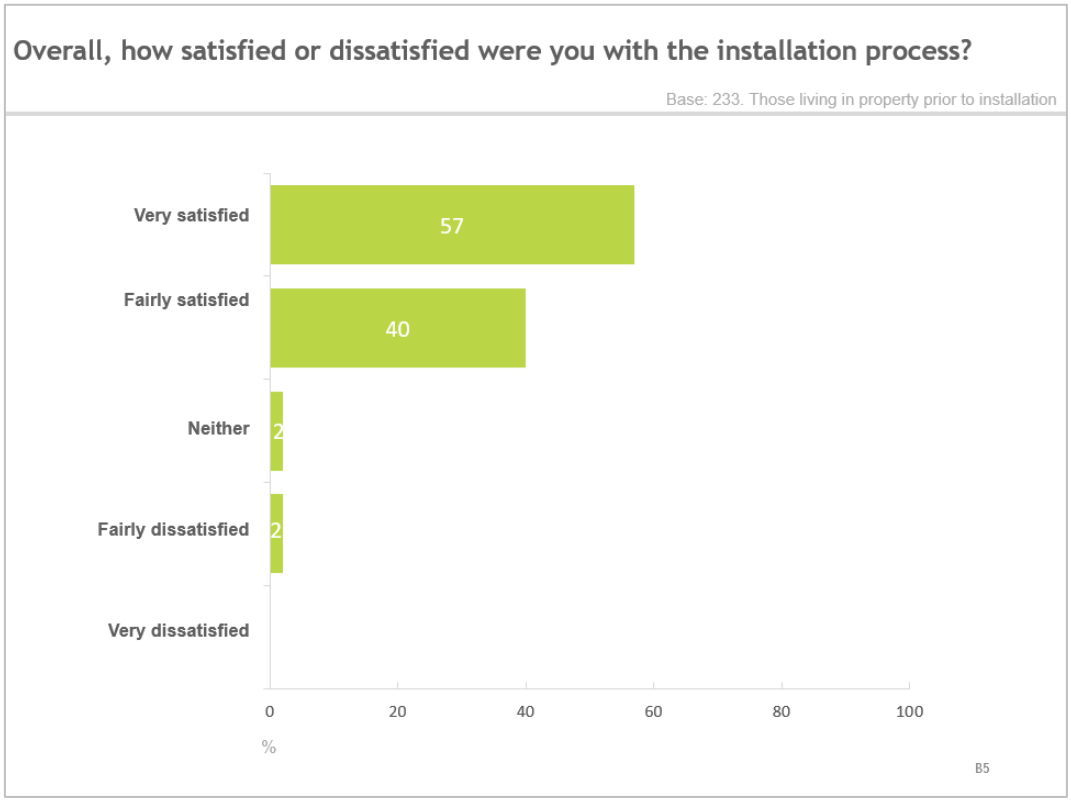
Experience of installation process

The majority (97%) of tenants were fairly or very satisfied with the installation process, with only 4 respondents saying they were fairly dissatisfied. Of these, 3 reported leaking where the panels had been installed and 1 said that roof tiles and insulation had been damaged. These findings were reflected in the follow up interviews:

"It didn't annoy us, and the men were very good and quick; it was not disruptive."

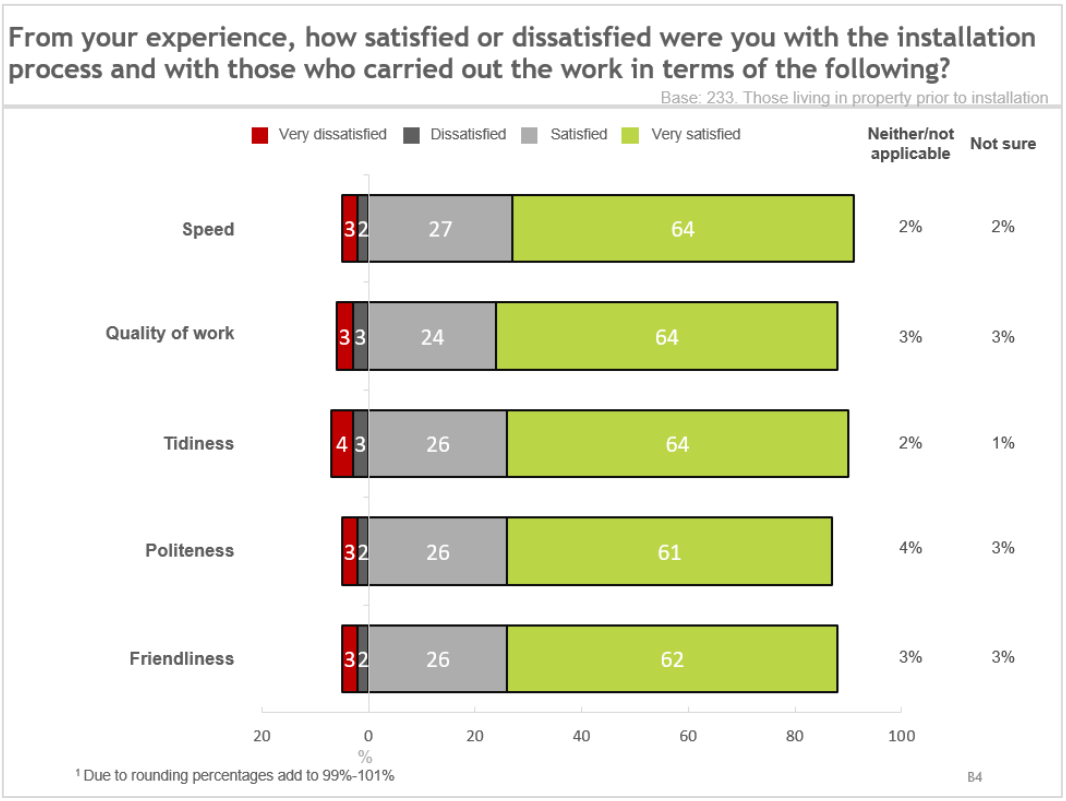
"I had no qualms with what they did, they left the place clean and tidy."

Figure 3.3. Overall satisfaction with the installation process



Respondents were asked to report their level of satisfaction with a number of aspects of the installation process and those that carried out the work. There were high levels of reported satisfaction across all aspects; speed (91% fairly or very satisfied), tidiness (90%), quality of the work (88%), friendliness (88%) and politeness (87%).

Figure 3.4. Satisfaction with different aspects of the installation process



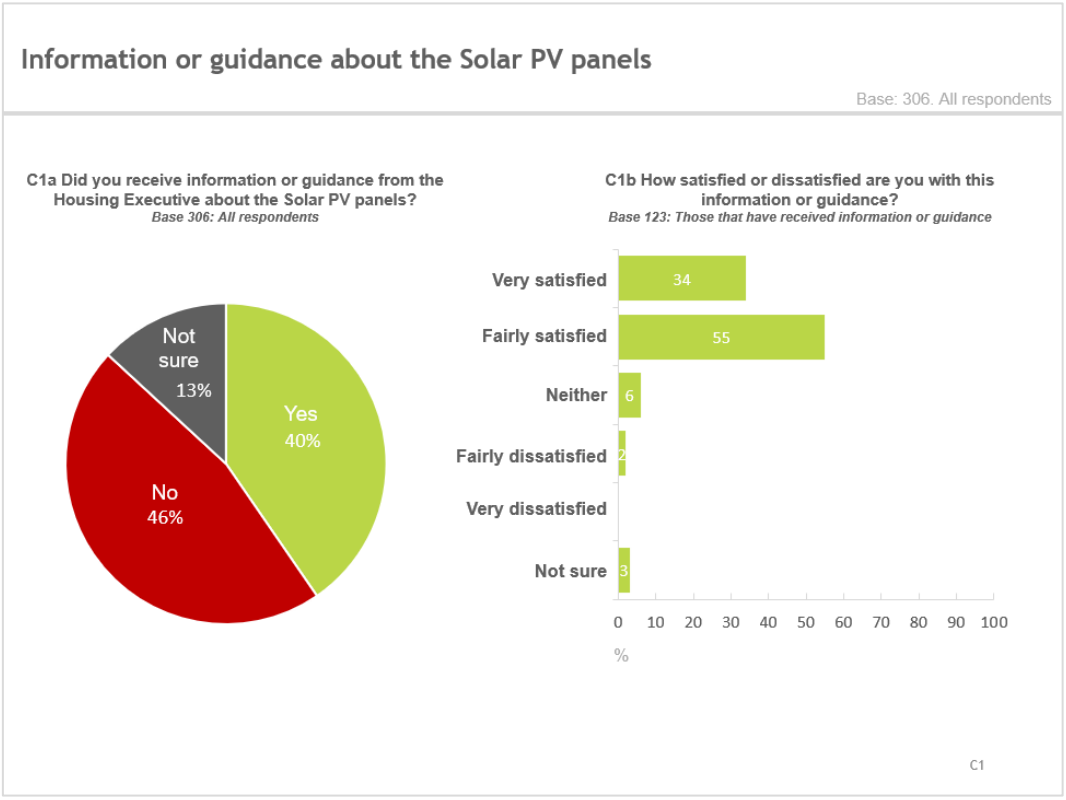
Information provided about the Solar PV panels

The following paragraphs explore the information received by tenants about the solar PV panels and whether they felt additional information was required.

Information received about the Solar PV panels

Overall, just under half (46%) of respondents reported not having received any information or guidance from the Housing Executive about the solar panels. However this rose to 79% of respondents who had taken up their tenancy after the panels had already been installed. Of the 40% who did receive information, nine in ten (89%) were fairly or very satisfied with it. Only two respondents said they were fairly dissatisfied, with one respondent saying they *"didn't understand it".*

Figure 4.1. Information or guidance about the Solar PV panels



These findings were reflected in feedback from the follow-up interviews. While a number of respondents described being told basic information about how to benefit from the panels, this was often remembered as being provided by Saliis rather than the Housing Executive themselves.

"When the Saliis engineer came out to check them he explained a lot of stuff to me then… I don't recall the Housing Executive giving me any information."

"They left a leaflet but I think they could have left a bit more information. I wouldn't be into gadgets. I am no good at that. If they gave a booklet to inform people like me that would be better."

"I was told if I need to do anything like washing and drying, to do it during the day when it is bright."

"The Executive never even came round to discuss anything with us. Just the letter to say we could be picked. It was the solar guys who came round to say we had been picked and it was up to us whether we want them or not."

"I feel very informed now because when the Saliis engineer came out to check them, he explained a lot of stuff to me then. I since went online and learnt a lot more. I don't recall the Executive giving me any information."

Those who had begun their tenancy since the installation of the panels were generally negative about the level of information they had received, although one individual described a more positive experience.

"They didn't inform me how to use the panels. It was the other occupant who was living there before me who said do anything you are doing clothes wise during the day."

"I wasn't in the house when they were put in unfortunately, and there was no information left on them. The NIHE didn't explain the workings of the panels. When I asked, they weren't really knowledgeable on them."

"Someone called out to the house not long after I moved in to explain how the panels worked. They told me the best time to use washing machines, tumble dryers."

