Economic and policy advice to support the design and implementation of the new microgeneration support scheme in Ireland

Report for Department of the Environment, Climate and Communications (DECC)

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Executive summary

The Climate Action Plan (CAP) for Ireland published in 2019 sets out the intention to put in place a coherent microgeneration scheme to support the achievement of its target to increase reliance on renewables from 30% to 70% over the period 2021 to 2030[1].

In the Climate Action Plan - although it is expected that this transition will primarily be delivered by the Renewable Electricity Support Scheme - it is specified that an ongoing support scheme for microgeneration should be put in place by 2021 at the latest, to ensure that microgenerators may sell excess electricity they produce back to the grid. According to the CAP, the new support scheme should be underpinned by some key pillars, including:

- Equity and accessibility for all
- Ensuring principles of maximising self-consumption and energy efficiency
- Ongoing technology cost and remuneration analysis
- Addressing technical barriers and planning constraints
- A clear grid connection policy
- Supporting community participation in microgeneration

This report provides research and analysis on the Irish microgeneration market and a range of designed policy options matching the Irish environment. Details include considerations for the development of a microgeneration market price compensation and support scheme for microgeneration in Ireland from June 2021, taking account of the objectives of the CAP in Ireland.

For this purpose, the report provides an:

A. Overview of the main microgeneration technologies in Ireland;
B. Assessment of their costs;
C. Analysis of the viability gap of these technologies in different sectors;
D. Identification of policy options for the Irish microgeneration market through assessment of international best practice;
E. Finally, it provides a review of each of the identified policy options in terms of their effectiveness, costs, funding mechanisms and complexity for implementation to provide a recommendation on the most suitable microgeneration scheme to be introduced in Ireland in June 2021.

A key assessment for any further policy designed is the calculation of viability gaps of microgeneration technologies in different sectors:

Microgeneration technologies have different characteristics that make them more appropriate for use within different sectors. An overview of the suitability of the main microgeneration technologies in Ireland (micro- solar, wind, hydro and CHP) for different sectors is provided in the table below.

Table 1-1 Suitability of technologies by sector

Sector	Solar	Micro-wind	Micro-hydro	Micro-CHP
Domestic				
SME (commercial)				
SME (industrial)				
Agriculture				
Community/social enterprises				

Key	RAG grading criteria
High	None/negligible issues identified with technology within sector
Medium	Technology is appropriate for sector although some issues to address
Low	Technology is not suitable for sector

[1] Government of Ireland. 2019. Climate Action Plan 2019 – To Tackle Climate Breakdown. Available from: https://www.DECC.gov.ie/en-ie/climate-action/publications/Documents/16/Climate_Action_Plan_2019.pdf

Citizen energy communities				
Public buildings (local authorities)				
Public buildings (schools)				

Microgeneration support levels should be set at a level to incentivise the uptake of the technology where there are gaps in the market (i.e. the revenue received from operating the technology does not compensate for the cost of that technology). A balance must be reached between providing a sufficient incentive to cover the difference that exists between the cost of installing a particular technology and the savings that result from self-consumption. This difference is defined as the viability gap.

The results of the levelized viability gap over lifetime of the technology show that none of the archetypes (technology and sector combinations) appear to be financially viable (this would be shown as negative viability gap). It is important to note that the difference between the viability gaps of similar technologies are mainly caused by the difference in discount rates.

Domestic Solar PV is expected to have by far the largest share of uptake under a microgeneration scheme in Ireland. The 2021 viability gap of the domestic rooftop solar is 12 c/kWh, that of the C&I ground mounted solar (which includes SME and agriculture) is in a range of 10-14 c/kWh whereas that of the C&I rooftop solar is about 8-24 c/kWh. The LCOE of the C&I wind technologies ranges between 20 and 26 c/kWh, the C&I hydro is 14-17 c/kWh and the C&I CHP is 9-19 c/kWh.

The viability gap assessment informs the policy design exercise in defining the eligibility criteria, as in principle, only generations with positive viability gap should be subsidised. The assessment also provides information on the indicative level of required support.

Policy identification and assessment

Based on a review of international best practice of schemes to promote microgeneration uptake, a set of five policy option was identified as listed in the table below.

Table 1-2 Overview of five proposed policy option for a microgeneration scheme in Ireland

Policy options	1	2	3	4	5
Smart Export Guarantee for all installations (old and new) based on the UK example	✓	✓		✓	✓
Investment subsidy for new installations as a percentage of total investment costs		✓			✓
Feed-in-tariff based on exported electricity for new installations			✓		
Feed-in-premium for exported electricity for new installations only based on difference between viability gap and smart export guarantee rate				✓	
Different **eligibility criteria** for **increased accessibility**					✓

Each of these five policy options were assessed in terms of their effectiveness, costs, funding mechanism and complexity for implementation, which is summarised in the table below.

Table 1-3 Summary of policy assessments

Assessment indicator	Policy option 1 (SEG)	Policy option 2 (SEG + Investment	Policy option 3 (FiT)	Policy option 4 (SEG + FiP)	Policy option 5 (SEG + Investment

		Subsidy)			subsidy + equity aspects)
Effectiveness	SEG will not meet viability gap. Payments over longer term help de-risk investments in non-domestic sectors and SEG is effective in promoting self-consumption	Addresses main barrier of upfront costs. SEG provides longer-term certainty.	Recognised and understood by the market and thereby addresses finance barrier, but effectiveness heavily dependent on design of FiT and degression profile.	Provides certainty that viability gap is met in any scenario (high or low export levels).	Similar to option 2, with the added benefit that eligibility criteria can be adjusted to address barriers for certain consumer groups. However, it may be difficult to target most vulnerable consumers
Cost assessment	While costs are low, there is a high risk that the viability gap will not be met for 2021-2024. For 2025-2030 costs are 8.4 million EUR per year when the viability gap is met.	Medium uptake scenario costs are 20.9 million EUR per year.	Medium uptake scenario costs are 32.9 million EUR per year	Medium scenario costs are 22.9 million EUR per year, but could be significantly higher if SEG payments are lower than expected	Medium uptake scenario costs are 20.9 million EUR per year, but additional support may be provided for vulnerable consumers
Ability to minimize costs to vulnerable consumers)	Costs only borne by suppliers and potential to be near cost-neutrality	Costs can be recovered either through unit rates or through ring-fenced revenues. Risk that there are high costs upfront for government	None of the costs covered by suppliers, costs likely to either pass through in unit rates or to taxpayers	SEG offered by suppliers, but remaining gap will be assumed to be covered by public sector through PSO levy or ring-fenced revenues	Costs can be recovered either through unit rates or through ring-fenced revenues. Risk that there are high costs upfront for government
Administrative costs and complexity for implementation	Low administrative costs as suppliers set SEG rates	Eligibility for investment grants need to be calculated and level degression over time. Easy to align with existing investment schemes through small adjustments	FiT need to be adjusted year-on-year and it requires certification of eligible participants	Most complex as FiP needs to be regularly recalculated as suppliers vary SEG although could be paid by the supplier	Similar to option 2, but more complex due to equity aspects for eligibility criteria.

The table above provides a summary of the policy option assessment presented in chapter 5.3, showing the trade-offs of each option. For example, while the Smart Export Guarantee combined with a FiP (policy option 4) provides long-term certainty to the microgeneration market that the viability gap for the main targeted capacity bands will be closed, it also comes with high administrative costs due to the complexity of recalculating FiP rates regularly. Alternatively, the smart export guarantee (policy option 1) has low overall and administrative costs, but also has the highest risk of all policy options that it will not be able to meet the viability gap for the domestic solar rooftop sector up to 2024.

Alternatively, both options that combine a Smart Export Guarantee with an investment subsidy (policy options 2 and 5) provide opportunities to address barriers to the uptake of microgeneration, especially those relating to high upfront costs. They may however be less effective in providing long-term investment certainty to the market compared to the FiT and FiP, as investment subsidy payback rates after the initial investment are only based on savings on the energy bill. While the investment subsidy options are less costly than the feed-in-tariff option, the risk for high costs to the government in the first years of the scheme and potential overcompensation are high in these options. Policy option 5 provides the additional benefit that eligibility criteria can be adjusted to ensure that barriers to microgeneration uptake for certain consumer groups is addressed, although this may also bring higher administrative costs and complexity to implementation. On the other hand, policy option 3 (FiT) provides the highest risk for over-subsidizing as it does not have an inherent mechanism to promote self-consumption or a mechanism to adjust its rates based on market values.

Based on this assessment, the recommended policy option for Ireland is an option that includes a Smart Export Guarantee. The advantages of a Smart Export Guarantee is that it can be provided at near cost-neutrality as the rates are provided by suppliers based on wholesale electricity prices, which also aligns with the European objectives of the Renewable Energy Directive. Moreover, a SEG is inherently able to provide incentives for self-consumption, energy efficiency and avoids the risk of overcompensation, which are all objectives set under the Irish Climate Action Plan. However, as the SEG will not be able to meet the viability gap for domestic rooftop solar (and other technologies and sectors) from 2021-2024, it is recommended that the option is supplemented by a FiP in the first years. The advantage of this mechanism (policy option 4) is that certainty is provided in the short-term that the viability gap is met in any scenario (independent of the rate of SEG provided), while also providing the long-term benefit of compensating exported electricity at market value. As the FiP is defined as bridging the difference between the viability gap and the SEG provided, there is also a natural phase-out of this subsidy over time, thereby reducing the risk of policy uncertainty or overcompensation.

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Glossary

Abbreviation	Description
ACA	Accelerated Capital Allowances Scheme
ACCU	Alternating Current Connection Unit
AD	Anaerobic Digestion
BER	Building Energy Regulation
CAP	Climate Action Plan
CAPEX	Capital Expenditure
CEFC	Clean Energy Finance Corp
CHP	Combined Heat and Power
CRU	Commission for Regulation of Utilities
DECC	Department of the Environment, Climate and Communications (DECC)
DCF	Discounted Cash Flow
DEC	Display Energy Certificate
DKK	Danish Krone
DNC	Declared Net Capacity
EII	The Employment and Investment Incentive
EPC	Energy Performance Certificate
ESB	Electricity Supply Board
EU	European Union
EUR	Euro
FIP	Feed-in-Premium
FIT	Feed-in-Tariff

GBP	Great British Pound
GHG	Greenhouse Gas
GW	Giga Watt
HICP	Harmonized Index of Consumer Prices
IMED	Internal Market in Electricity Directive
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
LCF	Levy Control Framework
LCOE	Levelized Cost of Electricity
MW	Mega Watt
NECP	National Energy and Climate Plan
NIRO	Northern Ireland Renewable Obligation
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PPM	Planned Preventative Maintenance
PSO	Public Service Obligation
PV	Photovoltaic
RE	Renewable Energy
RED	Renewable Energy Directive
RES	Renewable Energy System
RESS	Renewable Energy Support Scheme
RO	Renewable Obligation
SEAI	Sustainable Energy Authority of Ireland
SEG	Smart Export Guarantee
SME	Small and Medium-sized Enterprises
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital

1 Introduction

The Climate Action Plan (CAP) for Ireland published in 2019 sets out a detailed roadmap for the electricity sector aiming to increase reliance on renewables from 30% to 70% over the period 2021 to 2030[2]. It is expected that this transition will primarily be delivered by the Renewable Electricity Support Scheme, with any microgeneration support scheme having a minor role to play. The Climate Action Plan does outline the intention to put in place a coherent microgeneration scheme to support the achievement of this target. This will provide even greater opportunities for citizen participation in renewable energy generation.

Implementation of a microgeneration support scheme will bring Ireland in line with many other Member States, in which a number of microgeneration schemes have already been implemented in recent times. These have been particularly aimed at incentivising wind and solar installations which are typically the most cost-effective renewable technologies. It should be noted that these schemes have had varying degrees of success in terms of encouraging uptake of microgeneration technologies and representing cost-effectiveness to the implementing governments. Important lessons can be learned from these schemes and used to develop an effective microgeneration scheme in Ireland.

Action 30 from the Climate Action Plan was to set up a working group to set out the actions to deliver an enabling framework for microgeneration. This enabling framework will be developed from an assessment of possible support mechanisms for microgeneration across different market segments (domestic, SMEs, farming, social enterprise and public buildings) which is to be delivered prior to a public consultation at the end of 2020. This report outlines a set of proposed policy options for this and possible support mechanisms for microgeneration across different market segments in Ireland.

1.1 Ireland's climate and energy targets

The Irish economy has grown in recent years and carbon emissions continue to increase,[3] which is at odds with the country's commitment to the Paris Agreement.[4] The Irish Government has therefore identified the complete decoupling of energy consumption from economic and population growth as a vital step in successfully decarbonising the Irish economy within its National Energy and Climate Plan (NECP).[5]

In 2016 the Irish Government established a Citizens Assembly with the task to deliberate on five pressing topics in Ireland, including tackling climate change. Meetings of the Citizens Assembly took place over 12 weekends from 2016 and 2018 and paved the way for a radical reform in how Ireland is addressing the climate crisis. As a result of this, the Irish Government published its Climate Action Plan in 2019 which outlines a net zero target for the country by 2050 and a roadmap to get there. Ireland also became only the second country in the world to declare a climate and biodiversity emergency in May 2019.

After the general election in 2020, a Programme for Government was agreed between a coalition of Fianna Fáil, Fine Gael and Green Party and took effect on Friday, 26th June 2020. As part of the agreement, the three parties have committed to reduce greenhouse gas emissions (GHG) by 7% per year to reach the net zero target and deliver a green economy recovery from the Covid-19 crisis. In addition, the new coalition aims to revise the Climate Action Plan this year as well to reflect the updated ambition.

- *Relevant actions from the Programme for Government include the following:*

[2] Government of Ireland. 2019. Climate Action Plan 2019 – To Tackle Climate Breakdown. Available from: https://www.DECC.gov.ie/en-ie/climate-action/publications/Documents/16/Climate_Action_Plan_2019.pdf
[3] From 41.2 MtCO2eq. in 2011 to 43.8 MtCO2eq. in 2017 (according to Climate Action Plan 2019)
[4] UNFCCC. 2015. Paris Agreement, Available from: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[5] Ireland's National Energy & Climate Plan 2021-2030 https://ec.europa.eu/energy/sites/ener/files/documents/ie_final_necp_main_en.pdf

- *“Develop a solar energy strategy for rooftop and ground based photovoltaics to ensure that a greater share of our electricity needs are met through solar power.”*
- *“Prioritise the development of microgeneration, letting people sell excess power back to the grid by June 2021.”*
- *“Expansion and incentivising of micro generation including roof top solar energy.”*

The current Climate Action Plan also sets the following goals for the electricity sector:

- “*Increase reliance on renewables from 30% to 70% adding 12GW of renewable energy capacity (with peat and coal plants closing) with some of this delivered by private contracts”* by 2030. The main vehicle for delivery of this target is the Renewable Electricity Support Scheme (RESS).
- *“Put in place a coherent support scheme for microgeneration with a price for selling power to the grid”.* No specific targets for this microgeneration scheme have been set.
- *“Open up opportunity for community participation in renewable generation as well as community gain arrangements”*
- *“Streamline the consent system, the connection arrangements, and the funding supports for the new technologies on and off shore”*
- *In terms of increasing flexibility, the Delivering a Secure Sustainable Electricity System (DS3) Programme will be key to achieving a more flexible Irish energy system with the objective of raising intermittent generation penetration in the Single Electricity Market (SEM) from the current 65% to 75% by 2020, one of the world’s highest levels of renewable penetration.*

Previously a new Microgeneration policy was proposed via a private members Bill to promote the development of microgeneration in Ireland in the form of a supplier obligation to provide a tariff for electricity exported to the grid and was progressing through the legislative process. However, the proposed microgeneration bill lapsed in January 2020 with the dissolution of Dáil Éireann. The intention therefore now guided by the Climate Action Plan is to replace this bill with a new microgeneration support scheme starting in June 2021.

Action 30 of the Climate Action Plan also outlines the need for the establishment of a Microgeneration working group. This working groups has set out the steps needed to develop a microgeneration support scheme in Ireland. Some of the main steps outlined by this working group include[6]:

- A review of the charging structure of electricity network charges to ensure a fair and equitable charging mechanism that does not benefit owners of microgeneration
- A review of “*the current exemptions relating to solar panels as provided for in the Planning and Development Regulations* […] *and implement amendments arising from review”*
- Ensuring that there is an appropriate grid connection policy for renewable self-consumers and access for microgeneration. This comes in light of other development such as:
    - The Commission for Regulation of Utilities (CRU) are reviewing changes to the grid connection process for microgeneration with a capacity greater than 11kW, but less than 50kW[7]
    - Analogue meters are being replaced nationally by smart meters which will see 2,000,000 smart meters installed by the end of 2024, an essential step to facilitate the recording of the export of excess electricity generation.
- An assessment of impacts on the distribution network with higher proportions of microgenerators. ESB Networks Asset Management has carried out an initial analysis of these impacts and has concluded *“that the network can currently accommodate widespread microgeneration penetration at levels up to 3kWp (rural) and 4kWp (urban). At lower levels of*

[6] Government of Ireland. 2019. Terms of Reference – Microgeneration Working Group. Available from: https://www.DECC.gov.ie/documents/Microgeneration%20Working%20Group%20Terms%20of%20Reference.pdf
[7] For generators that produce less than 6kW for single phase connections and 11kW for 3 phase connections, there is a streamlined process already in place

penetration, 6kWp/11kWp can be provided and may result in some levels of reinforcement. At higher penetration levels of 6kWp/11kWp, or at greater than 11kWp, an individual system study is required for each connection assessing associated work and costs."[8]

- Evaluation of different types of microgeneration support schemes targeting different sectors and incorporating energy efficiency and equity principles as well as a public consultation of this evaluation.

The new microgeneration scheme will need to be aligned with the specifications for microgeneration under EU regulation. In particular, the updated Renewable Energy Directive (RED II) (EU) 2018/2001) will ensure owners of microgeneration are paid the market rate for the electricity they export to the grid. In addition, article 21(3)c of the RED II outlines that Member States may charge fees to renewable self-consumers on the renewable electricity they self-generated if the electricity produced is from an installation of electricity capacity of more than 30 kW. In addition, Regulation (EU) 2019/943 on the internal market of electricity outlines that *"power-generating facilities using renewable energy sources with an installed electricity capacity of less than 400 kW*" (reducing to 200 kW in 2026) are exempt from balance responsibility and may receive dispatch priority. This suggests a 30kW threshold would be most efficient for defining microgeneration, as it would not require a mechanism for charging prosumers, although other thresholds may also be possible. It is expected that all microgenerators will receive dispatch priority as there will be no control on when they export excess electricity to the grid.

1.2 Existing microgeneration support schemes

To ensure a smooth transition to a new microgeneration support scheme, it is essential to consider the mechanisms already in place to support microgeneration in Ireland, particularly wind and solar generation that need to be considered with the development of any new microgeneration policy. The existing schemes already in place in Ireland include:

The Accelerated Capital Allowances (ACA) Scheme[9]. This scheme is aimed at incentivising companies to invest in highly energy efficient plants and machinery. As part of the scheme, businesses can claim depreciation of up to 100% of the capital costs of energy efficient plant and machinery and deduct it from their tax liability in the year of purchase. The products that are covered by the scheme are listed in a register and include micro-solar PV and micro-wind technologies. All companies and unincorporated businesses who pay income tax or corporation tax in Ireland are eligible to apply for the scheme, including sole traders, farmers or companies.

The Targeted Agricultural Modernisation Schemes[10] (TAMS). This scheme provides an investment grant to farmers to improve the energy efficiency of farm buildings or their equipment. It includes within its overall budget 10 million EUR available for renewable energy generation (solar PV on farms) from 2015 – 2020. The investment grant can cover up to 60% of total installations costs for a 6kWp or smaller solar PV system.

The Sustainable Energy Authority of Ireland (SEAI) pilot programmes to support solar PV and micro-CHP. The government has put in place a pilot microgeneration grant scheme for solar PV and micro-CHP which covers around 30% of installation costs for individual homes[11]. Participants who are looking to participate will need to show they are the owner of dwellings built and occupied before 2011 and where SEAI has not previously provided support for a solar scheme.

The **Electric Ireland Microgeneration Pilot Scheme** also incentivised the installation of domestic micro-generators. This scheme—offered by Electric Ireland, the retail arm of Electricity Supply Board

[8] ESB Networks Asset Management. 2019. Assessment of potential implications for the distribution network of defined higher penetrations of distributed generators.
[9] DECC. 2016. Accelerated Capital Allowances. Available from: https://www.DECC.gov.ie/en-ie/energy/legislation/Pages/Accelerated-Capital-Allowances.aspx
[10] Department of Agriculture, Food and the Marine. 2020. Targeted Agricultural Modernisation Schemes. Available from: https://www.agriculture.gov.ie/farmerschemespayments/tams/
[11] SEAI. 2017. Solar Electricity Grant. Available from: https://www.seai.ie/grants/home-energy-grants/solar-electricity-grant/

(ESB)—gave customers free installation of an import/export meter and a support payment of 10 cent/kWh. This pilot scheme was closed to new customers from 31st December 2014 but still provides payments to customers who signed up prior to this date.

It is also worth noting that the **Building Regulations** (Technical Guidance Document L- Conservation of Fuel and Energy – Dwellings[12]) compliance has been a significant driver of Solar PV installations for new residential buildings constructed since 2011 (as well as for heat pumps). The schemes typically are less than 2kW, on average about 1.2kW, sized to comply with TGD L. On average 40% of newly built houses in 2019 have included solar PV installations and this is expected to rise to 50% this year, although this projection may be impacted by impacts from the coronavirus-crisis on construction rates. It can also be expected to reduce once bans on oil and gas boilers become effective in 2022 and 2025 respectively.

Better Energy Communities Better Energy Communities is the SEAI national retrofit initiative with grant support of €20 million for 2020. As part of wider retrofit measures, microgenerators (mainly solar) were supported in both domestic and non-domestic buildings.

Community Housing Scheme This is an SEAI grant suitable for Residential Service Providers, Employers, Financial Institutions, registered Housing Associations and Local Authorities who wish to participate in delivering energy efficiency upgrades to pre-2006 homes. This can include microgeneration. The recommended minimum grant application is €100,000, the maximum grant amount is €750,000 and co-funding of between 35% and 50% is offered depending on the type of applicant.

In addition to the microgeneration support schemes listed above, Ireland also recently introduced the **Renewable Electricity Support Scheme (RESS)** as the primary mechanism to achieve the renewable energy targets from the Climate Action Plan in Ireland, i.e. 70% of energy generated by 2030 depending on the cost-effectiveness level as set out in the draft National Energy and Climate Plan (NECP). The scheme works by organisation of auctions at frequent intervals. Project developers, including those of community renewable energy projects, can supply for support under the scheme when they meet a set of pre-qualification criteria, including a minimum threshold of 500 kW. Successful applicants to the scheme will receive support for approximately 15 years. The provisional results of the first auction (RESS-1 auction) were published on the 4th of August and showed that 114 projects applied to the RESS process and 109 of those were pre-qualified to participate in the auction (including eight community projects). Subsequently, 108 projects submitted a bid via the online portal during the auction window and 82 of those projects were provisionally successful in receiving support as part of the RESS. The successful offers have a deemed energy quantity of 767.315 GWh solar and 1469.338 GWh onshore wind leading to a total offer quantity of 796.3 MW solar and 479.236 MW onshore wind[13].

Table 1-4 - Weighted average offer price for successful bids under the RESS-1 Auction (Source: EirGrid, 04/08/2020)

	Community	Solar	All projects
Average offer price	104.15 EUR/MWh	72.92 EUR/MWh	74.08 EUR/MWh

RESS is funded via annual reconciliation of the Public Service Obligation (PSO) levy against wholesale market prices, to determine whether generators are paid a support or have to repay

[12] Department of Housing, Planning and Local Government. 2019. Technical Guidance Document L-Conservation of Fuel and Energy – Dwellings. Available from: https://www.housing.gov.ie/housing/building-standards/tgd-part-l-conservation-fuel-and-energy/technical-guidance-document-l-7
[13] EirGrid. 4 August 2020. Renewable Electricity Support Scheme 1 – RESS-1 Provisional Auction Results. Available from: http://www.eirgridgroup.com/site-files/library/EirGrid/RESS-1-Provisional-Auction-Results-(R1PAR).pdf

monies. It is a cost-effective mechanism for enabling development and financing of larger-scale renewable generators but is not a suitable support mechanism for microgeneration.

Three more rounds of RESS are currently planned to take place to support in total 12,000 GWh of generation through targeting of onshore wind, offshore wind, biomass and solar PV[14].

1.3 Objectives for new scheme

In the Climate Action Plan, it is specified that an ongoing support scheme for microgeneration should be put in place by 2021 at the latest, to ensure that people can sell excess electricity they produce back to the grid.

According to the CAP, the new support scheme should be underpinned by some key pillars, including:

- Equity and accessibility for all
- Ensuring principles of self-consumption and energy efficiency first are achieved
- Ongoing technology cost and remuneration analysis
- Addressing technical barriers and planning constraints
- A clear grid connection policy
- Supporting community participation in microgeneration

The aim for the new microgeneration support scheme is to be technology neutral, although from historical data and international experience it is expected that micro-solar will be the dominant technology incentivised by a support scheme. For example, the feed in tariff in the UK resulted in over 2,700GW of installed microgeneration of solar, micro-wind, micro-hydro and micro-CHP, of which the most significant contribution was solar PV (94%), with micro-wind (5%) next[15]. In addition, the objective of the scheme is to be lowest cost and minimise the risk of putting large amounts of subsidy at the risk of incentivising overcompensation at one time.

The scheme should also correlate with the electricity consumption landscape in Ireland. In particular, the scheme must encourage microgeneration that will fit with the consumption patterns of domestic households, farms, SMEs and the public sector.

The CAP also states that the new scheme will be further supported by measures in building regulations. The aim for the microgeneration support scheme will therefore be to ensure eligibility criteria promote high uptake of energy efficiency building regulations.

This report provides policy options and considerations for the development of a microgeneration market price compensation and support scheme for microgeneration in Ireland from June 2021 taking account of the objectives of the CAP in Ireland. For this purpose, the report provides an overview of the main microgeneration technologies in Ireland and an assessment of their costs, an analysis of the viability gap of these technologies in different sectors, identification of policy option through assessment of international best practice. Finally, it provides a review of each of the identified policy options in terms of their effectiveness, costs, funding mechanisms and complexity for implementation to provide a recommendation on the most suitable microgeneration scheme to be introduced in Ireland in June 2021.

2 Microgeneration technologies in Ireland

Microgeneration technologies have different characteristics that make them more appropriate for use within different sectors. As a first step to develop a microgeneration support scheme in Ireland, the characteristics of different sectors are assessed and compared against the suitability of different microgeneration technologies.

[14] GreenTechMedia. 2019. Ireland's Gigawatt-Scale Tender Opens Door for Onshore Wind. Available from: https://www.greentechmedia.com/articles/read/irelands-gw-scale-tender-opens-door-for-onshore-wind
[15] Ofgem. 2019. Feed-in Tariff Annual Report. Available from: https://www.ofgem.gov.uk/system/files/docs/2019/12/feed-in_tariff_annual_report_2018-19.pdf

2.1 Sector analysis

A range of technology and sector combinations were proposed by DECC for consideration for the development of microgeneration policy options. The technology options are:

1. Solar PV
    a. Ground mounted
    b. Roof mounted
2. Micro-wind
3. Micro-hydro
4. Micro-CHP (gas fired)

The sectors considered specifically for these microgeneration technologies are:

1. Domestic
2. Agricultural
3. Small-Medium Enterprises (SME's) (commercial and industrial)
4. Public buildings (school and local authority buildings)
5. Community/social enterprise
6. Citizen Energy Communities

The qualitative assessment outlines the suitability of each technology/sector combination based on the following metrics:

1. Electricity load
2. Installation requirements
3. Operation and maintenance requirements

Each of these technology sector combinations are considered as an archetype throughout this study. For example, domestic rooftop solar is one archetype. Each are qualitatively assessed on a red-amber-green (RAG) basis to give an outline of the suitability of a technology within a sector as in Table 2-1.

Table 2-1 - RAG grading criteria for suitability of technology within a sector

Key	RAG grading criteria
High	None/negligible issues identified with technology within sector
Medium	Technology is appropriate for sector although some issues to address
Low	Technology is not suitable for sector

The assessment considers the suitability of each technology on a broad scale and does not consider all potential scenarios for each technology/sector combination. It is likely that each technology could be implemented in any sector under specific conditions, however the assessment focuses on what can be commonly done given each sector's individual requirements.

2.1.1 Solar PV

Solar PV can be developed as either a roof or ground-mounted system depending on the sector and individual site requirements.

Domestic demand peaks during the morning and evening, with largely steady and low demand during the day due to typical domestic occupation hours. Conversely, PV generation peaks during the middle of the day when demand is typically reduced, whilst generation is lower during mornings and evenings when demand is at its peak. To maximise self-consumption for domestic solar requires additional battery storage to be added to the system.

Other commercial sectors (SMEs and large farms) are more suitable for PV, due to a higher power demand occurring throughout the day. Maximising yield from solar PV requires the panels to be oriented south. Ground-mounted systems often produce higher yields than roof-mounted systems as they can be optimally orientated with panels installed at the optimal elevation, whereas roof systems orientation and elevation is dictated by the roof. There are sectors that may require east-west facing panels to increase generation during the morning/afternoon with the sacrifice of total generation. For example, dairy farms have higher demand during the morning and afternoon so east-west arrays are more suitable to maximise self-consumption.

Public buildings (schools and local authorities) typically have a 5-day occupancy and lower occupancy during the summer months when generation peaks, particularly for schools. Further, community groups/social enterprises may also have seasonal demand if they are installed in places such as local sports club facilities (e.g. tennis and football grounds).

Installation requirements for solar PV are relatively simple, with most domestic schemes taking a few days[16]. Roof-mounted schemes require structural assessments to understand the load of the system on a given rooftop. Scaffolding will be required during the construction phase to access the roof space. Ground-mounted schemes may require studies to assess the suitability of the ground in which the system will be placed.