Further information about the Solar PV panels

Over half (53%) of respondents said they did not require further information. Of the 46% that would welcome further information, almost all (96%) wanted additional guidance on how to make the most of the panels to maximise their savings. A letter or leaflet through the post (82%) was the preferred method of communication, followed by email (16%) or a visit to their home by Housing Executive staff (9%). Respondents in the follow-up interviews suggested they would like more detailed information about the functioning of the panels and potential benefits:

"I would like information sent out of a yearly rundown of what electric is coming to the house, what is going to the grid and how am I benefiting."

"I have no idea of how many units of electricity have been used since they have been put in. That would be interesting to know; how many units of electricity the panels have managed to capture from this roof. I have no knowledge of that whatsoever."

Figure 4.2. Further information about the Solar PV panels

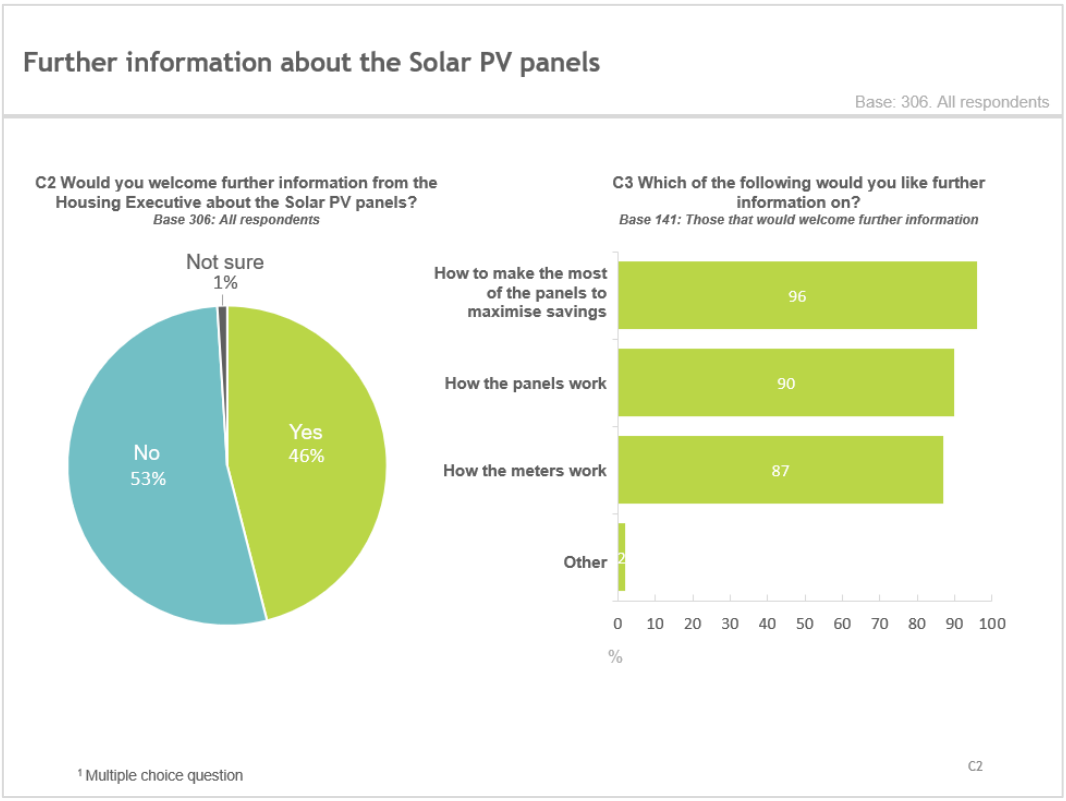
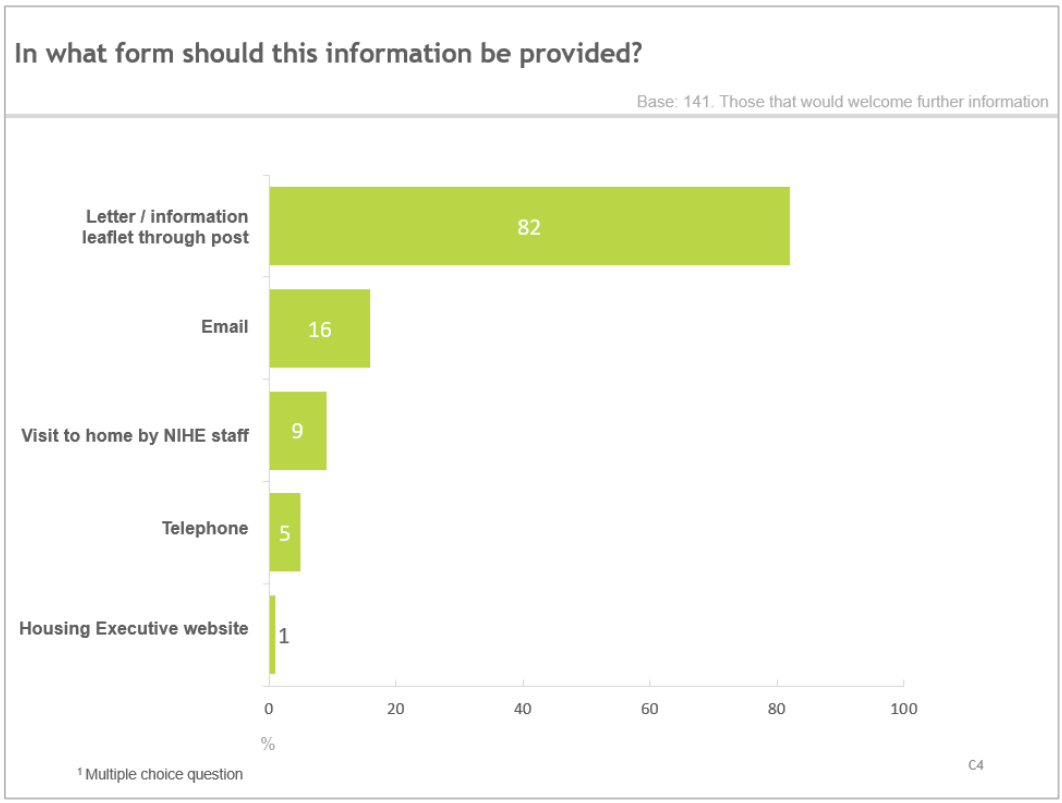


Figure 4.3. The form in which further information should be provided



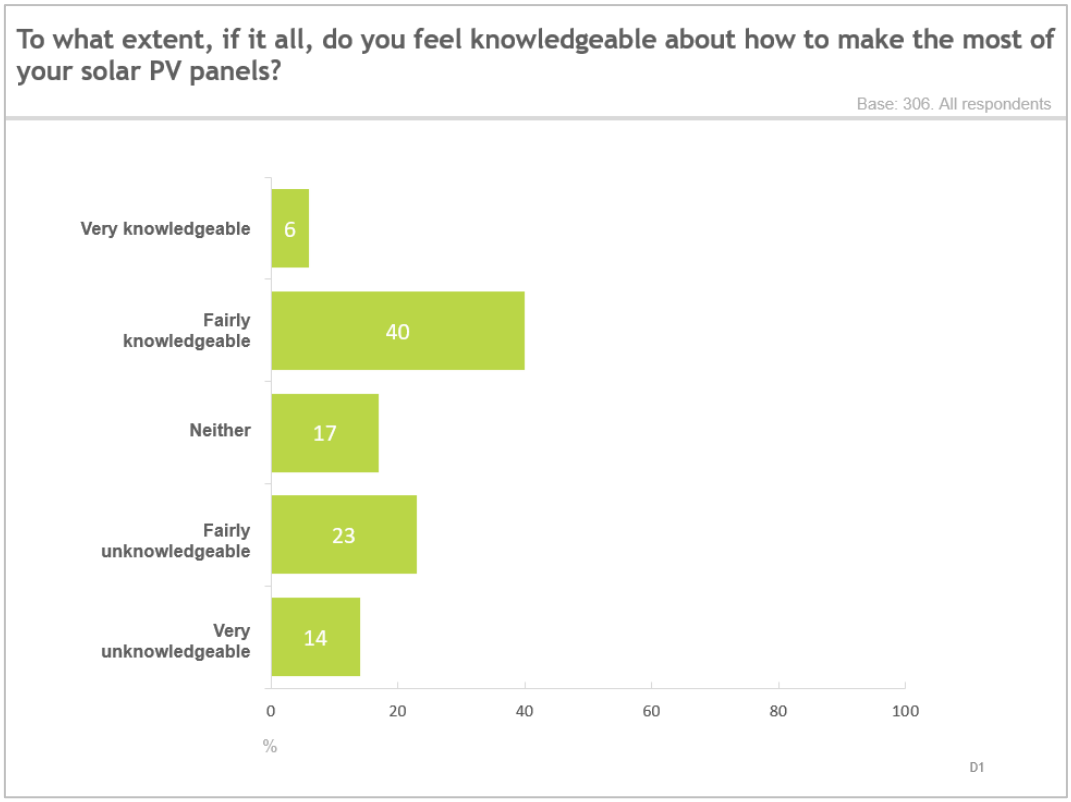
Understanding of solar PV panels

The following paragraphs examine how knowledgeable tenants felt they were about making the most of the solar PV panels in terms of energy usage behaviour, as well as any additional energy saving or efficiency measures taken.

Knowledge of the Solar PV panels

Under half (46%) of respondents reported feeling fairly or very knowledgeable about how to make the most of the solar PV panels. Two fifths (40%) thought they were fairly or very unknowledgeable about the panels. While 17% felt neither knowledgeable nor unknowledgeable.

Figure 4.4. Knowledge about making the most of the solar PV panels



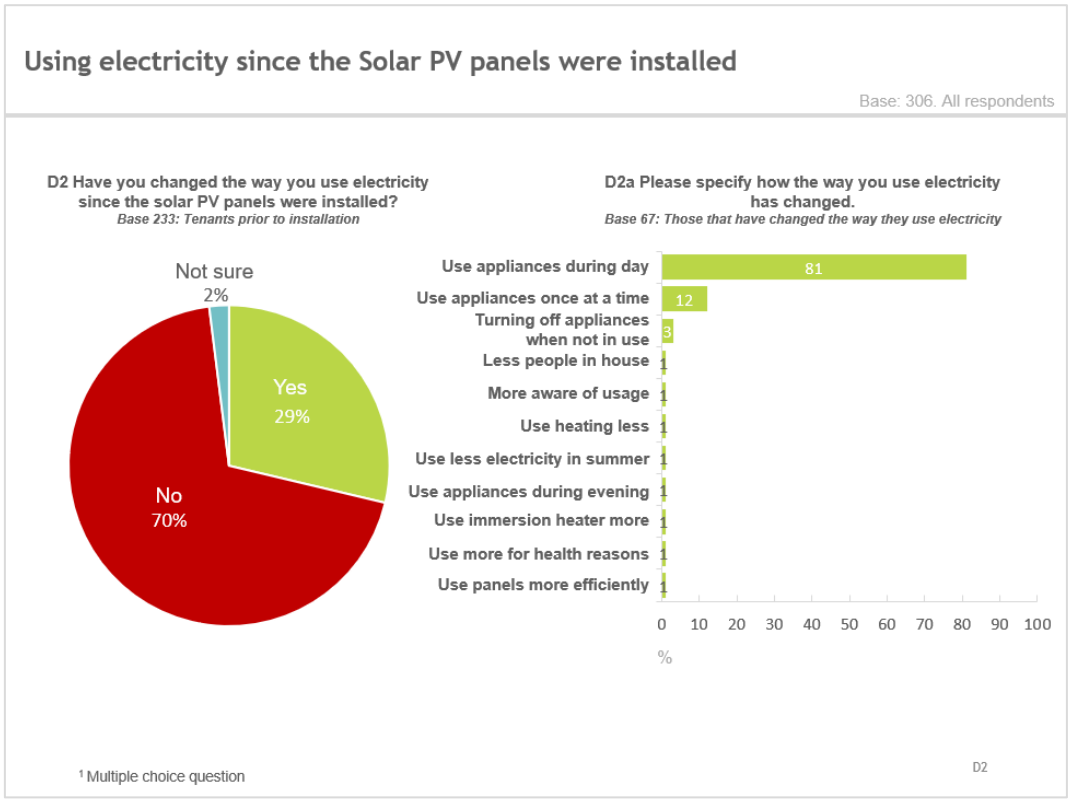
Energy usage behaviours

A minority (29%) of respondents who were living at the property prior to installation reported having changed the way they used electricity since the panels were installed, while over two thirds (70%) had not changed their energy usage behaviour. This may be somewhat reflective of the demographic profile of the households. Many of those chosen to participate in the scheme were of retirement age and likely to have existing energy usage behaviours which were compatible with energy savings through solar PV, such as daytime use of appliances.