A reasonably stream-lined process is in place for installations below 6kW on single phase and 11kW on 3-phase to connect to the grid using the inform and fit principles as described in ESB Networks Conditions[17]. At present the connection process for higher capacity connections is more complex, that can add extra capital costs and extend the time taken to issue a connection offer and connect a scheme. ESBN are currently reviewing the connection procedures and related protocols to accommodate a simplified grid connection process for microgeneration up to 50kW.

Operation and maintenance (O&M) requirements are simple for PV systems. Due to a lack of moving parts and fuel inputs, O&M typically requires an annual visit as part of a planned preventative maintenance (PPM) programme, which will usually include visual, electrical and mechanical inspections and testing. O&M will typically be more difficult for roof systems compared to ground-mount as roof access is required. Reactive maintenance is required for unplanned outage events such as inverter failures, although the failure rate for equipment is well-documented and often included within a PPM programme, reducing O&M risks.. As a result, O&M requirements are minimal.

2.1.2 Micro-wind

Wind generation is greater during the night and through winter, therefore correlating with higher electricity demand during winter across all sectors. There is greater potential for spillage (excess generation from the wind turbine not being used on site) during the night when wind generation output is high and demand is low, and optimising generation for self-consumption can be very site-specific. Small schemes that would typically be suited for domestic self-consumption (<3kW) are susceptible to turbulence and high landscape roughness factors, especially in an urban environment. So domestic scale turbines are generally only suitable for rural locations.

SEAI have produced a summary of planning constraints that covers all microgeneration schemes[18]. For wind, this includes visual impact, noise, blade diameter and other related environmental impacts. If a project is consented however, wind turbines are relatively straightforward to install although would require detailed structural and wind loading assessments.

[16] Energy Sage. 2020. How long does it take to install solar panels? Available from: https://news.energysage.com/how-long-does-it-take-to-install-solar-panels/
17 ESB Networks; Conditions Governing the Connection and Operation of Microgeneration Policy ;Policy DTIS-230206-BRL; October 2018
[18] SEAI. N.D. Conditional Planning Exemptions. Available from: https://www.seai.ie/publications/Conditional_Planning_Exemptions.pdf

O&M requirements are more frequent and costly for wind than for solar systems with scheduled O&M visits as part of a PPM programme often undertaken a couple of times a year.

2.1.3 Micro-hydro

Micro-hydro schemes can produce consistent power throughout the day for the entire year, if water levels are high enough. This means that higher winter demand can be largely offset by a micro-hydro scheme, although smaller rivers and streams can have low flow due to ice and snow. Generation is generally predictable and machines are usually sized by an installer to align with a river or streams flow and head or to meet demand on a site-specific basis.

Installation requirements for hydro are very site-specific. They are likely to include ground works, a penstock and require an abstraction licence. Turbine types are selected based on the flow and the head of the scheme.

A resource assessment across Ireland has not been completed as part of this study, however it is recognised that the domestic sector, SME's, community energy groups, social enterprises and public buildings are less likely to have direct access to a suitable resource to install a micro-hydro scheme for self-consumption, than access to space for a solar installation, even if there is a watercourse running nearby. It is therefore expected there will significantly fewer sites suitable for micro-hydro schemes. The agricultural sector has the largest potential for micro-hydro although this will still be very limited as evidenced by hydro mapping completed by SEAI, which although over 20 years old is still relevant[19].

Hydro schemes require regular O&M including regular clearing of intakes, particularly for small schemes with small intakes. Although this does not need to be completed by specialist maintenance providers, it does need to be completed regularly resulting in marginally higher maintenance costs than other renewable generators.

2.1.4 Micro-CHP

Micro-CHP (gas-fired) is a nascent technology suited to applications where heat and electricity are required. CHP systems are primarily sized to meet heat demands, so those sectors with a highest heat load are most suited, such as hotels and swimming pools. Public buildings and schools may, in general, have too large of a demand to be suitable for micro-CHP systems, so micro-CHP may require an additional top-up heating system.

A micro-CHP installation is similar in size and shape to a standard domestic gas boiler. They can be wall-hung or floor-standing and are therefore simple to install.

O&M for gas-fired micro-CHP is also simple, with similar requirements to a typical domestic boiler. This would include an annual service and call-outs for any unplanned outages.

A summary of this simple technical suitability assessment is shown in the following table. The next section presents a more detailed assessment of the sector demands.

Table 2-2 - Suitability of technologies by sector

Sector	Solar	Micro-wind	Micro-hydro	Micro-CHP
Domestic				
SME (commercial)				
SME (industrial)				

[19] https://maps.seai.ie/hydro/

Agriculture				
Community/social enterprises				
Citizen energy communities				
Public buildings (local authorities)				
Public buildings (schools)				

2.2 Capacity banding

The key principles behind the banding of the different technologies used in the assessment were:

- Alignment with European standard EN50549 "Requirements for generating plants to be connected in parallel with distribution networks";
- All connections will be behind the meter, such that any generator installed is to supply power to a specific load;
- Optimising the microgeneration scheme to support self-consumption with at least 70% of the electricity being generated used on site.

The 70% self-consumption threshold was set by DECC to minimise the level of export onto the network. This threshold ensures that one of the key pillars of the CAP, to ensure principles of self-consumption and energy efficiency first are achieved, supporting access to the microgeneration scheme to a larger number of self-consumers. The microgeneration scheme is being designed as a means of reducing energy costs for consumers, which reducing Ireland's carbon emissions. It is to incentivise additional installed capacity of renewables, supporting as many installations across the country as possible. It is not being designed to maximise the amount of renewable electricity generation at a site, which again supports the self-consumption principal.

The capacity banding exercise determined the appropriate capacity ranges for each technology to maximise self-consumption across the targeted sectors. The steps to complete this were:

1. Defining the energy demand of each sector
2. Examining the technical factors influencing generator capacities
3. Determining the generation of a technology at a range of capacities
4. Matching the generation capacity to meet approximately 70% of the estimated demand

Details on data assumptions and methodology can be found in Appendix A1.3.2.

2.2.1 Sector demands

The sectors considered have significantly varying annual, seasonal and daily energy demand profiles. This also applies to different consumers within each sector. For example, within the agricultural sector, dairy farms have much different energy requirements than those used for arable farming. Therefore, any forecast of energy demands for a sector are an estimate of typical demands. Data from a range of different sources has been used to estimate demands across the sectors. Energy demand for both social enterprises and community energy schemes is not explicitly examined as these sectors do not have definable end-use cases, so optimising for self-consumption varies considerably. For example, community schemes looking to use solar could develop rooftop PV on multiple dwellings or a town hall.

For the domestic sector, projections of varying demand, based on data provide by SEAI were used out to 2030. For all other sectors, demand estimated have been based on recent demand data and therefore do not account for any projected changes over time. SEAI have produced a range of future energy scenarios highlighting an absolute increase in demand[20][21]. The increase in demand may increase the levels of self-consumption rate above the 70% threshold, therefor reducing the amount of electricity purchased from the grid, increasing the levels of self-consumption and the associated cost savings, thereby further reducing energy spend across the sectors. As a result, the demand analysis is expected to be conservative in non-domestic sectors.

A significant proportion of microgeneration uptake is forecast to be from the domestic sector as has been seen across many other countries. Therefore, a more detailed projected domestic demand has been completed, based on seasonal and daily hourly demand profiles. This takes into consideration the increase in average domestic demand forecast by SEAI out to 2030[22], driven by an expected increase in the number of heat pumps installed and increased EV consumption.

The following table summarises the annual demand assumed across each sector, the details of which are shown in Appendix A1.3.2.

Table 2-3 - Assumed demand across sectors

Sector use cases	Annual power demand (kWh)	Annual heat demand (kWh)
Domestic[23]	5,220	13,500
Agriculture – small farms[24]	3,000	20,000
Agriculture – large farms	19,000	65,000
SME's – commercial[25]	146,500	132,375
SME's – industrial[26]	56,750	178,750
Public buildings – local authorities	146,500	132,375
Public buildings - schools[27]	28,000	132,250

Using these annual demands, annual hourly demand profiles are determined in section A1.3 to examine supply vs demand and generate self-consumed and exported power proportions.

2.2.2 Technical factors influencing micro-generator capacities

This section determines the technical factors that will influence the generator sizes and total system capacities which includes:

- Grid connection constraints;
- The capacities of generator currently available on the market.

[20] SEAI (2018) *National Energy Projections to 2030: Understanding Ireland's energy* transition. Available at https://www.seai.ie/publications/National-Energy-Projections-to-2030.pdf
[21] SEAI (2019) *National Energy Projections: 2019*. Available at https://www.seai.ie/publications/2019-04_SEAI2019ProjectionsReport_Final.pdf
[22] Domestic demand data 2020-2030 provided by DECC with detailed results in section A1.3.2
[23] Approximates energy use based on last 3-5 years of data as annual energy trends fluctuate. Data uses 'electricity' and 'non-electric energy' https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/residential/
[24] Agricultural data used from Department of Agriculture, Food and the Marine, Teagasc, National Farm Survey (NFS 2020) and the Central Statistics Office (CSO) detailed in A1.3.2
[25] Demand derived from CIBSE 2012 Guide F building standards using an average of 'Office' categories as a proxy, assuming a 100m x 100m (1000m^2) building for ease of comparison
[26] Demand derived from CIBSE 2012 Guide F building standards using an average of 'Mixed Use/Industrial' as a proxy, assuming a 100m x 100m (1000m^2) building for ease of comparison
[27] Demand data derived from CIBSE Guide F building standards using an average of 'Primary school' and 'Secondary school as a proxy, assuming a 100m x 100m (1000m^2) building for ease of comparison

2.2.2.1 Grid connection constraints

There are certain grid constraints that will apply to microgeneration schemes and affect potential banding capacities beyond simply matching supply and demand. The maximum single-phase connection is 6kW, whilst the maximum for a 3-phase connection is 11.04kW. Connecting generators above 6kW, not currently on a 3-phase connection, will therefore incur additional costs to upgrade their network connections.

2.2.2.2 Solar PV

The PV panel industry is large with a plethora of panel sizes. Panels are continuing to increase in capacity. Current projects typically use panels in the range of 250-350W, however future panels are likely to be in the 400W range with some 2020 models reaching 500W[28]. It is assumed that PV arrays can be designed in 0.3-0.4kW increments. Using this assumption, the maximum number of panels for a single-phase connection is 15 and for a 3-phase connection approximately 25-28.

At the time of drafting this report, the maximum permitted development for residential PV systems is 12m^2. Panels vary in size although many panels are approximately 1.6-2.0m^2. Assuming 1.7m^2 for a panel[29], this would allow a total of 7 panels on a dwelling at a rated capacity of approximately 2.8kW. However, it is recognised that there are draft revisions to the planning regulations being assessed at present. These revisions are likely to allow for larger permitted development exemptions across all sectors as well as allow for development on properties where there are currently none (e.g. apartments/ multi-occupancy buildings, educational and community buildings). This means planning constraints are being reduced.

Solar output figures were calculated from PVGIS[30] for both ground-mount and roof-mounted schemes. It was assumed that ground-mounted schemes are tilted at 20°, the optimal tilt striking a balance between maximising yield and minimising inter-row shading. Roof schemes in this study have been modelled at a typical 35° panel elevation. Rooftop elevation is generally between 20-40°, with the Ireland optimum for solar radiation is at 30°[31].

Several assumptions have been made to reflect average output performance from all rooftop domestic arrays across Ireland. Losses of 15% of rooftop PV output on a per kW basis is assumed to account for soiling, less than optimal roof orientations and tilts and shading. Accounting for these losses minimises the risk of overestimating their performance and subsequently underestimating the level of incentive required to stimulate the market.

Analysis of the UK residential FiT system performance identifies that domestic rooftop PV schemes achieved a capacity factor of approximately 9.7%[32], thereby confirming the above listed assumptions. Analysis of UK ground-mount schemes demonstrates capacity factors of 10-12%[33][34], justifying the 10.6% determined for this assessment.

The table below highlights the modelled output for each system.

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[28] Solar PV Magazine. 2020. How the new generation of 500 W panels will shape the solar industry. Available from: https://www.pv-magazine.com/2020/03/06/how-the-new-generation-of-500-watt-panels-will-shape-the-solar-industry/
[29] Zero Home Bills. 2020. Sunpower 400W SPR-Max3-400 mono solar panel. Available from: https://zerohomebills.com/product/sunpower-400w-spr-max3-400-mono-solar-panel/
[30] European Commission. 2019. Photovoltaic Geographical Information System. Available from: https://re.jrc.ec.europa.eu/pvg_tools/en/#PVP
[31] https://www.seai.ie/publications/Best_Practice_Guide_for_PV.pdf
[32] UK Government – DECC. 2013. Estimating generation from Feed in Tariff Installations. Special feature – FiT generation methodology. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/266474/estimating_generation_from_fit_installations.pdf
[33] Euan Mearns, 2015. UK Solar PV Vital Statistics. Available from: http://euanmearns.com/uk-solar-pv-vital-statistics/#:~:text=The%20National%20Grid%20generation%20data,10.1%25%20estimated%20by%20Roger%20Andrews
[34] UK BEIS. 2020. Digest of UK Energy Statistics: renewable sources of energy. Available from: https://www.gov.uk/government/statistics/renewable-sources-of-energy-chapter-6-digest-of-united-kingdom-energy-statistics-dukesm

Table 2-4 – performance comparison of ground-mounted vs rooftop solar PV

PV location	Annual power (kWh/kWp)	Capacity factor (%)
Ground-mounted	930	10.62
Rooftop	799	9.12

Further analysis using these benchmarks is conducted using PV-Sol with further details presented in section A1.3.2.2

2.2.2.3 Wind

Currently small-scale wind turbines are only manufactured at specific sizes and therefore any wind archetype must consider this when determining sizes for different sectors. It may be optimal for a large farm to utilise a 17.5kW turbine to optimise for self-consumption and wind speeds, however, the capacity of installed turbines will be influenced by the availability of turbines on the market.

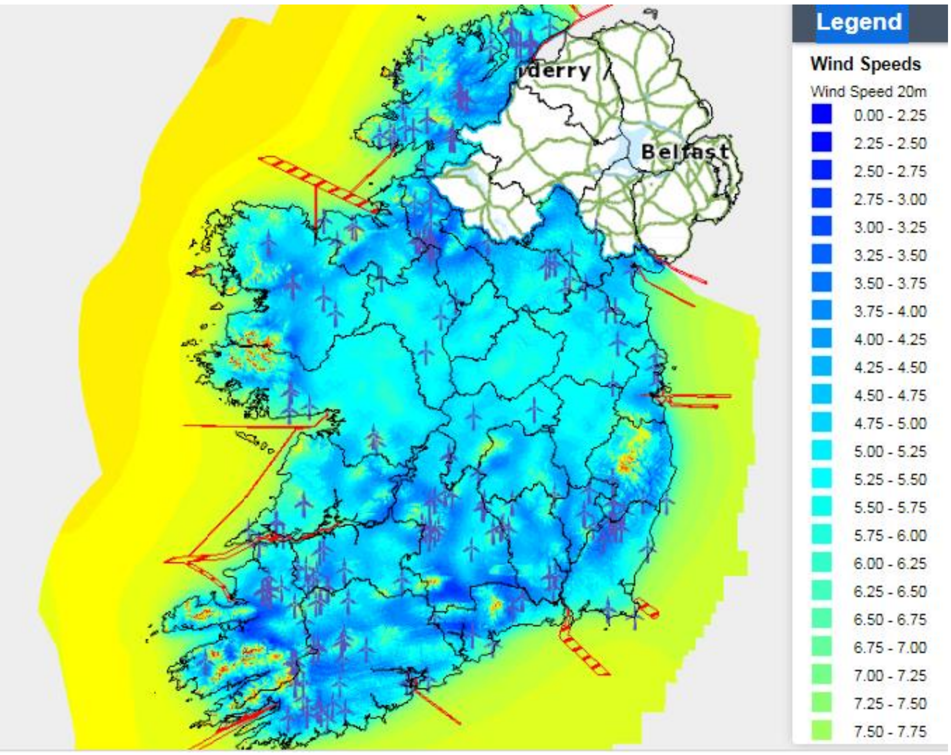
Wind turbine banding has largely been based on the available turbine capacities. A range of currently available wind turbines under the 50kW threshold are presented in Appendix A1.3.2. Of the 41 collected available wind turbines under 50kW, 22 are 10kW and under, whilst there is a cluster of 13 from 10-25kW and only 6 from 25-50kW.

Generation for these turbines is dependent on a large range of factors such as:

1. Wind speed (generated power is proportional to the cube of the wind speed; therefore, a doubling of wind speed can result in 8 times the generation);
2. Hub height (higher hub heights are subject to higher wind speeds);
3. Swept rotor area; and
4. Landscape roughness (dense objects such as trees and buildings near the turbines, increase turbulence and reduce windspeeds).

Typical generation for a given turbine therefore varies considerably. Generation was modelled for wind speeds of 5, 6 and 7m/s for each turbine given their hub height, based on SEAI's wind speed map as depicted in Figure 2-1 below.

Figure 2-1 – Wind speed data at 20m height (SEAI[35])



As can be seen from Figure 2-1, 5.5-6.5m/s wind speeds are common in Ireland. A key factor which influences the output from turbines is the impact of landscape characteristics (roughness factor). For example, highly built-up urban environments have a high roughness factor. The study assumes a wind speed at hub height of 5m/s as a conservative estimate to account for landscape roughness.

Table 2-5 shows the typical power output of wind turbines of different capacities at 5m/s wind speed. Power output is both site- and turbine-specific so these figures should be interpreted as typical outputs that might be expected.

Table 2-5 – annual generation of 6, 25 and 50kW wind turbines based on 5m/s wind speed

Wind turbine capacity (kW)	Annual power generation (kWh)
6	9,500
25	50,000
50	97,500

Further detail on the profiling of wind generation to achieve 70% self-consumption can be found in section A1.3.

2.2.2.4 Micro-hydro

Micro-hydro generators have been in operation for over 100 years. Different generators on the market are typically designed around how the generators will be connected to the grid:

- <6kW for grid connection on a single phase;

[35] SEAI. 2017. Wind Atlas. Available from: https://www.seai.ie/technologies/seai-maps/wind-atlas-map/

- <50kW for larger loads and exporting and including the 3-phase 11kW connection limit.

Micro-hydro generation is dependent on several factors such as head and flow. Low head schemes, typical of those in Ireland are normally Crossflow or Archimedes Screw turbines. As hydro schemes are installed in environments with known and predictable resource conditions, they generally operate at a higher capacity factor to that of wind with 40-60% as a typical figure[36]. A 50% capacity factor is considered reasonable.

The table below demonstrates the generation for the upper size threshold of each micro-hydro capacity banding.

Table 2-6 – micro-hydro capacity bands and generation

Micro-hydro capacity (kW)	Annual power generation (kWh)
6kW	26,280
50kW	219,000

Further detail on the sizing micro hydro to accommodate 70% self-consumption in each sector is detailed in section A1.3.2.2.

2.2.2.5 Micro-CHP

Micro-CHP schemes are typically sized to meet peak heat loads but can be altered based on site-specific demands. There are a limited range of capacities available for CHP due to different technologies with the most common commercially used CHP systems being Stirling engines, Organic Rankine Cycle or Internal Combustion Engines (ICE). Stirling engines come in sizes of 1-25kW although are not often used at larger capacities as they are very expensive[37]. As a result, Stirling engines are typically used in domestic settings at much lower capacities (e.g. 1kW). ICE engines can also be used in a domestic setting and have higher electrical efficiencies, however due to being much larger than Stirling engines they are mainly installed in commercial-scale applications[38] The micro-generation scheme has been defined to only support micro-CHP using natural gas, so the efficiencies used in the study have been selected accordingly.

Appendix A1.3.2 details the performance and sizing of CHP considering factor such as peak heat load, electrical/heat efficiencies and H:P ratios.

2.2.3 Demand factors influencing system sizes

Considering the technical factors on performance described, each technology has been sized for 70% self-consumption, for a specific sector, thereby minimising export to the grid. This is further detailed in Appendix A1.3.2, with the results shown in Table 2-7.

The single-phase threshold of 6kW and three-phase threshold (i.e. 400V) of 11kW (11.04kW)[39] defines the non-domestic rooftop solar bands into 3-11kW (to ensure sizes above the micro-schemes) and 11-50kW. Ground-mount schemes are banded as 0-11kW and 11kW-50kW largely based on the

[36] IRENA. 2012. Renewable Energy technologies: Cost Analysis Series. Working paper – Volume 1: Power Sector. Issue 3/5 Hydropower. Available from: https://www.irena.org/documentdownloads/publications/re_technologies_cost_analysis-hydropower.pdf
[37] Stirling Engine (2018) https://www.sciencedirect.com/topics/engineering/stirling-engine#:~:text=Stirling%20engines%20usually%20contain%20either,between%201%20and%2025%20kW.
[38] Energy Saving Trust: Micro-CHP. Available at https://energysavingtrust.org.uk/renewable-energy/electricity/micro-chp
[39] This is in line with the European grid code IS EN50549 which sets the standard for connecting to a distribution network

demand for each sector and on the basis that there is expected to be less scope for ground-mounted systems for the domestic sector.

Table 2-7 - Required approximate capacity to self-consume 70% of generation per technology and sector

Technology	Capacity range (kW)	Sector	Required approximate capacity to self-consume 70% of generation (kW)
Small_rooftop_solar	0-3	Residential	3.00
Small_rooftop_solar	0-3	Small agriculture	1.70
Medium_rooftop_solar	3-11	Large agriculture	9.24
Medium_rooftop_solar	3-11	School	9.24
Large_rooftop_solar	11-50	SME-commercial	50*
Large_rooftop_solar	11-50	SME-industrial	31.68
Large_rooftop_solar	11-50	Local authority	50*
Small_ground_solar	0-11	Small agriculture	1.40
Small_ground_solar	0-11	Large agriculture	9.24
Small_ground_solar	0-11	School	9.24
Large_ground_solar	11-50	SME-commercial	50*
Large_ground_solar	11-50	SME-industrial	27.06
Large_ground_solar	11-50	Local authority	50*
Small_micro_wind	0-6	Small agriculture	2.00
Medium_micro_wind	6-11	Large agriculture	8.00
Medium_micro_wind	6-11	School	11.00
Large_micro_wind	11-50	SME-industrial	15.00
Large_micro_wind	11-50	SME-commercial	38.00
Large_micro_wind	11-50	Local authority	38.00
*	0-6	Domestic	1.50

Small_micro_hydro	0-6	Small agriculture	0.90
Small_micro_hydro	0-6	Large agriculture	5.00
Small_micro_hydro	0-6	School	5.5
Large_micro_hydro	6-50	SME-industrial	7.5
Large_micro_hydro	6-50	SME-commercial	19.00
Large_micro_hydro	6-50	Local authority	19.00
Small_micro_CHP	1-1	Domestic	Sized to meet peak heat load but can be adjusted to reduce export
Small_micro_CHP	1-1	Small agriculture	Sized to meet peak heat load but can be adjusted to reduce export
Medium_micro_CHP	1-5.5	Large agriculture	Sized to meet peak heat load but can be adjusted to reduce export
Medium_micro_CHP	1-5.5	School	Sized to meet peak heat load but can be adjusted to reduce export
Large_micro_CHP	5.5-30	SME-commercial	Sized to meet peak heat load but can be adjusted to reduce export
Large_micro_CHP	5.5-30	SME industrial	Sized to meet peak heat load but can be adjusted to reduce export
Large_micro_CHP	5.5-30	Local authority	Sized to meet peak heat load but can be adjusted to reduce export

* for 70% self-consumption, these schemes would be sized at 60kW, so the maximum capacity of 50kW is assumed

A key influencing factor to how wind turbines will be deployed is the availability of a 3-phase grid connection. The wind bandings have been set at 0-6kW, 6-11kW and 11-50kW. Further, the bands are dictated by the availability of turbine sizes detailed in Table 7-18.

Similarly, hydro banding is adjusted to 0-6kW and 6-50kW to account for the grid connection limits. As hydro is site-specific and generator sizes can be designed accordingly, this is considered the biggest influencing factor on capacity banding.

CHP is not adjusted for the connection limits, as CHP engines are only available in specified sizes. Further, CHP is sized to meet peak heat loads and is not subject to the 70% self-consumption threshold as applied to the solar, wind and hydro technologies.

Table 2-8 demonstrates technology sizing based on these assumptions for wind, hydro and CHP.

Table 2-8 – Technology capacity bands matched with sectors

Technology	Sector	Capacity banding range (kW – kW)
Rooftop solar	Domestic and small agriculture	0-3
Rooftop solar	Large agriculture and schools	3-11

Rooftop solar	SME-commercial/industrial and local authorities	11-50
Ground solar	Small/large agriculture and schools	0-11
Ground solar	SME-commercial/industrial and local authorities	11-50
Wind	Small agriculture	0-6
Wind	Large agriculture and schools	6-11
Wind	SME-commercial/industrial and local authorities	11-50
Hydro	Domestic and small/large agriculture	0-6
Hydro	Schools, SME-commercial/industrial and local authorities	6-50
Micro-CHP	Domestic and small agriculture	1 – 1
Micro-CHP	Large agriculture and schools	1 – 5.5
Micro-CHP	SME – commercial/industrial and local authorities	5.5 - 30

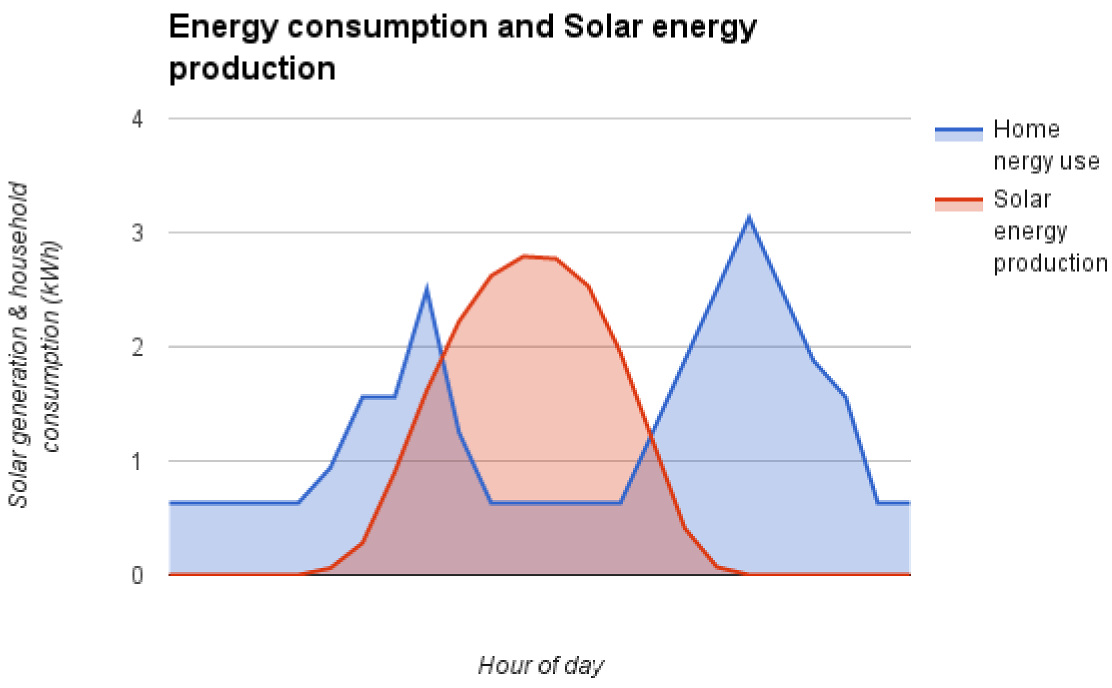
2.2.3.1 Solar PV sizing

Across a number of the sectors we have developed a demand profile that allows us to align solar generation with demand, when determining the capacity of generators that will deliver the 70% self-consumption threshold.

With domestic PV expected to account for a significant majority of installations within the microgeneration scheme, based on international uptake rates, , detailed analysis is required to understand timing of supply vs demand, to ensure the microgeneration support policy is targeted correctly. The figure below highlights the disparity in solar generation and residential demand.

An hourly residential demand data profile was scaled to represent a typical Irish dwelling annual consumption of 5,219kWh, based on forecast figures provided by SEAI.

Figure 2-2 – Solar energy supply vs domestic demand[40]



The analysis uses a solar generation profile acquired from the solar PV modelling tool, scaled for the installed capacity to represent the determined rooftop PV output.

The following table compares the performance of a 2, 3, 4 and 5kW domestic rooftop system.

Table 2-9 – Performance comparison of a 3, 4 and 5kW domestic rooftop PV system

Performance metric	2kW system	3kW system	4kW system	5kW system
Annual domestic demand (kWh)	5,219	5,219	5,219	5,219
Annual generation (kWh)	1,598	2,397	3,196	3,995
Generation used on site (kWh)	1,382	1,525	1,651	1,732
% of generation used in the house	86%	68%	56%	47%
% of total demand met by generation	26%	29%	32%	33%

The 5kW system can only meet 33% of domestic annual demand with 47% of the generation for self-consumption, whilst a 3kW system still meets 29% of domestic annual demand with 68% of the generation for self-consumption, which is the closest of the capacities assessed to meeting the 70% self-consumption figure. So, by increasing the size of the PV array, more electricity is exported (from 14% to 53%) however there is a significantly lower increase in the amount of total demand that is met,

40 https://www.solarchoice.net.au/blog/solar-self-consumption-overview

so there is proportionately less offset of purchased electricity and so less savings to the householder compared to the additional investment that would be required.

As a result, this exercise determines that a 3kW system strikes the appropriate balance between maximising self-consumption and minimising export to the grid for a domestic rooftop PV scheme.

Further detail on the methodology is described in section A1.3.2.4 - A1.3.2.11 and presented in Table 7-25 and Table 7-26.

2.2.3.2 Hydro and wind sizing

As with solar, both hydro and wind are sized so that the generator can self-consume 70% of generated power. Explicit generation profiles are not used as with solar, although a range of assumptions regarding both seasonal and daily fluctuations in generation are stated in section A1.3.2.2.

2.2.4 Finalised capacity bands

The table below demonstrates the finalised capacity bands of each technology and the sector that these are suitable for. This coupling of technology to sector use cases defines an archetype. These archetypes are analysed further to determine what level of financial support will be needed to incentivise the uptake of the technology within that sector.