Of those that had changed their energy usage pattern, 81% specified that they were using appliances during daylight hours or during sunny periods while eight respondents said they only used one appliance at a time. A number of respondents reported energy usage behaviours that were not consistent with maximising savings from the panels which may indicate a lack of understanding as to how they work

such as ‘using appliances during the evening’ and ‘turning off appliances when not in use.’

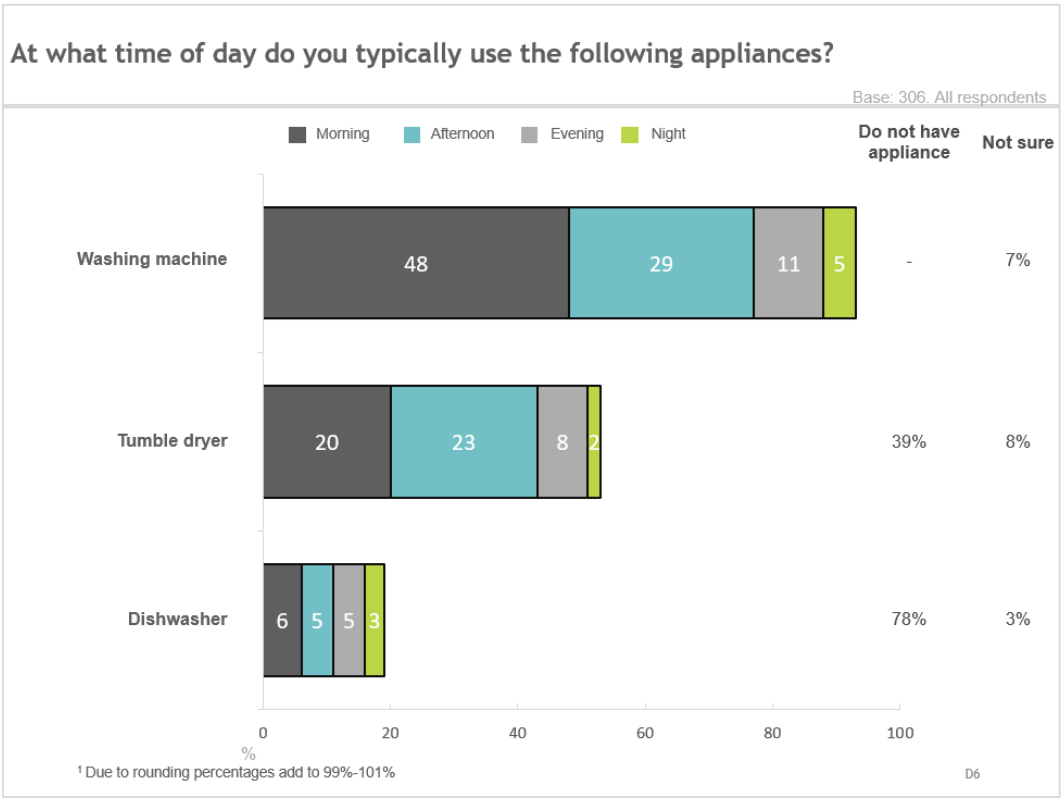
Figure 4.5. Electricity usage since the panels were installed



Respondents were also asked when they used specific household appliances. All survey respondents owned a washing machine, with just under half (48%) using it during the morning and 29% using it in the afternoon. 16% used it during the evening or at night. However, respondents who had moved into the property after installation were much less likely to use the washing machine in the morning or afternoon than original tenants (40% compared to 51% and 25% compared to 31% respectively) and more likely to use it the evening/at night (26% compared to 13%).

Of the 61% that owned a tumble dryer, 20% used it in the morning, 23% in the afternoon and 10% in the evening/at night. Only 22% of households surveyed owned a dishwasher.

Figure 4.6. Appliance usage



The follow up interviews revealed varying levels of understanding of how the panels work and of behavioural change as a result. Some were totally unclear as to the purpose of the panels and others appeared to misunderstand their purpose, stating that they were principally installed to provide hot water or to benefit the NIHE directly.

"I am not actually sure what they do, I take it they supplement my electricity."

"I use my washing machine and dryer in the evenings. If the solar panels are operating during the day, would it be wiser during the day? I don't know."

"Whatever electricity they generate goes straight onto the power grid. I am sure the NIHE must be getting something for it for having them. Apart from that, nothing really."

"The water is brilliant. I wouldn't be without it now. Usually, I would have to put the immersion on for 30 minutes for dishes, but I don't have to think about that now, even in the bathroom."

"I don't touch the panels and don't have anything to do with them, they are just there. They are great for hot water, that's all that I thought they were for; hot water."

A number of respondents were aware that to benefit from the panels, it was necessary to use larger appliances during the day, however they expressed a reluctance to make sure to do so if it did not fit with their existing routine. Others had not needed to alter their behaviour as they already used, for example, the washing machine during the day.

"I am using a lot more of the main stuff that uses electric like tumble dryers and washing machines, things like that during the day which they told me to do. Rather than in the evenings."

"Washing machine goes on in the mornings now. Today, I had the washing machine on a couple of times because the sun was shining. The rest of the time, if it was a grey and misty day, you wouldn't get any free electric. I wouldn't use washing machines then if possible. I will wait until it is a good day."

"All I know is that during daylight hours, if you are using the washing machine, the solar units would be used for your equipment."

"I use appliances when I use them. We don't work to timetables anymore since retirement."

"I would have used my washing machine during the day anyway."

"They tell you things like 'run your washing machine and tumble dryer separate' but I never think of them, they are there and that is that."

Others appeared to have more detailed knowledge of how benefits could be maximised with the addition of storage technologies and awareness of the wider societal benefits to renewable energy.

"They convert sunlight into energy, that is all I know about it. The thing they are really missing is that if they had batteries for them, I could save it up and use it more."

"Big organisations are meant to be reducing their use of electric, gas, oil, all of these fuels and going towards alternative sources of energy production i.e. solar, wind and other environmentally so called ways of producing it."

Energy efficiency and saving measures

Nine out of ten (90%) tenants had not undertaken any additional energy efficiency or saving measures since the panels were installed. Installing energy saving lightbulbs and appliances and using appliances during the day were common responses by the 10% who had taken additional measures.

However, most respondents did still engage in several energy efficiency and saving techniques. When asked separately if they engaged in a number of specific energy usage behaviours, 88% said that they switched off lights and other appliances when they are not needed, 77% only used as much water as they need when filling the kettle, 76% had energy efficient appliances and 72% washed their clothes at a lower temperature. Only 2% said they did not engage in any of these behaviours. While these behaviours do not contribute savings through the solar PV panels, these responses nevertheless demonstrate that participants in the scheme are otherwise mindful of conserving energy. In addition, 76% of respondents reported using large appliances during daylight hours rather than during the evening or at night. This finding reflects positively on householder understanding of how to best use the panels.

Figure 4.7. Additional energy efficiency measures since the panels were installed

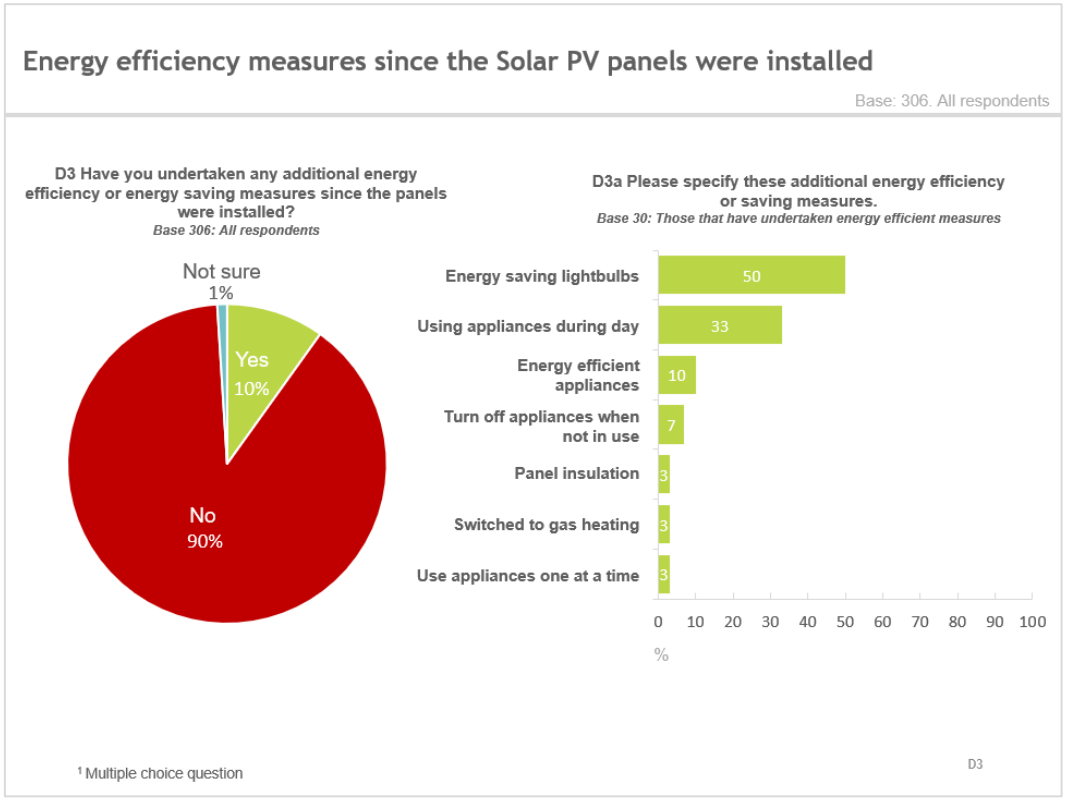
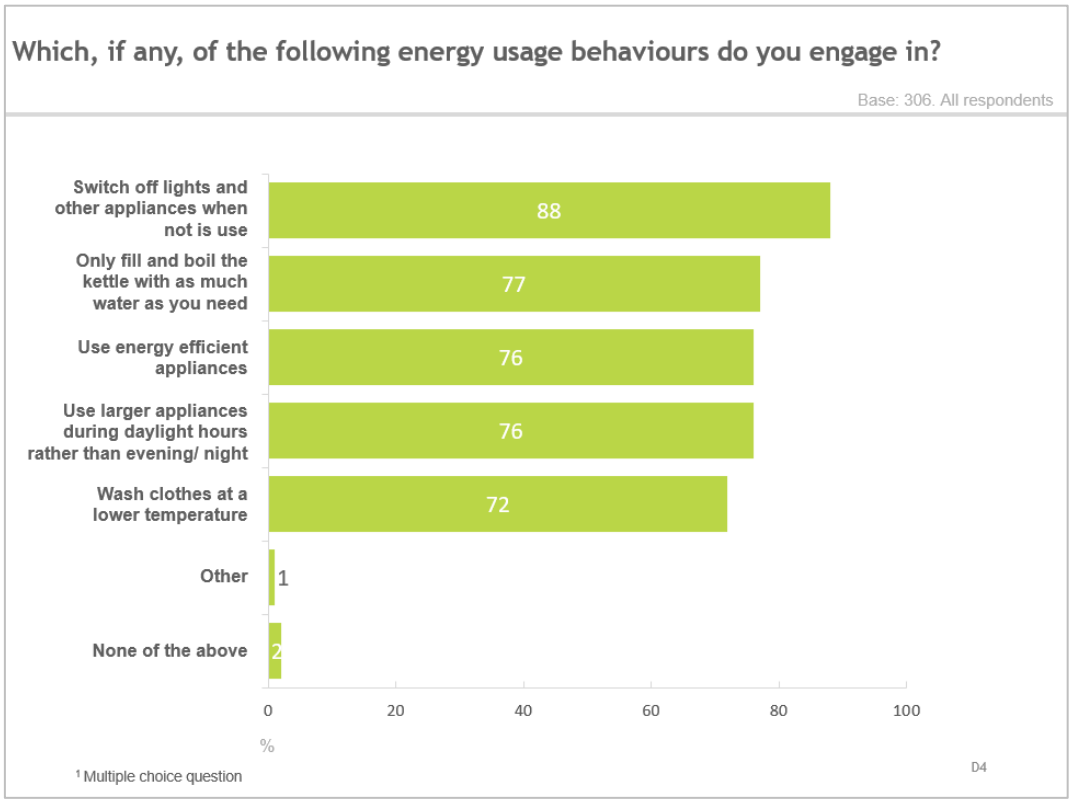