Table 2-10 – Finalised technology/sector archetype capacity bands

Technology	Sector	Capacity banding range (kW – kW)
Rooftop solar	Domestic and small agriculture	0-3
Rooftop solar	Large agriculture and schools	3-11
Rooftop solar	SME-commercial/industrial and local authorities	11-50
Ground solar	Small/large agriculture and schools	0-11
Ground solar	SME-commercial/industrial and local authorities	11-50
Wind	Small agriculture	0-6
Wind	Large agriculture and schools	6-11
Wind	SME-commercial/industrial and local authorities	11-50
Hydro	Domestic and small/large agriculture	0-6
Hydro	Schools, SME-commercial/industrial and local authorities	6-50
Micro-CHP	Domestic and small agriculture	1 – 1
Micro-CHP	Large agriculture and schools	1 – 5.5
Micro-CHP	SME – commercial/industrial and local authorities	5.5 - 30

2.3 Cost assessment

This section details the costs associated with each technology capacity band projected from 2020-2030. The costs determined are the capital costs (CAPEX) and O&M (OPEX) costs. It is important to note that the OPEX costs include both fixed OPEX (costs that are constant regardless of operation usually given as €/kW) and variable OPEX (costs that vary depending on factors such as power generation usually given as €/kWh/year) combined. This is common amongst the literature, with many reports detailing OPEX as an annual proportion of CAPEX (usually expressed a % CAPEX/year)[41].

The overall goal of the policy is to provide enough financial incentive to consumers to invest in renewable technologies to stimulate the market, resulting in a reduction of both CAPEX and OPEX over time. It is expected that the technology costs across most technologies reduce over time in such a way that financial incentives are no longer required when the cost of the technology is offset by the savings in the cost of electricity to the consumer (i.e. no net-costs borne by the consumer).

The reduction in costs over time, or learning rates, applied in this study are taken from a number of references as shown in the appendix. The microgeneration tariff levels need to take account of these learning rates.

The tables below present the CAPEX and OPEX for each technology capacity band projected for the years 2020, 2025 and 2030. Further details on data assumptions, references and methodology are available in Appendix A1.3.3, as well as the annualised costs for the period 2020-2030 for each technology banding.

Table 2-11 – Technology CAPEX costs 2020, 2025, 2030

Technology	Capacity banding range (kW – kW)	2020 CAPEX (€/kW)	2025 CAPEX (€/kW)	2030 CAPEX (€/kW)
Small_rooftop_solar	0 – 3	2,180	1,853	1,744
Medium_rooftop_solar	3 – 11	1,530	1,301	1,224
Large_rooftop_solar	11 – 50	1,300	1,105	1,040
Small_ground_solar	0 – 11	1,830	1,556	1,464
Large_ground_solar	11 – 50	1,600	1,360	1,280
Small_micro_wind	0 – 6	5,750	5,405	5,175
Medium_micro_wind	6 – 11	5,500	5,170	4,950
Large_micro_wind	11 – 50	4,250	3,995	3,825
Small_micro_hydro	0 – 6	11,550	11,545	11,540
Large_micro_hydro	6 – 50	9,900	9,895	9,890
Small_micro_CHP	1 – 1	5,700	5,130	4,617
Medium_micro_CHP	1 – 5.5	4,636	4,172	3,755
Large_micro_CHP	5.5 - 30	2,086	1,877	1,689

[41] Tsiropoulos, I., Tarvydas, D., Zucker, A. 2018. Cost development of low carbon energy technologies. JRC Technical Reports. Available from: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC109894/cost_development_of_low_carbon_energy_technologies_v2.2_final_online.pdf

Table 2-12 – Technology OPEX costs 2020, 2025, 2030

Technology	Capacity banding range (kW – kW)	2020 OPEX (€/kW/year)	2025 OPEX (€/kW/year)	2030 OPEX (€/kW/year)
Small_rooftop_solar	0 – 3	54.5	46.3	43.6
Medium_rooftop_solar	3 – 11	38.3	32.5	30.6
Large_rooftop_solar	11 – 50	32.5	27.6	26.0
Small_ground_solar	0 – 11	36.6	31.1	29.3
Large_ground_solar	11 – 50	32.0	27.2	25.6
Small_micro_wind	0 – 6	115.0	108.1	103.5
Medium_micro_wind	6 – 11	137.5	129.3	123.8
Large_micro_wind	11 – 50	106.3	99.9	95.6
Small_micro_hydro	0 – 6	115.5	115.5	115.4
Large_micro_hydro	6 – 50	99.0	99.0	98.9
Small_micro_CHP	1 – 1	120	120	120
Medium_micro_CHP	1 – 5.5	63	63	63
Large_micro_CHP	5.5 - 30	58	58	58

2.4 Carbon abatement

Carbon abatement is a key performance metric of the archetypes derived from the capacity banding exercise. The carbon abatement of each archetype is influenced by two main factors:

1. Energy generation of each technology and;
2. The emissions intensity of fuel sources that are offset through self-consumption.

Emissions factors were supplied by SEAI and are detailed in Appendix A1.3.4. All power generated by the technology is considered when accounting for offset emissions. Any excess power exported to the grid still contributes towards grid decarbonisation and should be considered a net benefit, even if that benefit is not directly borne by the owner of the generator.

The following method is used to calculate the carbon reduction of each archetype:

Annual energy generation (kWh) *x* grid emissions intensity ($kgCO2_e$/kWh)

All technologies that have a lower banding threshold of 0kW (such as domestic PV 0-3kW) use 1kW installed capacity to provide the lower threshold lifecycle carbon abatement (e.g. abatement figures represent a range of 1-3kW).

Further, CHP produces a net increase in emissions under some circumstances. This is because when the grid carbon intensity decreases below the CHP fuel input (in this case, natural gas) carbon intensity, there is a negative emission saving. In other words, the emissions generated by combusting natural gas are higher than the offset grid emissions and therefore produce a net increase in carbon emissions. The grid emissions factor undercuts the natural gas emissions factor by 2026 (170.43gCO_2e/kWh for the grid compared with 184gCO_2e/kWh for natural gas).

The table below outlines the carbon abatement of the upper capacity threshold for each archetype.

Table 2-13 - Lifecycle carbon abatement of archetypes

Technology band	Capacity banding range (kW)	Lifecycle carbon abatement lower range (tCO_2e)	Lifecycle carbon abatement upper range ($tCO2_{e)}$
Small_rooftop_solar	0-3	3.7	11.2
Medium_rooftop_solar	3-11	11.2	41.0
Large_rooftop_solar	11-50	41.0	186.5
Small_ground_solar	0-11	4.3	47.8
Large_ground_solar	11-50	47.8	217.1
Small_micro_wind	0-6	7.0	35.4
Medium_micro_wind	6-11	35.4	95.0
Large_micro_wind	11-50	95.0	363.1
Small_micro_hydro	0-6	22.4	134.4
Large_micro_hydro	6-50	134.4	1,120.0
Small_micro_CHP	1-1	1.5	4.3
Medium_micro_CHP	1-5.5	-32.0	1.5
Large_micro_CHP	5.5-30	-216.4	-32.0

Further details on methodology and data assumptions can be found in Appendix A1.3.4.

3 The viability gap

Microgeneration support levels should be set at a level to incentivise the uptake of the technology where there are gaps in the market (i.e. the revenue or benefits received from operating the technology does not compensate for the cost of that technology). A balance must be reached between providing a sufficient incentive to cover the difference that exists between the cost of installing a particular technology and the savings that result from self-consumption. This difference is defined as the viability gap.

In this analysis, viability gaps are calculated in 2020 EUR/kWh terms for each year between 2021 and 2030, for all archetypes, i.e. the combinations of the technologies and sectors. The detailed description of the methodology and the assumptions used for the modelling are summarised in Appendix A1.4.

The viability gap assessment informs the policy design exercise in defining the eligibility criteria, as in principle, only generations with positive viability gap should be subsidised. The assessment also provides information on the indicative level of required support.

3.1 Inputs and assumptions

To support the viability gap calculation and assessment, a financial model was developed. Details about the model can be found in Appendix A1.4.1.

The viability gap can be defined as the difference between the levelized cost of electricity for a technology and the value of self-consumption over the lifetime of the technology. The model uses technical and performance data, the capital expenditure (CAPEX) and operating cost (OPEX) inputs from the capacity banding and cost assessment exercises to calculate the total generation, onsite consumption and exported electricity and lifetime costs of each archetype. The self-consumption is valued as the avoided purchase of electricity, for which retail electricity prices are used. The price trajectories were provided by the SEAI for two scenarios: 'High price scenario' and 'Low price scenario'. Further details can be found in Appendix A1.4. The 'Low price scenario' is used in this study for the base case for consistency with Ireland's National Energy and Climate Plan (NECP) where this was also used as the baseline price scenario.

The price trajectories also include domestic and business retail natural gas prices, which are used to calculate the fuel cost for CHP. For this, the heat generation of the CHP archetypes can be derived from the efficiency parameters based on the outputs of section 2.2. The fuel consumption is derived from the combined electricity and heat generation using the system efficiency inputs from the same section.

The opportunity cost of investing in a comparable investment is captured in the discount rates. Although discount rates vary across different archetypes, as they reflect the hurdle rate for any investment, to set a level playing field, DECC requested the same discount rate for all archetype is used. As a result of the research and optimisation process DECC suggested a 3.75% discount rate is used in the Base case.

The Base case is defined by the CAPEX and OPEX figures described above, using the 'Low price scenario' and the 3.75% discount rate. It is against the Base case that all sensitivities are assessed.

3.2 Results

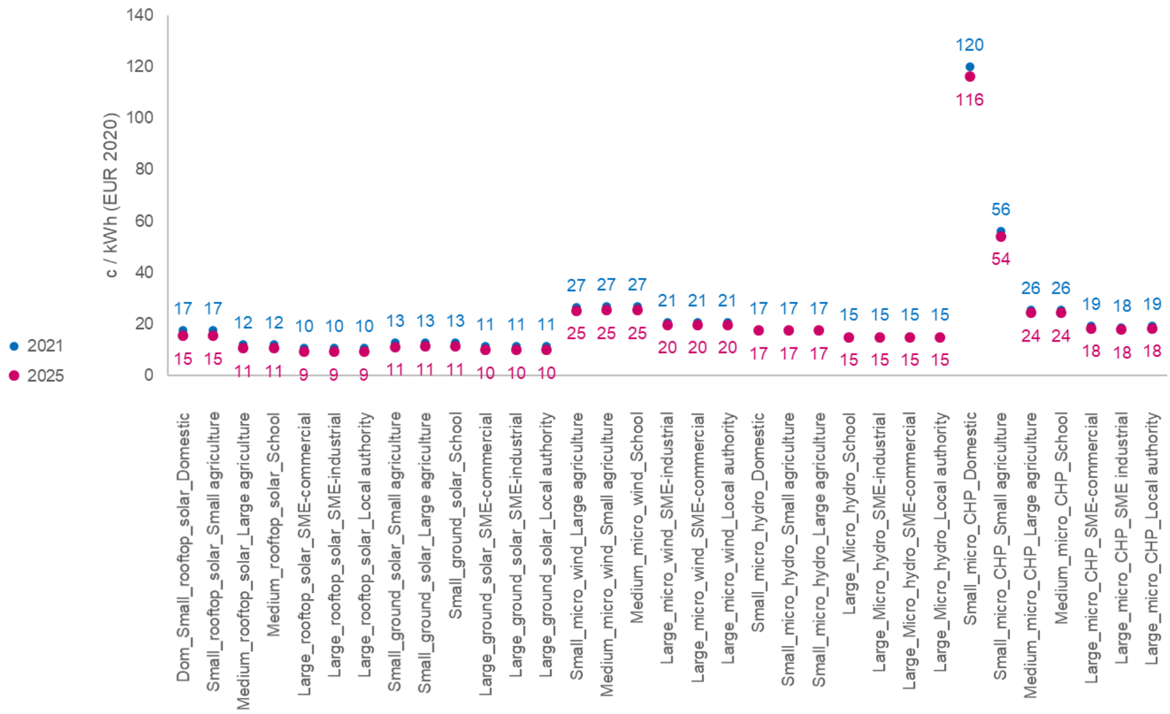
The main results of the model are calculated using a cash flow analysis for the useful lifetime of the technologies in each archetype. With the inputs described in the previous section, the levelized cost of electricity (LCOE) per archetype is calculated first. This is then used to determine the levelized viability gaps per archetype. These are calculated for the Base case scenario.

Sensitivity tests are run, varying input parameters to compare the results with those of the base case. The main outputs of the model are set out in the following section.

3.2.1 Base case scenario

The LCOE can be interpreted as the relative cost effectiveness of the archetypes, as it is expressed per unit of electricity generated. We present the results for two years, the first year of the policy and the mid-point of the policy in Figure 3-1.

Figure 3-1 - Base case LCOE per archetype in 2021 and 2025



The LCOE figures under the base case suggest that the large rooftop and large ground mounted solar archetypes are the most cost-efficient means of generating electricity on the microgeneration scale followed by the medium rooftop and the small and medium ground mounted solar. The small rooftop solar archetypes are the least cost-efficient among the solar technologies.

After the above solar archetypes, the most cost-efficient microgeneration technologies are hydro technologies, large then medium then small. The capital and operating costs figures from hydro are taken from international examples and with a relatively low hydro resource in Ireland, there is a lot of uncertainty in how these cost figures might translate to the Irish market.

The wind and the CHP archetypes appear to be less cost-efficient microgeneration sources compared to the other technologies. Given the high wind resource in Ireland, any operating scheme could be expected to have a reasonable capacity factor, if sited appropriately. The market should respond well to an appropriate price signal. However, there is less correlation between the wind generation profile and typical archetype demand profiles, meaning it is not well suited for high levels of self-consumption.

It can also be observed that LCOE figures for almost all archetypes decline over the period of 2021 and 2025, except the hydro technologies, mainly due to the assumed learning curves in technology costs.

The viability gap is defined as the difference between lifetime costs and lifetime electricity savings from self-consumption. In other words, it is the additional revenue that generators need to earn to cover their costs. The lifetime costs, the volume and value of the self-consumption and the discount rates are the main drivers of the viability gaps over the lifetime of the archetypes.