Figure 4.8. Energy usage behaviours



General experience of Solar PV panels

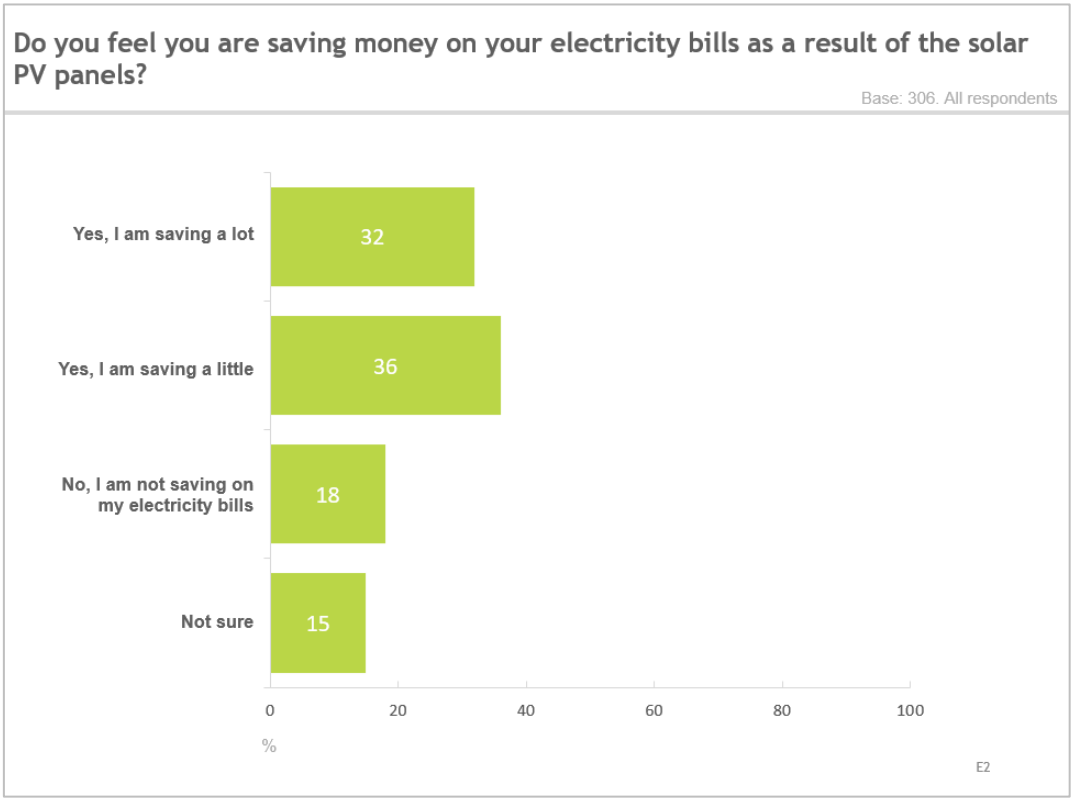
The following paragraphs explore the savings tenants had made since the panels were installed and their overall satisfaction with the scheme.

Perceived savings

Over two thirds (68%) felt that they are saving money on their electricity bill as a result of the solar panels, with 36% saying they were saving a little and 32% reporting that they were saving a lot. 18% felt they were not making any savings on their electricity bills and 15% were not sure.

Again there was a distinction here between those tenants who had been in the property prior to install and new tenants. 30% of new tenants felt they are not making any savings compared to only 14% of the original tenants.

Figure 5.1. Perceived saving on electricity bill



Those who believed they were saving on their electricity bills were asked to estimate their annual savings. While 41% were unable to provide an estimate, one quarter (24%) thought they were saving over £100 and 23% estimated the figure at between £51 and £100. Almost all (95%) of those that reported savings on their bill were satisfied with these savings.

Figure 5.2. Estimated amount saved on electricity bill

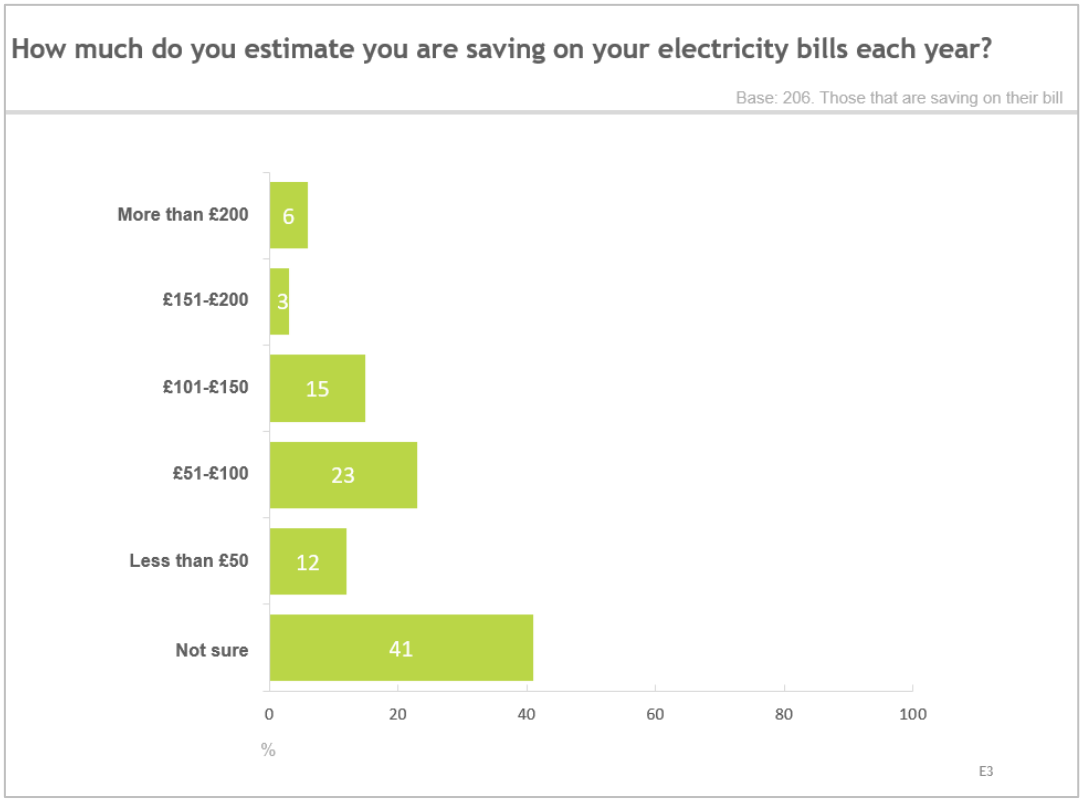
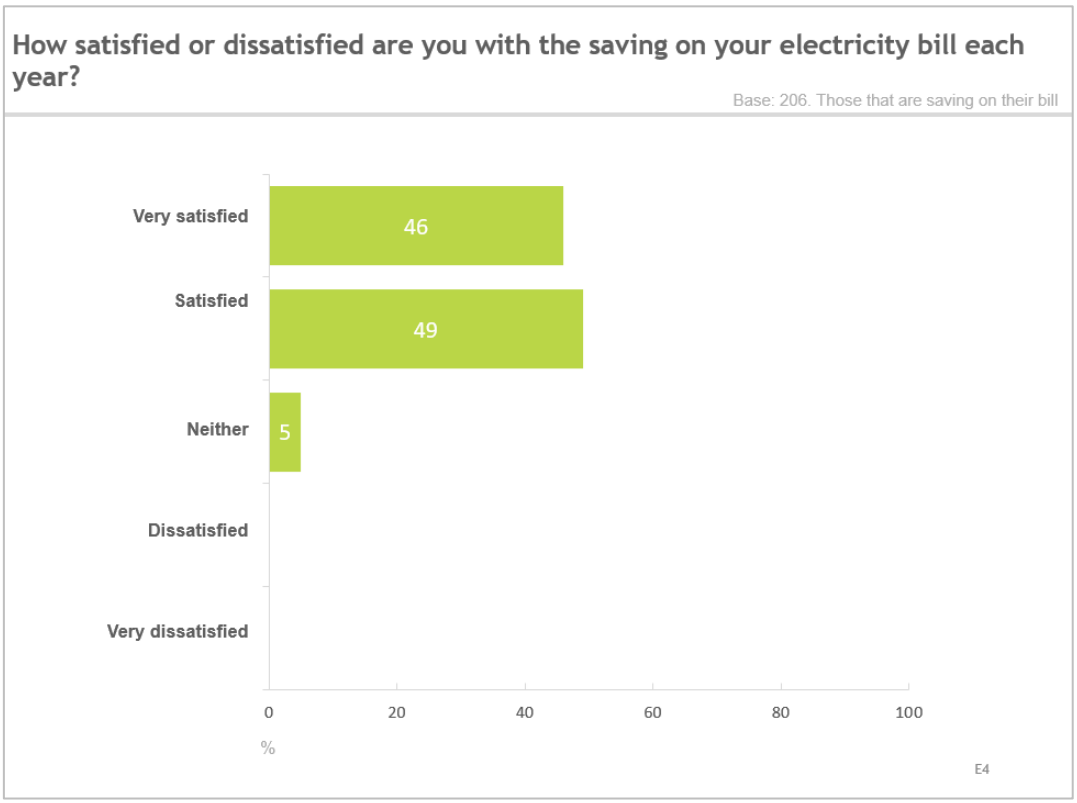


Figure 5.3. Satisfaction with amount saved on electricity bill



A number of participants from the follow-up interviews were very positive about the impact of the solar panels on their electricity bills:

"It is very good. Once it comes to spring, that is when you start to notice a difference in your electric bill. You are saving. I don't keep a record of how much I save to be honest."

"I am saving a lot on my electricity as I wash and cook a lot. In the winter I used to put £20 plus in it, now I am only putting around £10 a week in the meter."

"I do notice a difference having the panels in definitely. I would have gone through a lot of electricity when I was living in the bungalow. Because it was such a dull bungalow, I would have to have lights on during the day in all the bungalow. I find now I do not use as much electricity. I was saving maybe £20 a week sometimes."

"During the spring and summer months, our electric bill goes down so much it is unbelievable. During the winter it is not as great, but they make up for it during the summer."

Others felt that they were not receiving any savings benefits or were unable to quantify the benefit as they had nothing to compare their current bills to.

"I don't really benefit from them. I work all day and they are meant to be used during the day. I am not really getting the benefit. So, whoever owns them is essentially getting the money back."

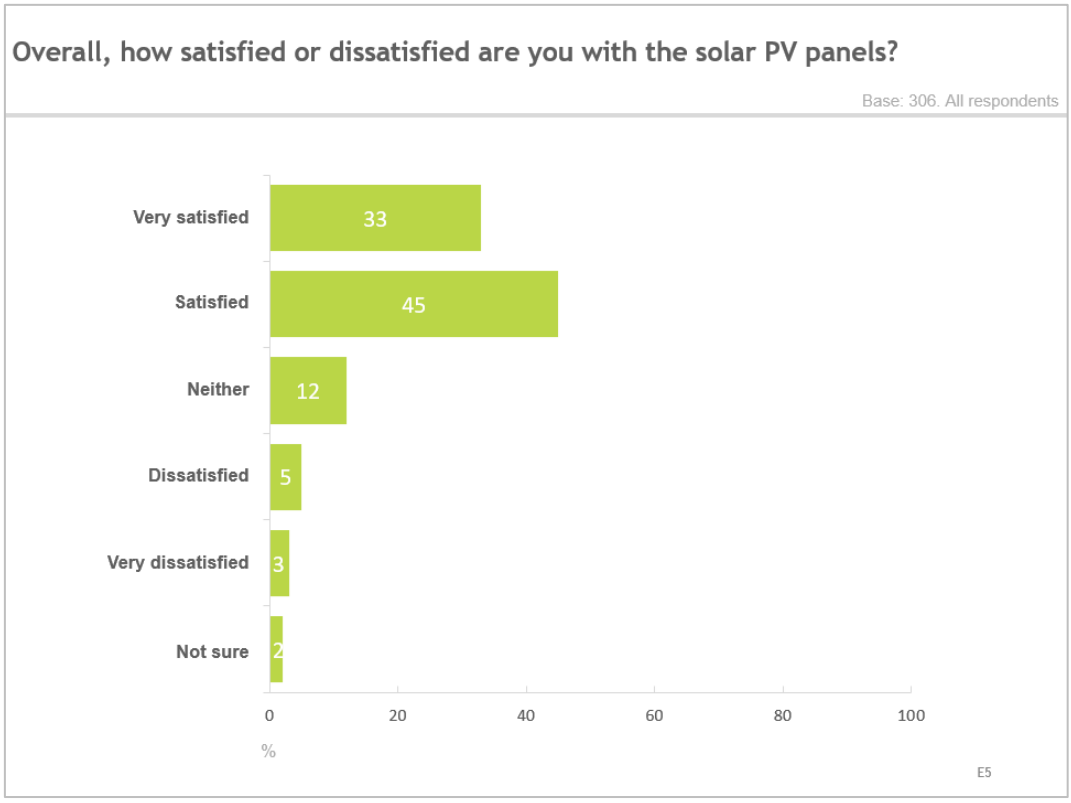
"I don't see any difference in them. I don't see any savings."

"I don't know to be honest as the panels were here when we moved in, I have nothing to compare them to. As far as I know, I am putting around £10 a week into the meter. I don't know whether that is good or bad or whether I should be putting less or more in."

Satisfaction with the Solar PV panels

Over three quarters (78%) were satisfied or very satisfied with their solar PV panels, compared to 8% who said they were dissatisfied or very dissatisfied. Again, a higher proportion of new tenants were dissatisfied or very dissatisfied with the panels than original tenants (13% compared to 6% respectively). When asked why they were dissatisfied, 15 respondents said it was because they felt they were not saving any money on their electricity bills, while five respondents said the panels were not working or were not switched on. Three respondents were unsure of how to use the panels, and a further three respondents said they had caused water damage.

Figure 5.4. Satisfaction with the Solar PV panels



Participants in the follow up interviews were asked to describe what worked well or did not work well about the scheme in their view. A number were positive about the impact that the scheme had had on their household:

"You don't have to put your oil on as much because you don't have to put your oil on to heat the water, you just have to use the switch in the kitchen, and it works great now. It is all electric. I would use the oil for heating the house or something."

However, others described specific problems with the system or a lack of perceived benefit from the panels:

"We do not get any benefit from them, we do not get a discount on our electric, no one has ever been out to inspect them. Nothing has worked well."

"It is just the same as what it always was. They told me at the start that we would be saving money but I think it was only a spoof to get someone to put the panels on the roof. I don't see any difference."

"…there were 40 pigeons living in beneath them. You couldn't walk out the front without getting a hat because you would be scared of getting excreted on. It took them nearly a year to get that sorted. They ended up putting a mesh thing around the panels."

"I have only one complaint about it, they put the meter board thing in the attic. I cannot get in and out of the attic, I am disabled, there is no way I can get in and out. My son has the most awful job trying to get in and out. It is directly beside the trap door."

Again participants in the follow up depth interview were asked if they had any advice for how a similar scheme in the future could be improved. It was suggested that more information should be provided about how well the panels were functioning and the levels of household usage. The responses included concerns around the equity of the scheme, that is, that only a select number are currently benefiting from it and noted that the benefits to tenants could be increased through hot water storage.

"They need to make sure that they read the person's electricity meter the day before they come and install them so that the person has an accurate reading of their electricity usage prior to installation. Also, at least give people some information about how many units they have made and what they have gained. I don't even know if they can assess that under the scheme, but they do know how many units of electric that the panels have produced for each individual house because there is a meter box up in the loft."

"I would advise that all the houses and bungalows, especially the elderly, should receive something like this. Especially, those living on old age pensioners benefits. It can be quite costly for anyone living alone. It should be a scheme offered to everybody. If they are doing new builds, the solar panels should be put in straight away definitely."

"Some solar panels can actually heat water, something to do with that would be very good as well. It would also be a great job if they could send us a few pounds, if we have them on our house. That would be a bonus and very helpful."

"They could let us know and give us some advice on them to let us know what is going on. They tell us nothing about it."

"They need to have more communication to make people aware this is a scheme that they could be picked for and inform and discuss with them. Tell them the good and the bad points, whatever it is."

"There are only two houses on the street that has them. They were supposed to install them on all the bungalows on the street but for some reason they have done two and stopped at that. There are about 25 bungalows on the street."

Participants in the follow up interviews were also asked if they would recommend participation in the scheme to someone else. Responses largely depended on whether the householder felt they were benefitting in respect of bills savings:

"I live in a bungalow and that is probably why they put them on. My neighbour does not have them who is a pensioner and home all day; it would be more beneficial for them."

"Not particularly, I don't think it is of any advantage to the householder. It may be of some advantage to the Executive on the whole."

"Definitely. I know there are a lot of people out there struggling because of the pandemic. A lot have lost their jobs or are on furlough and every little helps. That is the way I look at it. If it is helping them save in some way, as I know it puts a lot of pressure on a lot of families."

“Yes, whole heartedly. There are four houses on the road and three are still Executive houses. They were offered the panels and they said no, they are both now regretting it. They thought they were going to be a lot of hassle and bother but they weren’t.”

Opportunity to utilise Solar PV

The following paragraphs look at the number of people in the household during the day. The findings in this section will indicate the opportunity that householders have to utilise the energy generated. It should be noted that the impact of Covid-19 and national lockdown restrictions had a significant impact on this section of the survey. Initially respondents had been asked about a 'typical' day; however, most answered in respect of their lifestyle at the time of the survey, during the pandemic. Therefore, this question was replaced with two separate questions looking at pre- and during Covid-19. As such, the bases in this section are smaller to reflect this change. 228 respondents were asked the replacement questions.

Time spent at home before and during the Covid-19 pandemic

Respondents were asked how many people would have been at home at various times of the day before the start of the Covid-19 pandemic and then during it. Almost four in five (79%) households had at least one person at home in the mornings (8am to 12pm), but this rose to 97% during the pandemic, with just 2% of homes being empty at this time. Between 12pm and 4pm, respondents indicated 72% of households would have been occupied by at least one person pre-pandemic, rising to 96% during the pandemic. Across the day (8am to 4pm), 80% of respondents reported their household would have had at least one person at home before the pandemic, which had risen to 96% during the pandemic. Only 18% said their home would have been totally unoccupied between 8am and 4pm prior to the pandemic. These findings indicate that the households selected for the study had considerable opportunity for daytime use of electrical appliances.