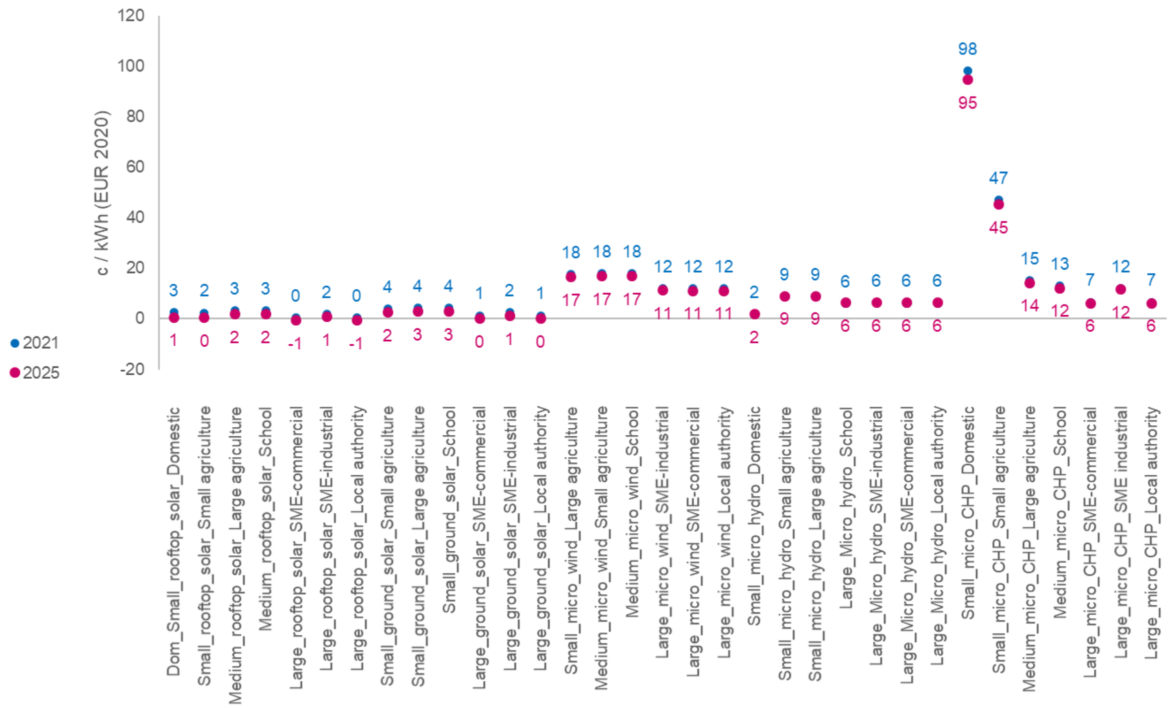
Consequently, the variables that need to be considered when modelling the viability gap include:

a) whether an incentive is paid on electricity generated or electricity exported
b) the life of the technology
c) the life of the incentive scheme

The scenarios that are modelled below are:

1) incentive is paid on electricity generated over the life of the technology, as presented in Figure 3-2
2) incentive is paid on electricity exported over the life of the incentive scheme, as presented in Figure 3-3
3) incentive is paid on the electricity generated, over the life of the incentive scheme, as presented in Figure 3-4

Figure 3-2 - Base case viability gap over lifetime generation per archetype in 2021 and 2025

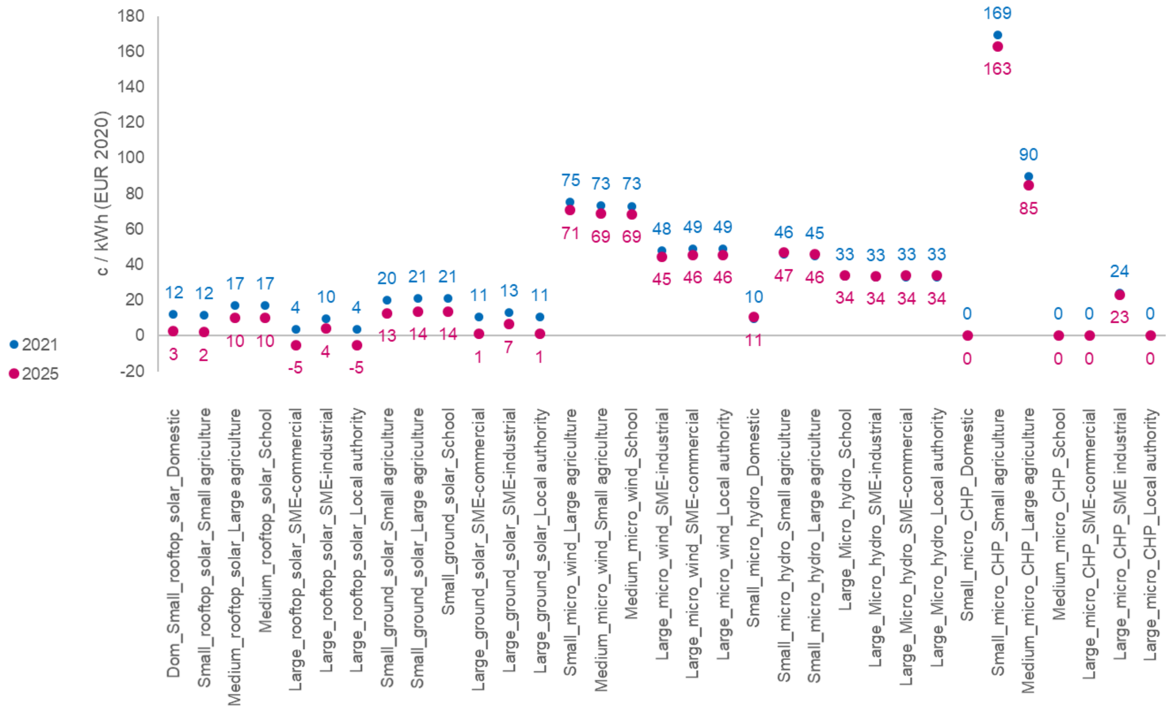


The results of the levelized viability gap over lifetime of the technology (scenario 1) show that under the 'base case' some large rooftop solar archetypes appear to be financially viable (shown as zero viability gap) in 2021. It is important to note that the difference between the viability gaps of similar technologies are mainly caused by the slight difference in self-consumption rates. The 2021 viability gap of the domestic rooftop solar is around 3 c/kWh, that of the C&I ground mounted solar (which includes SME and agriculture) is in a range of 1-4 c/kWh whereas that of the C&I rooftop solar is about 0-3 c/kWh. The viability gap of the C&I wind technologies ranges between 12 and 18 c/kWh, the C&I hydro is 6-9 c/kWh and the C&I CHP is 7-47 c/kWh.

The levelized viability gap can be considered as a proxy for the required subsidy level. One option for a microgeneration support scheme is to pay an incentive on electricity generated. Another option is to pay an incentive on electricity exported. Therefore, it is important to explore the viability gap levels also over the exported electricity. Further, the subsidy life has a significant impact on the levelized viability gap figures as the total lifetime viability gap needs to be recovered over a shorter period and thus over a smaller electricity generation or exported electricity volume. This is shown in Figure 3-3. The assumed 15 year subsidy life here aligns with the current RES scheme subsidy duration.

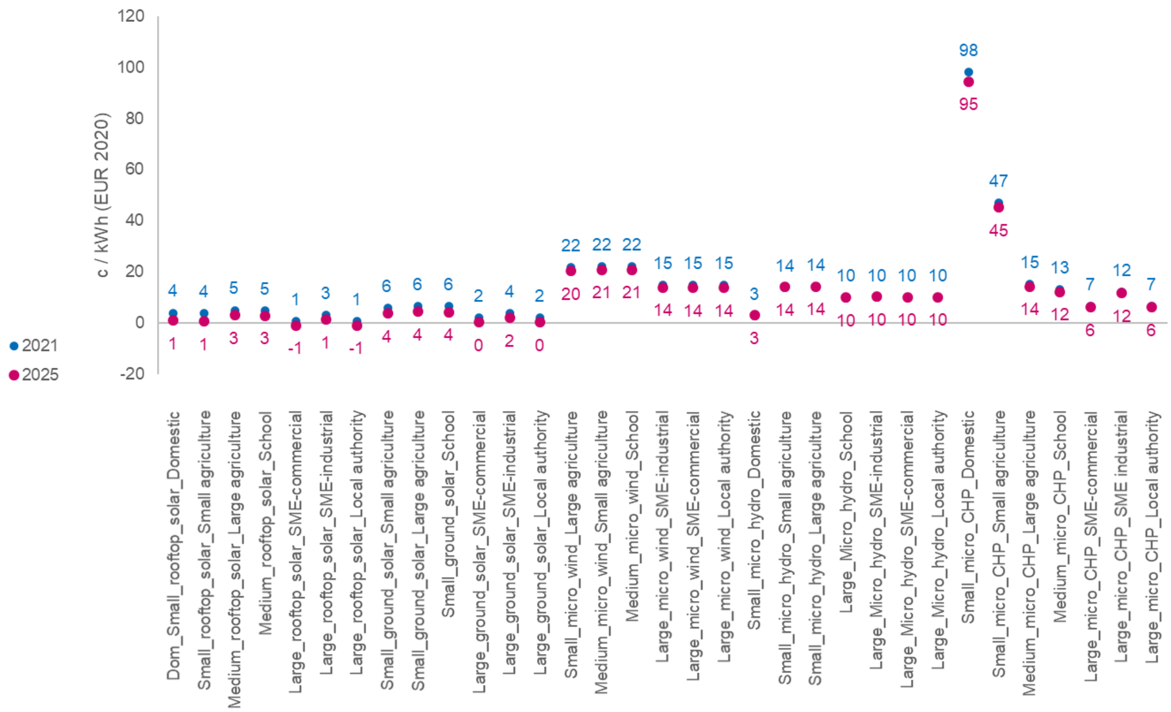
Another important consideration for the policy design is that the viability is optimised through encouraging higher self-consumption, which is more likely if the subsidies are set lower than the retail tariffs, which is explored in Chapter 5.

Figure 3-3 - Base case viability gap over exported electricity during an assumed 15-year subsidy life per archetype in 2021 and 2025



The viability gap over the electricity export provides a proxy to determine the support level which would be required for a certain archetype to cover its lifetime viability gap over the subsidy life if the scheme would be designed to be paid on exported electricity. As the self-consumption and therefore the exported electricity levels vary significantly among the archetypes, the levelized viability gap figures fluctuate significantly, when they are expressed over the exported electricity. These figures suggest that all archetypes to be installed in 2021 have viability gaps. Please note also that some of the CHP archetypes have no excess electricity so therefore the viability gap over export is zero, but it doesn't mean that these archetypes are financially viable as can be seen in Figure 3-3.

Figure 3-4 - Base case viability gap over generated electricity during an assumed 15-year subsidy life per archetype in 2021 and 2025



Offsetting the retail price paid for electricity consumption is the key driver for promoting self-consumption. Considering both the assumed consumption profiles which have high self-consumption figures across the archetypes and the underlining policy goal to promote self-consumption, an option that DECC have proposed is that the microgeneration scheme is designed to be paid on export from a site.

It is important to note that for the CHP technologies the viability gap over the assumed 15-year subsidy life is the same as the lifetime viability gap. The reason is that the assumed useful lifetime of these archetype is also 15 years.

Given the large number of potential archetypes, an archetype-based remuneration doesn't seem to be practical. Therefore, other factors such as technology neutrality and cost-efficiency need to be considered to select the optimal remuneration approach. This is further discussed in section 5.

3.2.2 Sensitivity analysis

In order to test the robustness of the results of the viability gap calculations and to show the impact of the changes in the key assumptions, a number of sensitivity tests on the financial model outputs are run. Those factors that are expected to have the most significant impact on the scheme cost and viability gaps levels are the discount rates, the retail energy prices and the capacities assumed for domestic solar PV (as previously stated it is expected that this will be the archetype with the largest uptake). In particular, the following main sensitivity testing are considered:

- Discount rate sensitivities: A range of discount rates have been considered to show the impact if this factor on the outputs;
- Price sensitivities: High retail electricity and retail natural gas prices and low electricity and natural gas prices;
- System size (only for domestic solar): 2kW, 2.5kW and 3kW.

The graphical representation of the model results is shown on the charts below focusing on the viability gaps over exported electricity over the assumed 15-year subsidy life to provide an indication on the potential subsidy levels. The detailed output data tables are presented in Appendix A1.4.

Figure 3-5: Discount rate sensitivity (5.5%) viability gap over exported electricity during an assumed 15-year subsidy life per archetype in 2021 and 2025

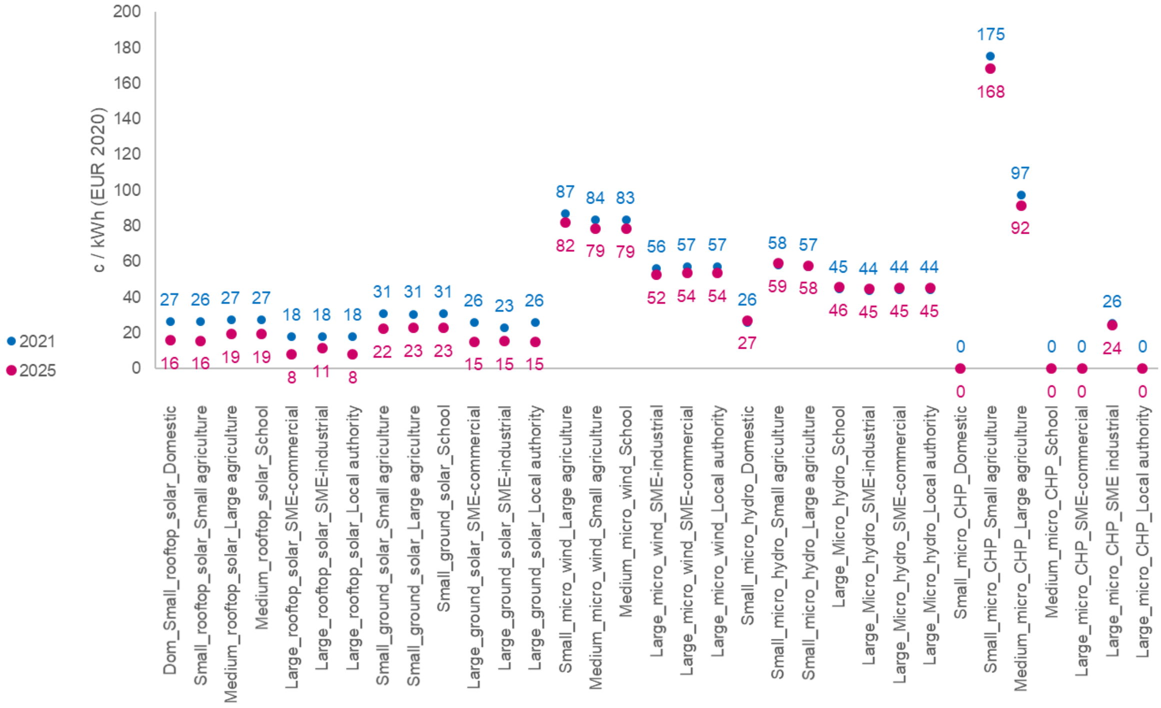


Figure 3-6: Discount rate sensitivity (2.5%) viability gap over exported electricity during an assumed 15-year subsidy life per archetype in 2021 and 2025