Figure 6.1. People in home between 8am and 12pm

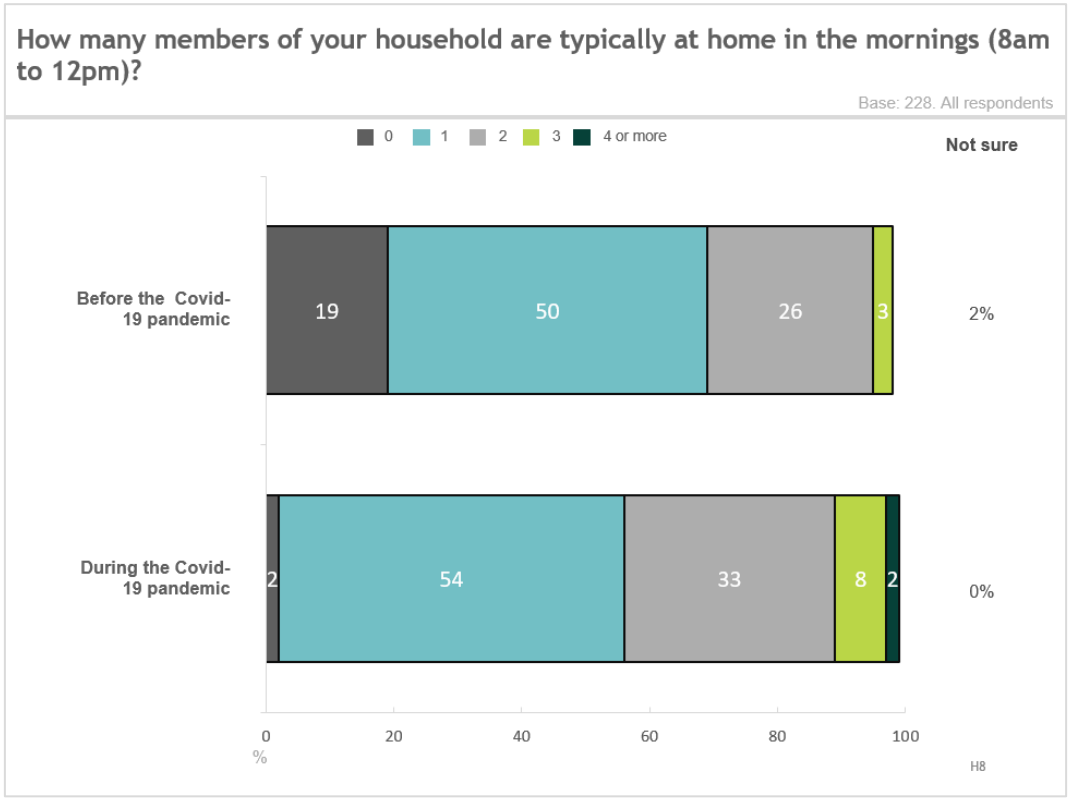


Figure 6.2. People in home between 12pm and 4pm

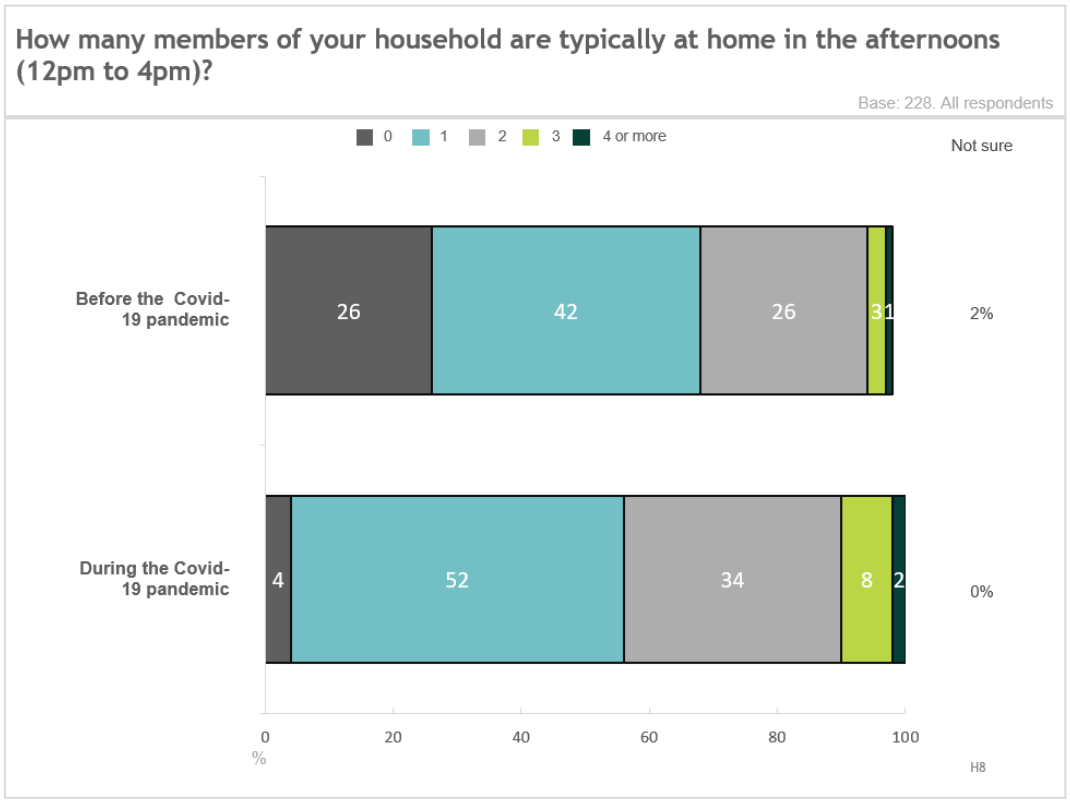
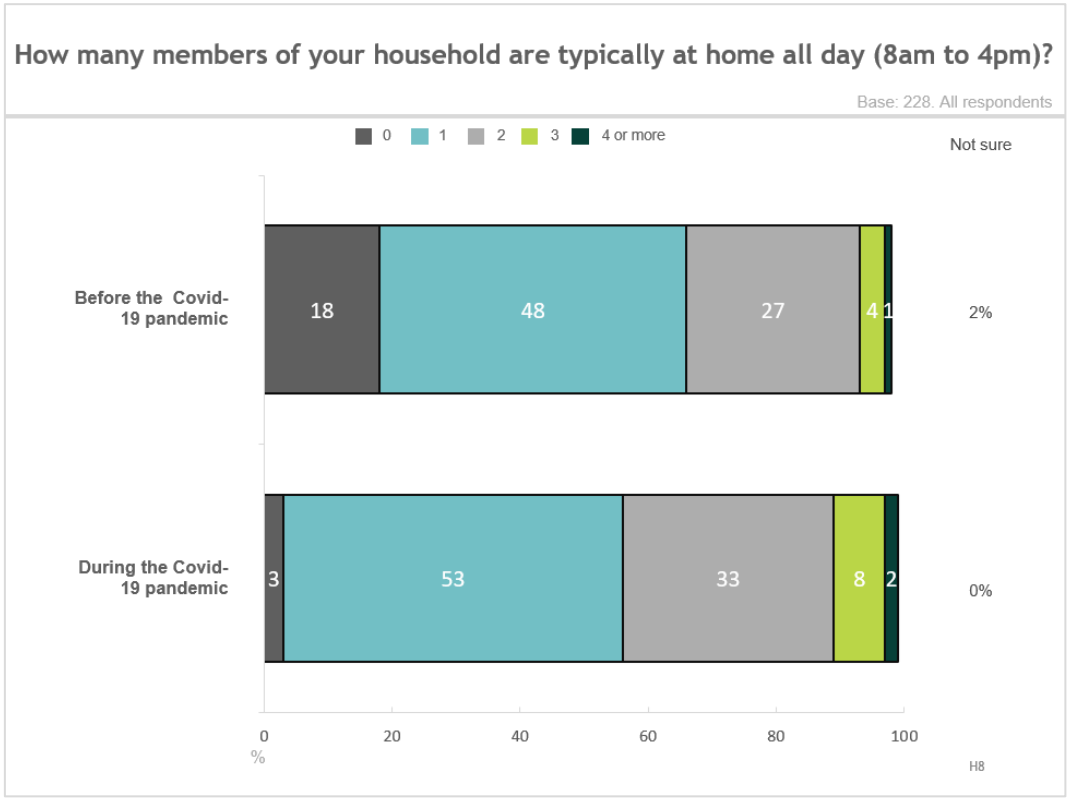


Figure 6.3. People in home between 8am and 4pm

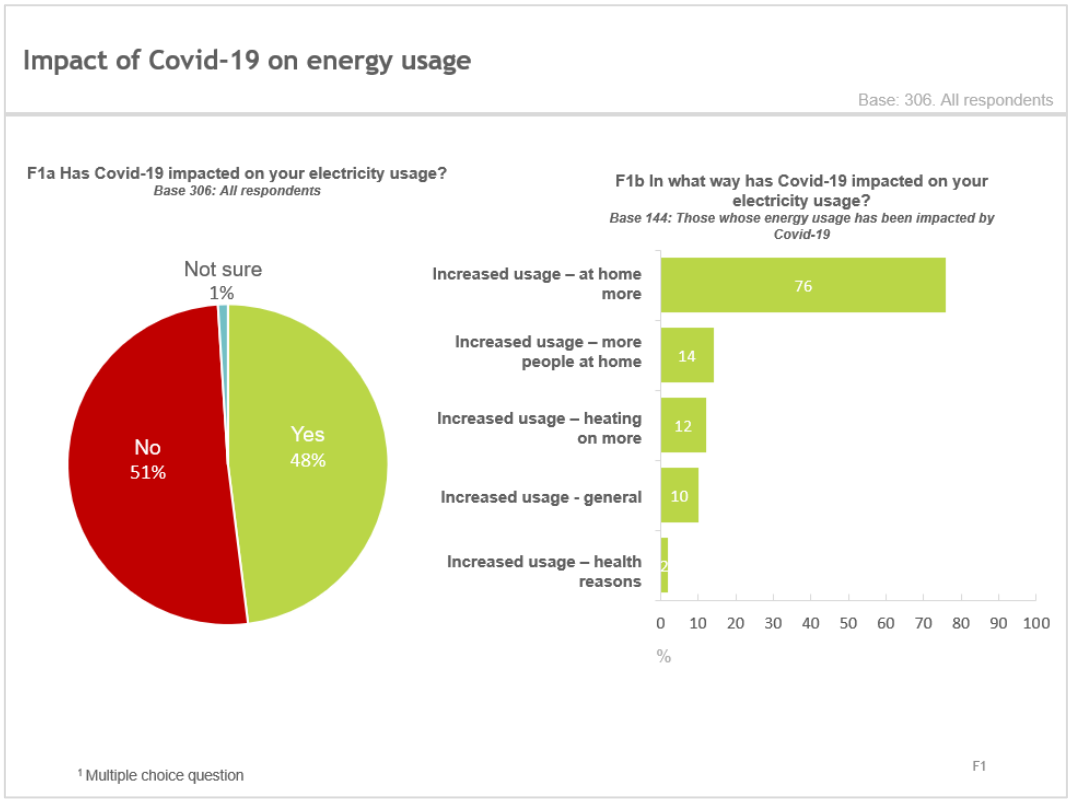


Covid-19

Impact of Covid-19 on energy usage

Just under half (48%) of respondents reported that their electricity usage had been impacted by Covid-19, compared to 51% who had seen no change. All those who had seen a change said that there had been an increase in their usage. Reflecting the findings from the previous paragraph, nine in ten (90%) said this increase was due to there being more people at home, with several respondents saying that household members who would previously be out working during the day were now working from home. 12% also mentioned they had their heating on more. While householders may have been at home more during the day to utilise the electricity generated by the panels, it is unlikely that this benefit will have fully offset the increased fuel costs in the winter months.

Figure 7.1. Impact of Covid-19 on energy usage



Estimated annual bill savings

The following section assesses the impact solar PV panels have had on householder electricity bills.

Methodology for calculating savings

The purpose of the exercise was to estimate the annual energy bill saving to tenants due to the solar PV panels for the years covered by the scheme to assess impact on fuel poverty. Perceptive Insight was provided with 1,007 addresses for households that participated in the scheme. Over a third (34%) of those households were located in the most deprived quintile of the NI population according to the Multiple Deprivation Measure.