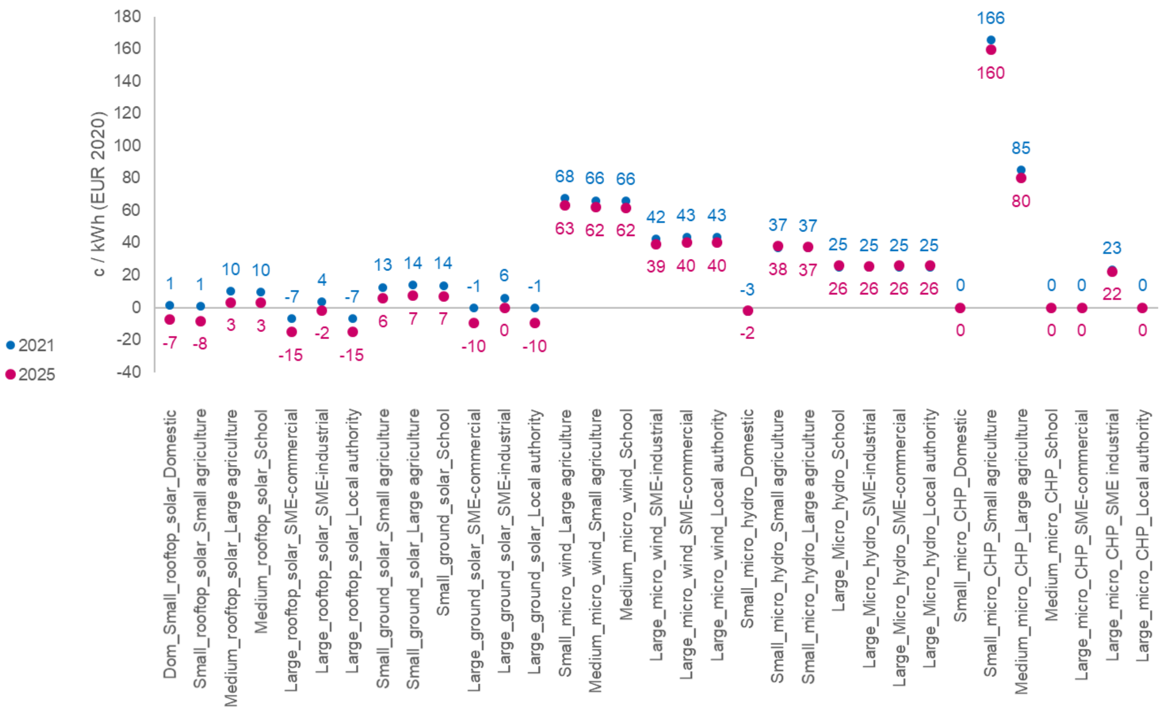
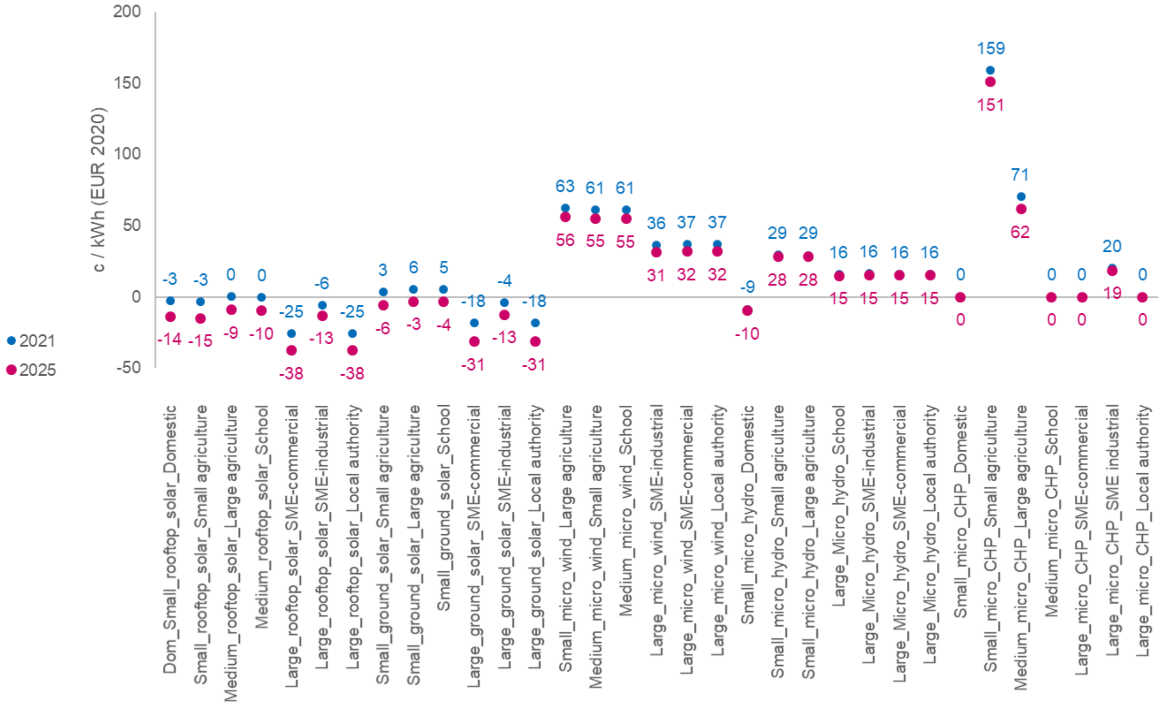


Figure 3-7: High price sensitivity viability gap over exported electricity during an assumed 15-year subsidy life per archetype in 2021 and 2025



From assessing the 'base case' results and the sensitivity analysis, it can be concluded that both the discount rate and the price has a significant impact on the viability gaps through the value of the self-consumption which is around the target 70% level in most cases. In both the lower discount rate and the 'high price' scenarios a lot of archetypes would become financially viable compared to the base case. This high sensitivity is, in part, due to the subsidy being paid on export, so the viability gap needs to be recovered over a small proportion of the electricity generated.

Based on the assessment of microgeneration supporting schemes in other jurisdictions, it can be concluded that most of the installed systems that are expected to be supported under the microgeneration support scheme in Ireland will be domestic rooftop solar. The following chart, Figure 3-8, focuses on this archetype and captures the development of viability gap of this archetype across the selected scenarios.

The capacity of the installation is varied to demonstrate the impact of differing levels of self-consumption.

Figure 3-8: Viability gap per unit exported over subsidy life and LCOE - Domestic solar (2021-2025)

The Base Case assumes a 3kW scheme is installed, which is close to the target of 70% self-consumption. If the assumed capacity is dropped to 2.5kW, the level of self-consumption increases to 76%, so the savings to the consumer from offset electricity are higher, hence the viability gap per unit is lower. However, this will reduce the amount of renewable electricity generated and the reduction in carbon emissions that will result. If the capacity is reduced further to 2kW, the level of self-consumption increases further to 86%, however the amount of electricity generated falls considerably to 1,598kWh from 2,397kWh at 3kW.

The 3kW is therefore a good threshold to deliver the 70% self-consumption target without incentivising the export of electricity onto the network.

Changes in the assumed retail price for electricity are also demonstrated in Figure 3-8. The base case retail electricity price is 232 €/MWh in 2021 (2020 price) and 215 €/MWh in 2045 (2020 price). It is clear from this that if the retail price of electricity is at the SEAI High price forecast of 242 €/kWh in 2021 (2020 price) and 273 in 2045 (2020 price), this has a significant impact on the savings that will be realised from a 3kW domestic solar scheme, with the viability gap in 2021 falling from 12.23c/kWh to -2.57c/kWh.

4 Policy option identification

As previously highlighted, there are a number of other jurisdictions across Europe that have already implemented microgeneration support schemes. Ireland is therefore able to ensure lessons are learnt from other jurisdictions in their policy development. There are many examples of improvements that can be made to the design of policies to ensure that they are efficient and to prevent market distortions. If designed poorly, policies can either be ineffective or result in overcompensation of the market, resulting in the inefficient deployment of technologies and impacting the policy cost.

The main policy types that have been used to incentivise microgeneration and that are in line with the updated Renewable Energy Directive (RED II) are outlined below:

- A **feed-in tariff (FIT)** incentivises investment in renewable energy technologies by offering long-term contracts to renewable energy producers. In a FIT, cost-based compensation is offered to renewable energy producers, providing price certainty and long-term contracts that help finance renewable energy investments. This is an attractive option for technologies that lack maturity, in order to accelerate their uptake.
- Under a **feed-in premium (FIP)** scheme, generators receive a premium on top of the market price of their electricity production. Premiums can either be fixed (at a constant level independent of market prices) or sliding (with levels varying in line with wholesale electricity prices). Fixed FIP schemes are simpler in design but there is a risk of overcompensation in the case of high market prices or under-compensation when market prices are low. In the case of sliding FIP schemes, the regulator faces some risk in case electricity prices decrease, as support levels fluctuate with changes in electricity market prices. On the other hand, the regulator does not risk having to pay for overcompensation, as is the case under a fixed FIP scheme. The sliding FIP scheme does however make the scheme more complex, thereby adding additional administration costs.
- **Investment subsidies or grants** can also be provided for costs associated with the purchase and installation of microgeneration equipment.
- An alternative policy mechanism is the use of **Renewables Obligation Certificates (ROCs)**, which can be issued for eligible microgeneration from an accredited station. These certificates can be traded with third parties, or sold to electricity suppliers directly, who use them to meet their Renewables Obligation.
- A **Smart Export Guarantee (SEG)**, which is an obligation on licensed electricity suppliers of a specific size to offer an export tariff to renewable generators with eligible installations. The suppliers can decide the level of the export tariff as well as its type and length. This could mean there could be a variety of different SEG tariffs available and generators may consider switching to suppliers with the most favourable SEG.

4.1 Ireland's policy principles

A set of six case studies of international experience with microgeneration support schemes were identified as part of this study to distil lessons learned and understand what factors can impact on the successful functioning of the scheme in terms of its effectiveness, efficiency, feasibility and other impacts such as on equity elements. Case studies were selected based on their alignment with the microgeneration policy principles prioritised by Ireland, including:

Table 4-1 - Overview of microgeneration policy principals and their implications for case study choices

Microgeneration Policy Principal	Implication for policy option choices
Establish the **'renewables self-consumer'** model of energy generation and consumption in Ireland, meeting the	• Prioritise case studies that are inclusive to sector/technology options and promote

commitment within the Climate Action Plan and the tenets of energy communities as set out in the recast RED and the IMED.	technologies that have high potential in Ireland • Prioritise options that give consumers the greatest opportunities to use their own renewable generation, i.e. because it is generated at appropriate times of demand, for instance for solar PV in dairy farms. • Exclude net metering case studies • Prioritise more recently introduced policies as these are more in line with the recast RED and IMED
Support the concept of **community empowerment and participation** set out in the Climate Action Plan,	• Prioritise case studies that address barriers specific to energy communities (such as pre-registering / tariff guarantees) • Prioritise case studies that provide enabling framework for community participation (Article 22(4)), e.g allowance of shared grid connections between installations.
Any support scheme needs to be **equitable** and address the issue of cost burden sharing. The scheme needs to protect customers, focus on protection of vulnerable customers and be **accessible** to all electricity customers,	• Prioritise options in which the level of support is dependent on ability to pay, with preferential support, e.g. through export rates, to vulnerable and poorer householders or those that address capital cost barriers such as capital grants. • Prioritise options that have made adjustments to allow for equal access to the scheme to all electricity consumers.
An **energy efficiency first approach** to building retrofit should be promoted where possible, and decision makers should consider microgeneration installations in conjunction with other home energy retrofit measures,	• Prioritise case studies that include eligibility criteria related to energy efficiency principles, use of building energy efficiency performance minimum standards, such as apply in the UK FIT.
Focus on **self-consumption** (including storage and demand response) and sizing the installation appropriately to meet relevant electricity demand (note increased electricity demands due to electrification (heat pumps and EVs),	• Prioritise options where generation thresholds for support are defined so that they allow larger installations in settings where there is demand (e.g. large public buildings/facilities), or where battery technologies could apply, e.g. domestic (mirroring battery grants under solar PV pilots).
Based upon **data and evidence** from existing and historical schemes including other research (behavioural and attitudes, stakeholder workshops etc.) and other relevant economic and financial assessments,	• Develop and review policy options based on a strongly data driven approach. • Only case studies with sufficient data availability have been selected for further analysis
Supports a sustainable and enduring microgeneration industry in Ireland, supporting **local enterprise and employment**,	• Prioritise policy options that have a long-lasting effect, yet also avoid the risk of over-subsidy in the case that technology costs decline, for example using planned banding and rate updates are regular intervals.
Deliver a **coherent scheme**, including any suitable supports, with provision for	• Prioritise policy options where the core financial incentive needs to be augmented by enabling

a feed-in tariff for selling power to the grid to be set at least at the wholesale price point,	support, such as advice services/calculators, streamlined administrative procedures (for example for vulnerable customers) and so on.

Based on the above listed principles, the following case studies were selected for further analysis:

- **UK - Feed-in-tariff:** This policy was introduced in 2010 and provided microgenerators of renewable electricity (under 5MW) with a feed-in-tariff for 10 to 25 years for the electricity that is fed back into the grid. The feed-in-tariff rate was different by technology type and split into an export tariff for electricity supplied to the grid and a generation tariff for all generated energy regardless of use. The feed-in-tariff rate was degressive aligned with cost reductions over time and phased out completely in 2019.
- **UK - Smart export guarantee.** A policy that was introduced to replace the UK Feed-in-Tariff. Under this policy licensed electricity suppliers with more than 150,000 customers are required to offer a compliant export tariff to any generator with an eligible installation. The SEG licensees decide exactly how they want their SEG export tariff to work in terms of its rate, type and length. However, the tariff must be greater than zero pence per kilowatt hour exported at all times. As with tariffs for the purchase of electricity, there could be a variety of different SEG export tariffs available. Suppliers can compete to offer attractive terms and, if the tariff becomes uncompetitive, generators may consider switching to another supplier.
- **Germany - subsidy for solar PV and storage.** This is an incentive scheme, which was renewed in March 2016 after an initial implementation in 2013. It consists of a low-interest loan of up to €2/W for solar PV systems and a direct payment for up to 22% of the eligible costs of the system (not to exceed €0.50/W of the PV capacity). The portion of eligible costs to which the grant can be applied will decrease by three percentage points every six months until it reaches 10% in the second half of 2018, at which time the program will expire.
- **Austria - Investment subsidies for small solar PV installations. Under this policy** PV installations under 5kWp in private households and commercial buildings are eligible for investment subsidies from the Austrian Climate and Energy Fund. The promotion budget – annually announced in spring – is only granted for new projects and can be claimed by private individuals, companies, associations and confessional facilities. Since 2015, private individuals can build a PV system conjointly by accessing the funds for max. 5 kWp per capita and 30 kWp in total. Furthermore, it is also possible to apply for the funding more than once if the applicant aims to build another unit at a different site.
- **Denmark - Premium tariff (Law on the Promotion of Renewable Energy).** Under this scheme plant operators receive a variable bonus on top of the market price (technology/capacity dependent). The sum of the bonus and market price shall not exceed a certain statutory maximum, which depends on the date of the connection of given plant/source of energy used. In some cases, plant operators are granted a guaranteed bonus on top of market price, negating the statutory maximum. This is known as a 'sliding premium'
- **Northern Ireland – (Micro)-Renewables Obligation.** Ofgem provide Northern Ireland Renewables Obligation Certificates (NIROCs) for eligible generation from an accredited station. NIROCs can be traded with third parties, or sold to electricity suppliers directly, who use them to meet their Renewables Obligation.
- **France – Investment bonus for solar PV.** Under this scheme households that install renewable energy plants of 3 kWp or lower at their principal residence may deduce 30% of the net hardware costs from their income tax. Using survey analysis, this scheme expects around a third of all participants to use 100% of the electricity they produce themselves.