Figure 8.1. MDM quintile distribution of households included in the scheme

MDM Quintile	Number	Percentage
1 - Most deprived	339	34%
2	283	28%
3	231	23%
4	104	10%
5 - Least deprived	50	5%
Total	*1,007*	*100%*

In order to calculate estimated annual bill savings, generation and export data were obtained from Saliis Ltd. Generation data can be read remotely via a portal with both daily and cumulative readings available. Export meter readings, however, must be done manually and in the initial years of the scheme, readings were not required as a deemed figure of 45% of generation was used by Ofgem (on behalf of the Utility Regulator) and NIE Networks to calculate export payments. The approach subsequently changed and in 2018 a manual reading was required. Therefore, a cumulative export reading is available for most of the properties involved in the scheme for spring 2018.

In calculating the average annual saving, an average domestic retail electricity unit price was calculated for the years covered by the available meter readings, sourced from the Utility Regulator's Annual Transparency Reports.[71] The value used was 15p per unit. The current unit value is approximately 18p per unit, however the average price has been used to be indicative of the actual average annual saving experienced by householders over the lifetime of the scheme.

[71] https://www.uregni.gov.uk/market-information

Figure 8.2. Domestic retail unit price by year and semester

Year	Semester	Unit price
2018	S1	14.6
	S2	15.6
2017	S1	14.1
	S2	14.2
2016	S1	15.3
	S2	13.9
2015	S1	16.6
	S2	15.7
Average 2015-2018		15

The steps taken to estimate annual savings are as follows:

- Cumulative generation reading obtained for March 2018 (A);
- Cumulative export reading obtained for March 2018 (B);
- (A) subtracted from (B) to provide the number of units utilised by the household in kWh (C);
- (C) divided by number of months between install and meter reading date, then multiplied by 12 to provide estimated annual usage (D); and
- D multiplied by 15p to provide estimated annual saving.

It should be noted that the methodology used does not account for:

(a) Changes to supplier and/or tariff changes for individual households pre- and post- installation; or

(b) Increased consumption by a householder pre – and post-installation either due to a change within the household (for example, increase in occupants) or due to a misunderstanding about how to benefit from the panels.

Therefore, there may be instances where the calculated annual saving and that actually experienced by a householder differ.

Sample outliers

While generation and export readings were obtained for most of the 1007 addresses provided, there were several instances where this data was not available or potentially incorrect or misleading, and so these have been excluded from the analysis in this section.

To minimise the impact of household changes on savings estimates, only those properties with a consistent tenancy from pre- to post- installation were included in the analysis; 212 properties had experienced a change of tenancy, were unoccupied or had been sold. A further 93 households had incomplete meter reading data (generation and/or export data missing) or had exported more energy than was generated, which is not possible and indicated a meter fault.

The annual amount generated by the panels and the percentage of generated electricity utilised by households was then examined to identify any outliers in the remaining sample. The panels of four households appeared to have generated more than 4000 kWh per year, while 12 appeared to have generated less than 2000 kWh

per year. Based on an average panel size of 3.75kWp with expected annual output of approximately 3200kWh,[72] it was determined that these readings were likely to be a result of faulty meters and excluded from analysis. Thirteen households were excluded for having utilised more than 75% of the electricity generated, which would not be possible in the absence of additional storage technologies and therefore this percentage was likely to be due to a faulty meter. Analysis was therefore based on a sample size of 655 remaining households.

Figure 8.3. Amount of PV generated electricity (tenants prior to installation)

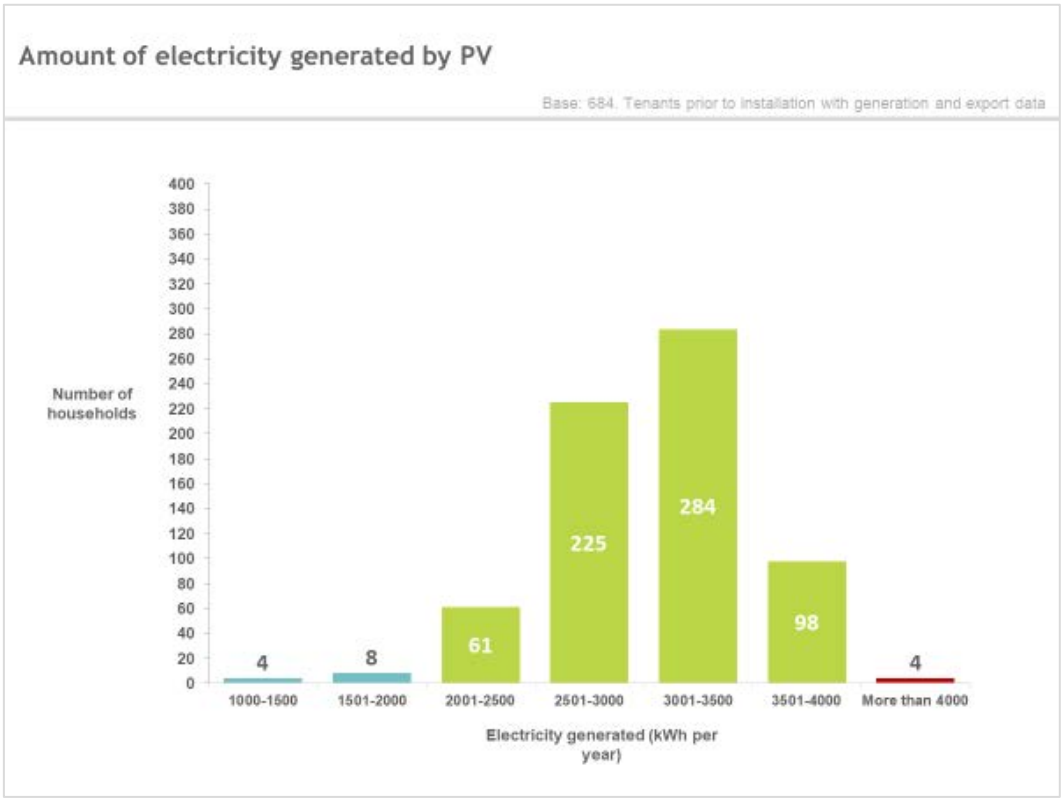
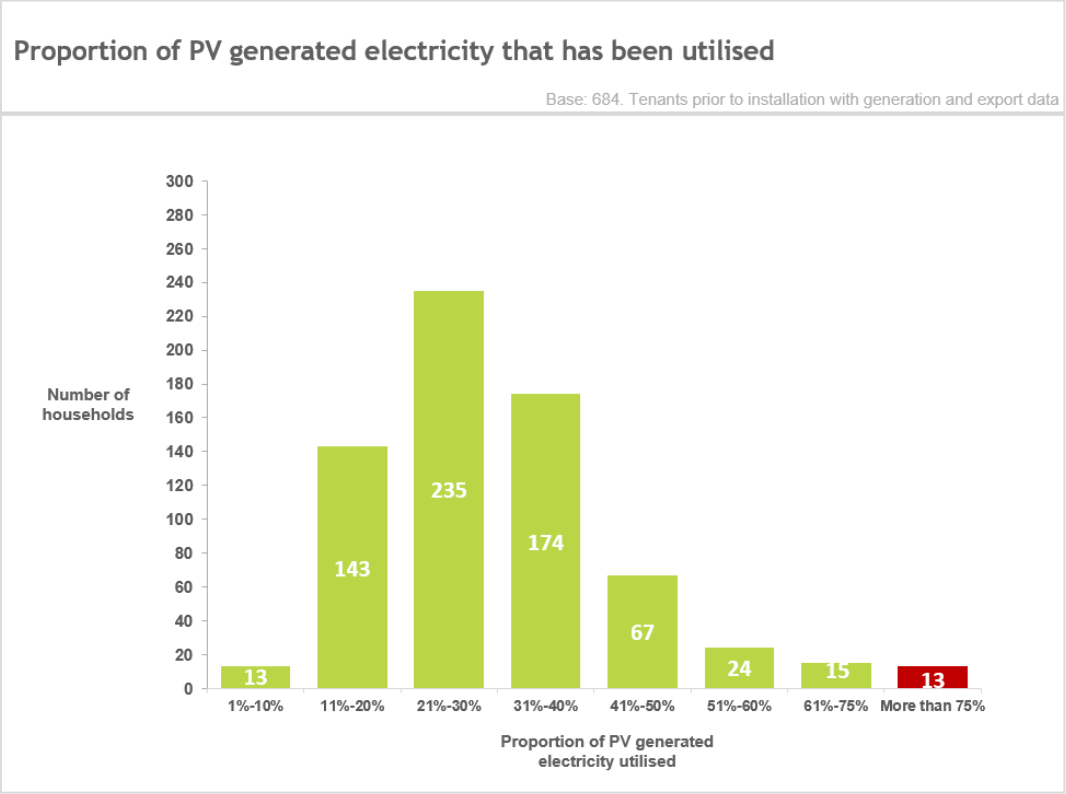


Figure 8.4. Proportion of PV-generated electricity utilised by households (tenants prior to installation)

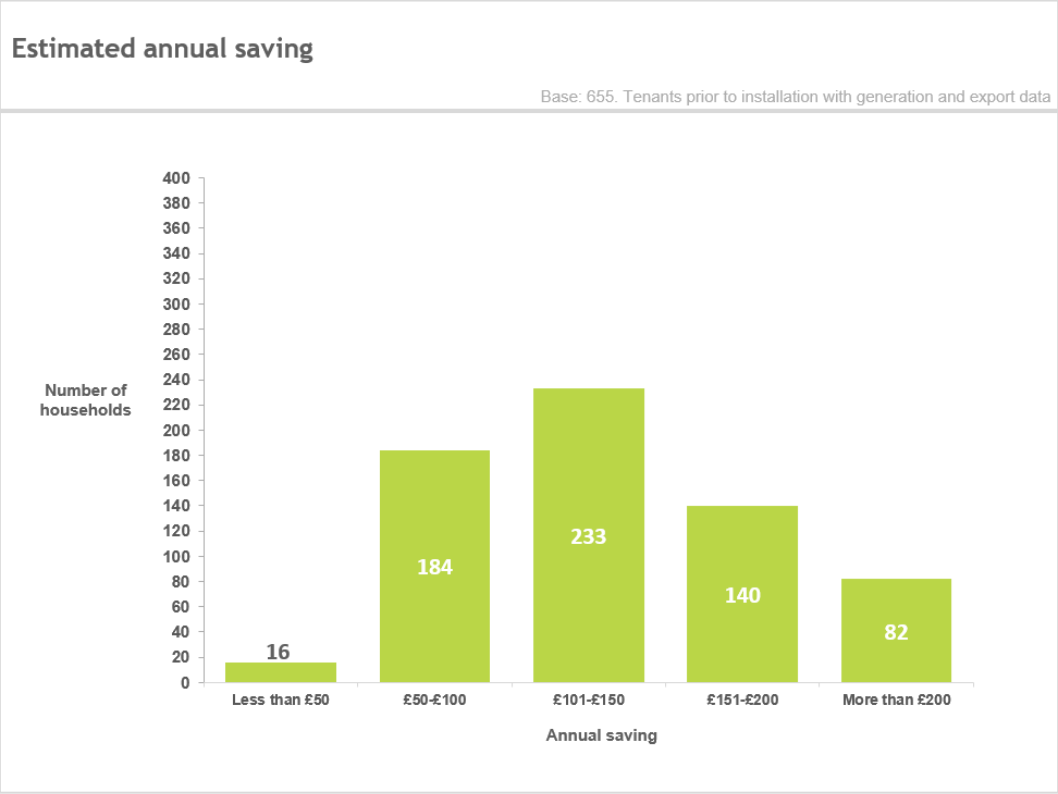
[72] Based on Energy Saving Trust Solar Energy Calculator at most preferable orientation https://www.pvfitcalculator.energysavingtrust.org.uk/



Estimated bill reductions

According to the generation and export data, 233 (36%) households had experienced annual savings between £101 and £150 due to the panels, 140 (21%) households have saved £151-£200 annually, with 82 (13%) saving more than £200. However, 184 (28%) saved between £50 and £100 annually and 16 (2%) saved less than £50.

Figure 8.5. Estimated annual savings



Average estimated bill savings

On average, the estimated bill saving post-PV installation was:

- £134.95 per year for 655 households

Median estimated bill savings

The median estimated bill saving was:

- £123.54 per year for 655 households

Estimated bill savings range

- The minimum estimated saving was £11.41 per year
- The maximum estimated saving was £362.05 per year

Average estimated savings per kWp

The average estimated saving per installed kWp based on the average panel size being 3.75kWp was:

- £35.98 per year for 655 households

The table below illustrates the savings that may be possible when using different sizes of panel based on these averages.

Figure 8.6. Estimated savings based on different panels sizes

	1.5 kWp	2 kWp	2.5 kWp	3 kWp	3.5 kWp	4 kWp
Base: 655	£53.98	£71.97	£89.96	£107.95	£125.94	£143.93

Proportion of PV generated electricity utilised

The average and median proportion of the PV-generated electricity that was utilised by households is detailed in tables 8.7 and 8.8 below.

Figure 8.7. Average electricity generated per year

Base: 655	kWh	kWh/kWp
Mean	3059.482	815.862

Figure 8.8. PV generated electricity utilised per year

Base: 655	kWh	kWh (%)
Mean	899.589	29%

Impact on fuel poverty

The House Condition Survey 2016 found that average household fuel costs in Northern Ireland were £1,500 per annum. However, the average annual fuel bill of the sample under evaluation is likely to be lower than the regional average, given the demographic profile of the households selected for participation in the pilot scheme (as indicated by the tenant survey findings i.e. social housing tenancies, pensionable age, single occupancy). Given this, an average electricity bill saving of £134.95 per year is likely to equate to a minimum 9% bill reduction for those households included in the scheme.

It should be noted however, that calculated savings varied significantly, with 16 households saving under £50 per year. This indicates that the savings potential of solar PV is very much dependent on a household's electricity usage behaviour and lifestyle. The average proportion of solar generated electricity utilised was lower than had been assumed at the outset of the pilot (29% rather than the expected 50%), which indicates that additional efforts should be made to inform and encourage householders to adjust their energy usage patterns for optimal benefits. In addition, the findings indicate that a considerable number of the panels may be performing less effectively than had been anticipated, with 44% of households included in the bill savings calculation generating at or below 3000kWh per annum.

Conclusions and recommendations

The following section outlines a number of conclusions and areas for further consideration by the Housing Executive based on the survey findings and views of the various stakeholders.

Consultation and installation process

While the majority of those surveyed (55%) felt that the Housing Executive had sought their views fairly or very well about the scheme prior to installation and two thirds (65%) said that the Housing Executive had kept them fairly or very well informed about the installation process, the depth interviews indicated that consultation prior to installation had been minimal and that a letter sent to short-listed households had caused confusion in some cases. It was acknowledged by the Housing Executive, that if a future scheme should be commissioned, efforts would be made to better manage the expectations of households in respect of their selection for the scheme. It is suggested that improved face-to-face consultation by NIHE staff with short-listed households at the outset of the process would be beneficial to ensure tenant buy-in and allow tenants to raise any concerns or queries at an early stage.

Conversely, 97% of respondents were fairly or very satisfied with the installation process, with only isolated reports of leaks. This finding aligns with the view widely stated in the literature and held by sector stakeholders that solar PV installation involves minimal disruption to householders.

Information provided about the panels

Just under half (46%) of respondents reported not having received any information or guidance from the Housing Executive about the solar panels, however this rose to 79% of respondents who had taken up their tenancy after the panels had already been installed. Overall, 46% said they would welcome further information with almost all of these (96%) wanting additional guidance on how to make the most of the panels to maximise their savings. This is consistent with the finding that under half (46%) of respondents feel fairly or very knowledgeable about how to make the most of the solar PV panels.

While the NIHE did provide an A5 leaflet and fridge magnet with useful “dos and don’ts” in respect of the panels to tenants at the time of install, it is again suggested that face-to-face instruction may be more impactful. Of those participants in the follow-up interviews who spoke about information received, it was usually in reference to a visit and demonstration from Saliis personnel rather than the Housing Executive. It is also suggested that follow-up reminders at intervals may be useful to support tenants to make money saving changes. There appears to be a particular

shortfall in information and explanation provided to new tenants. It is suggested that additional checks are put in place to ensure that information and guidance on how best to use the panels are provided as standard at the beginning of any new tenancy in a property involved in the scheme.

Understanding of the panels and energy usage behaviours

Only 29% of respondents who were living at the property prior to installation reported having changed the way they used electricity since the panels were installed, while over two thirds (70%) had not changed their energy usage behaviour. However, 76% of all respondents reported using large appliances during daylight hours rather than during the evening or at night which reflects positively on levels of understanding of how to benefit from the panels. At the same time, over a quarter (26%) still reported using the washing machine in the evening or at night. Despite evidence of energy usage behaviours which were consistent with best practice in respect of solar PV panels, analysis of generation and export data indicated that households were only utilising on average 29% of the solar PV electricity generated. This is somewhat below the 50% anticipated and indicates that improvement could be made, particularly in light of the finding that prior to the pandemic, 80% of survey respondents' households had at least one person at home during the day (8am to 4pm).

It is therefore suggested that any future solar PV installations should include a device to provide a visual prompt as to when the panels are generating electricity and, as such, when appliances should be used or turned off. These devices would assist householders to feel more informed and in control of their energy use and bill savings. It is further suggested that participating householders could be provided with information about how much electricity the panels are producing and how much of this they are utilising, again to reassure householders of the effectiveness of the panels and allow them to adjust their behaviours to maximise benefits.

Perceived savings and general satisfaction

Over two thirds (68%) of respondents felt that they were saving money on their electricity bill as a result of the solar panels. While 41% of those who felt they were saving were unable to estimate by how much, one quarter (24%) thought they were saving over £100 and 23% estimated the figure at between £51 and £100. Almost all (95%) of those that reported savings on their bill were satisfied with these savings. Over three quarters (78%) of all respondents were satisfied or very satisfied with their solar PV panels, compared to 8% who said they were dissatisfied or very dissatisfied. Again, a higher proportion of new tenants were dissatisfied or very dissatisfied with the panels than original tenants (13% compared to 6% respectively).

It is positive that the majority of those surveyed felt they were saving money on their energy bills; however, it is concerning that almost a fifth (18%) of all respondents and almost a third (30%) of new tenants felt they were not making any savings. This perception could in part be due to the way in which solar panels function, as highlighted by the stakeholder interviews, in that the panels are generating electricity most effectively in the summer when financial stress due to fuel bills is lowest, and not producing in the winter when fuel costs are highest. It is noteworthy that interviewing for the study took place in January and February. However, as noted

earlier in this section, it also appears that tenants, especially new tenants, could be better supported to improve their savings through behavioural change.

Effectiveness in tackling fuel poverty

An assessment of generation and export data for a sample of 655 properties, where the same tenant had lived in the property since installation, indicated that the following bill savings could be attributed to the panels:

Average estimated annual bill saving
£134.95

Median estimated annual bill saving
£123.54

The calculation did not account for changes in supplier or tariff pre- and post-installation or an overall increase in energy consumption due to a household change or misunderstanding of how the panels function; therefore these savings may not totally align with those actually experienced by householders before and after installation. It is suggested that the median value may be a more accurate indication of the saving actually experienced by most tenants when considering the distribution of savings across households (see figure 8.5.). It should also be noted that there was a considerable range in the savings calculated, with the minimum saving being £11.41 per year and the maximum saving being £362.05 per year. 16 households produced savings of under £50. Therefore, the effectiveness of the panels to address fuel poverty will vary significantly depending on householder behaviour and lifestyle. It was strongly suggested in the stakeholder interviews that any future scheme should include the installation of a hot water diverter to increase the savings to tenants through thermal storage, in a manner which does not require any specific action from individuals.

Considerations of equity and fairness

The scheme has been effective in targeting householders within the profile more likely to be impacted by fuel poverty as identified by the HCS 2016, namely: those aged 65 and over (49% of survey respondents); households which include an individual with a long-term disability (63% of survey respondents); those not in work due to retirement, disability or unemployment (86% of survey respondents); and those with oil heating (54% of survey respondents). Of the 1,007 addresses included in the scheme, 34% were located in the most deprived quintile of NI. However, it should be noted that, depending on the load-bearing capacity of the rafters, solar PV panels may not be suitable for older properties, and may not provide a viable solution for householders in energy inefficient older buildings. In addition, solar PV panels are only effective for particular roof orientations and issues of network capacity will limit the number of feasible installations in a locality. This gives rise to considerations of equity and fairness for social housing landlords and it is suggested that the NIHE give consideration to how any future business model for a scheme of this nature might include a method for redistributing the benefits; for example, a revenue stream that can be reinvested in other fuel poverty initiatives.

Going forward, the NIHE should also consider the installation of smaller solar PV systems on a greater number of roofs. The size of the arrays installed under the scheme was largely dictated by the Renewables Obligation Certificates (ROCs) revenue stream and, as such, single-storey properties were generally chosen for participation in the scheme to accommodate PV systems of up to 4kWp. Such systems are substantially larger than required to deliver maximum bill savings to householders as they are unable to utilise a large portion of the units generated. Therefore, 2kWp or 2.5kWp systems could be used instead to reduce the strain on the electricity network and benefit more households.

Challenges for future solar PV deployment within NIHE dwellings

In the absence of a government support scheme, as was in place at the time of installation of the scheme under review, the NIHE will have to identify an alternative and viable business model for the financing of any future installations. This may include covering the initial outlay through existing capital budgets or borrowing at a low rate of interest. It may still be possible to attract third party investor interest through export revenues, however it was beyond the scope of this study to determine the feasibility of this approach. There is, however, an inherent conflict between monetisation of solar panels through exports, and the aim of addressing fuel poverty, as installing diverters or other technologies to enable storage of the solar generated electricity will reduce the amount exported to the network and therefore reduce the potential revenue stream from export payments. Another possible revenue model might include the NIHE's involvement in the energy market through demand side response should a sufficient number of panels be installed. However, it was beyond the scope of the present evaluation to determine if, at present, the infrastructure exists in respect of network capacity, to enable connections of domestic PV installations to the grid at the scale required. It is suggested instead that the installation of zero export installations is a more viable option.

Additional considerations for the NIHE

Given the resource implications for the current installer in terms of accessing export meter readings, it should be considered how this would be managed within any future scheme in the absence of a smart meter roll out in Northern Ireland.

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