4.2 Lessons learned from international case studies

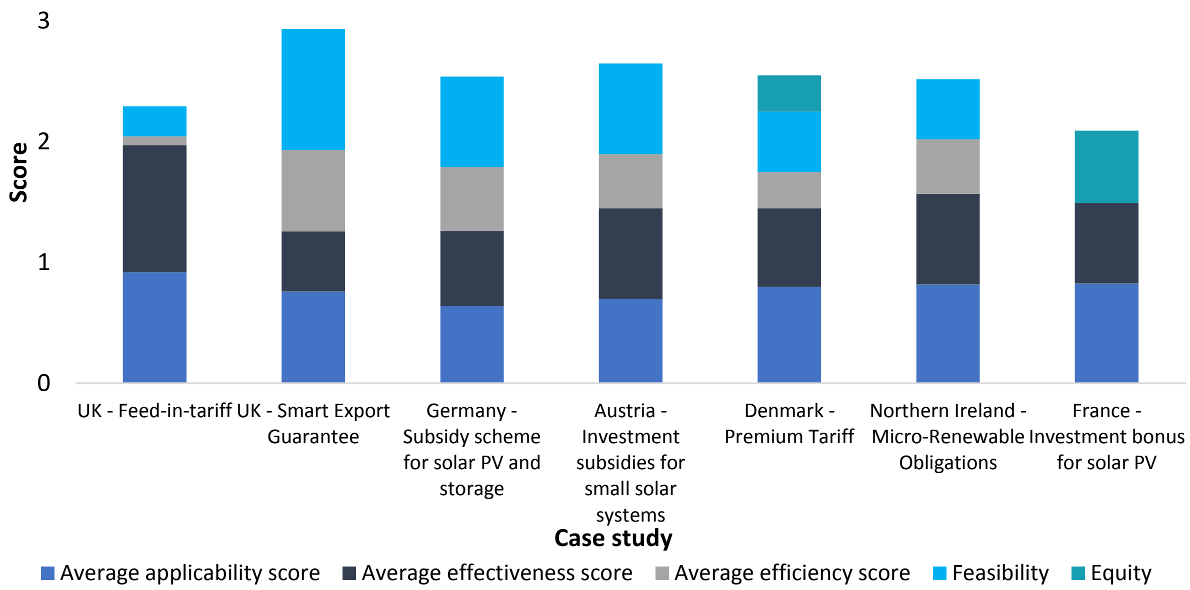
The six case studies selected for further analysis were assessed based on the criteria listed below[42].

- **Applicability** (20%)
  - Alignment of technology scope with Irish objectives to target micro-solar mainly, supported by micro-wind, micro-CHP and micro-hydro.
  - Alignment of size threshold with Irish objective of <50kW.
  - Alignment of sectoral scope with Irish objective to cover domestic, SMEs, farming, social enterprise and public buildings.
  - Inclusion of energy efficiency principles in eligibility criteria for scheme.
- **Effectiveness** (25%)
  - Effectiveness at promoting microgeneration in terms of installed capacity realised (MW) or electricity generated (MWh) (per year) as a percentage of total generation
  - Effectiveness at promoting self-consumption in terms of % of generated energy through scheme (per year)
  - If relevant, effectiveness in terms of meeting pre-determined target (or projection)
- **Efficiency** (15%)
  - Costs to public sector in terms of overall costs of scheme per year and per kWp installed
  - Costs to consumer per year
- **Feasibility** (25%)
  - Complexity of implementation in terms of institutional capacity and administrative costs required
- **Equity** (15%)
  - Provisions for lower income and fuel-poor households or measures to increase accessibility of scheme for everyone.

The scores assigned to the case studies are shown in the figure below.

[42] The criteria were weighted to reflect the priorities for the scheme in Ireland, with the relative weightings shown here in brackets.

Figure 4-1 - Scores assigned to international case studies, including breakdown by criteria (calculated using weighted averages, overall score out of 5)



A full summary of the data collected for each case study and their assessment can be found in Appendix A1.1 and A1.2.

Below a summary is provided of the main lessons learned from the case study policies through the data collection and scoring exercise.

Applicability

The highest scoring policies for applicability are the UK FiT, the Danish premium tariff and the Northern Ireland micro-renewable obligations. All three of these policies have a technology scope that includes micro-wind, micro-CHP and micro-hydro with a strong emphasis on micro-solar and have a broad sectoral scope for customer type.

One of the main lessons learned from scoring the applicability of the different case study policies, is that a scheme that incentivises high level of consumption (i.e. over 75%) has not been demonstrated. The UK FIT and the German investment subsidy both expected an average of about 50% of self-consumption and no data has been found of any of the schemes achieving higher rates than 75%.

Effectiveness and Efficiency

One way to measure the effectiveness of microgeneration schemes is to investigate whether policies set targets or projects at the implementation stage and how they performed against these. However, none of the case study policies set capacity targets for the microgeneration scheme, but some did make projections for expected impacts or established budgetary limits. While none of the case studies analysed indicated that targets were set in terms of installed capacity for microgeneration, the two policies from the UK (Feed-in-Tariff and Smart Export Guarantee) did set projections as part of their impact assessments at the start of the policy. The UK FIT scheme was projecting to support 750,000 installations and deliver approximately 6TWh (or 1.6%) of final UK electricity consumption in 2020 in its original impact assessment. The policy ended up incentivising 850,000 installations, thereby greatly overachieving its target. Likewise, the SEG impact assessment projects 12.5 MW of capacity to be installed per year. In addition, the investment subsidy schemes identified a budgetary limit which functioned as a target in a way, although no expectations were set for the number of installations or installed capacity to be achieved with the policy.

Secondly, schemes that distinguish by type of system have higher scores for effectiveness although it can also increase costs. For example, the Austrian scheme distinguishes its level of support by type of system, e.g. free-standing, rooftop and for building-integrated systems, which has impacted positively on its uptake rate. However, in the UK case technology capacity banding has impacted on the efficiency of the scheme by incentivising developers to derate their wind turbines to take advantage of higher tariffs, resulting in turbines operating at lower efficiencies than expected

The higher scoring policies for both effectiveness and efficiency often make use of combination of policies, either simultaneously or planned sequences. For example, the Austrian investment subsidy works in a complementary manner to the existing FiT scheme in Austria, thereby making both policies more effective in incentivising renewable energy deployment. By providing an investment subsidy, the FIT has also become more accessible for lower-income households. In addition, both the Danish premium tariff and the UK Smart Export Guarantee have been introduced after the phase-out of previous policies (net metering and FiT respectively), taking into account the lessons learned and cost developments of the previous policies to tailor new policies as much as possible to the remaining barriers and electricity landscape in each jurisdiction.

Feasibility

The UK FiT and Danish premium tariff have an average score for feasibility. In these cases the tariffs have changed over the course of the policy requiring authorities to recalculate rates regularly. Moreover, FIT payments are made quarterly (at least) for the electricity generated and exported and verification and accreditation processes need to be carried out as well, which is also the case for the investment subsidy policies.

On the other hand, the UK Smart Export Guarantee received the highest score for feasibility. In this case, the scheme administrator will face some administration costs although these are expected to be significantly less than the costs of administering the FITs scheme, given the light touch nature of the authority's role, in line with the market based approach of a SEG.

Microgeneration schemes that are based on market-type mechanisms such as the Northern Ireland example can instead pose significant barriers for smaller entities to make use of the offerings of the scheme as it increases the administrative burden; and increases uncertainty regarding return on investment. In addition, the scheme can also be costly to consumers as all costs are passed through.

Equity

Few examples exist of schemes including equity aspects, such as provisions for lower and fuel-poor households. Only the Danish example provided some kind of provision, as the subsidy within the annual pool of 20 MW can be granted to commonly owned PV installations as well as household PV installations. However, the inherent exposure to market signals associated with the premium tariff system has itself created barriers for community-led microgeneration projects.[43] Therefore, we researched the French investment bonus scheme for solar PV to see what other equity measures could be integrated into a microgeneration scheme. The French scheme allows for households that install renewable energy plants at their principal residence to deduct 30% of the net hardware costs from income tax, therefore focusing more on the accessibility of the scheme for all households.

In the boxes below a summary is provided of the three highest scoring policies in terms of their applicability to Ireland's ambition for a new microgeneration support scheme. This includes the UK's transition from a feed-in-tariff to the smart export guarantee, the investment subsidies used in Austria

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[43] IEA-RETD. 2016. Cost and financing aspects of community renewable energy projects. Volume II: Danish Case study. Available from: https://s3.eu-west-2.amazonaws.com/prod-wl-cee/resources/files/2119-cost-and-financing-community-renewables-volume-ii-danish-report.pdf

and the premium tariff in Denmark. Each of the boxes provides a summary of the policy as well as a summary of its assessment.

Box 1 - UK Feed-in Tariff (FIT) and Smart Export Guarantee schemes

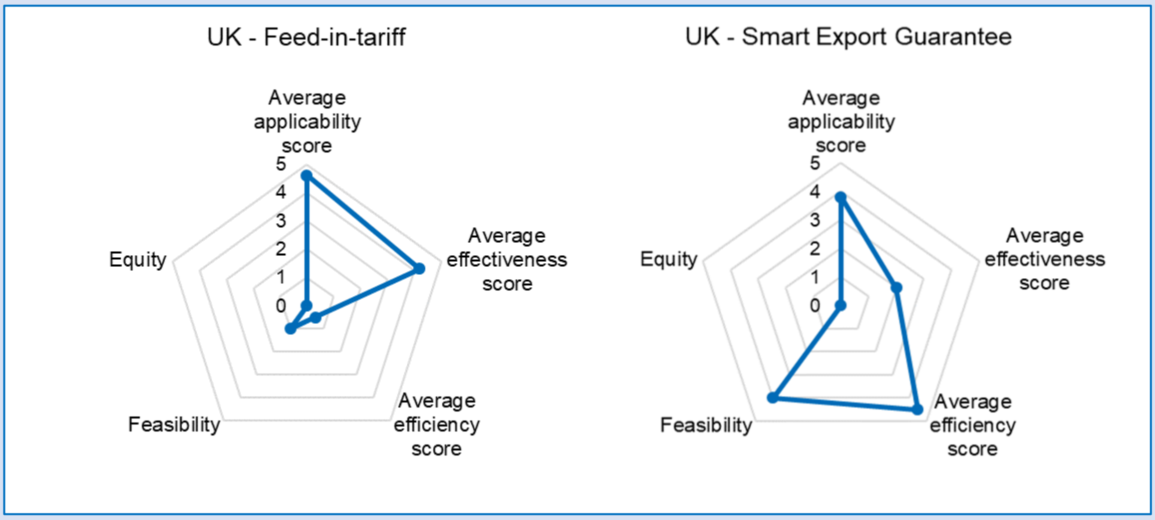
The FIT was intended to be a subsidy framework for small-scale low carbon technologies which could be easily understood, offered certain returns and covered a wide range of technologies.

The scheme has supported the installation of over 850,000 installations, some 6.6GW of UK generation capacity. This is equivalent to 7.8% of the UK's electricity generation capacity (or 0.9% per year).[44]

The UK FIT scheme has over-achieved its targets and has therefore been regarded as successful. However, while the FIT has been effective at encouraging microgeneration, the cost-effectiveness of the policy overall for the UK government is poor. This is because the scheme assumes that generators export 50% of the electricity they produce and are paid for it-even when the electricity is not needed by the grid or they export less than 50%.

The FIT ended on 31st March 2019 and was replaced in 2020 by the Smart Export Guarantee (SEG) with the government citing a desire to “move towards market-based solutions, cost reflective pricing and the continued drive to minimise support costs on consumers.”

Under the SEG, electricity suppliers set their own tariff for exported electricity, so tariffs can be set so that net costs to suppliers are avoided. The SEG is therefore unlikely to carry any policy costs which are typically paid for by final consumers. However, the SEG is also expected to be less effective, with the impact assessment carried out in advance of its implementation predicting that it will deliver 12.5 MW per year until 2026, equivalent to 0.09% of the UK's electricity capacity (or 0.015% per year).[45]



[44] Based on 85 GW total capacity of the UK in 2014
[45] UK BEIS. 2019. Impact Assessment for Smart Export Guarantee. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/807422/smart-export-guarantee-impact-assessment.pdf

Box 2 - Investment subsidies for small solar systems in Austria

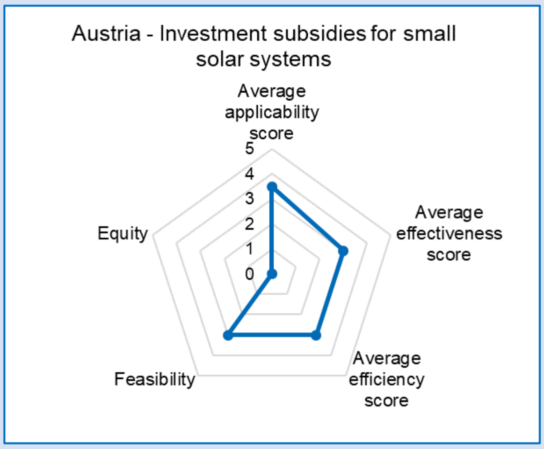
The Austrian Climate and Energy Fund states that its aim is to create attractive incentives for environmentally and climate-friendly electricity supply. This has led to the implementation of not only a Feed-in Tariff, but also an investment subsidy for small scale solar electricity generation.

Subsidies are granted for maximally 5 kWp of a PV installation (PV Subsidy Guidelines 2018).[46] However, the installation's size is generally irrelevant for eligibility.[47] Photovoltaic systems must be grid-connected and eligible investment costs include:

- PV modules
- Inverters
- Elevations, tracking systems (both single and biaxial)
- Installation, assembly, cable connections, control cabinet conversion
- Lightning protection, data logger
- Necessary conversion of the meter box
- Planning (to a maximum of 10% of the recognizable net investment costs)

The scheme led to approximately 3,600 new PV systems with a total capacity of 20.2 MWp in 2018 alone and is still in operation today. In 2020, the annual budget for the scheme doubled to EUR 10 million.

While the scheme has been successful in driving uptake of solar PV, a recent paper suggests that significant inefficiencies occur as a result of incentives to install relatively small PV systems.[48] The authors argue that deployment of larger PV systems in the residential sector would allow costs to be decreased. For instance, they model that an increase of minimum system sizes to 10 kWp would reduce the total investment costs by 10%.



Relatively low administrative costs are associated with operation of this scheme and the scheme has changed little since its introduction.

[46] Klima und Energie Fonds. 2018. Leitfaden – Photovoltaik-Anlagen in der Land- und Forstwirtschaft. Jahresprogramm 2018/2019. Available from: https://www.klimafonds.gv.at/wp-content/uploads/sites/6/Leitfaden-PV-in-LW-FW-2018-1.pdf
[47] Except in the forestry and agriculture sector; the maximum capacity allowed is 5 kWp in this sector as the "Photovoltaic and storage systems in agriculture and forestry" scheme is also in place. This promotes photovoltaic systems in agriculture and forestry in the size of 5 kW to 50 kW and electricity storage systems up to 3 kWh / kW.
[48] Hartner, M., Mayr, D., Kollmann, A., Haas, R. 2017. Optimal sizing of residential PV systems from a household and social cost perspective. A case study in Austria. Solar Energy 141 – 49-58. Available from: https://publik.tuwien.ac.at/files/publik_252781.pdf

Box 3 - Denmark premium tariff (Law on the Promotion of Renewable Energy)

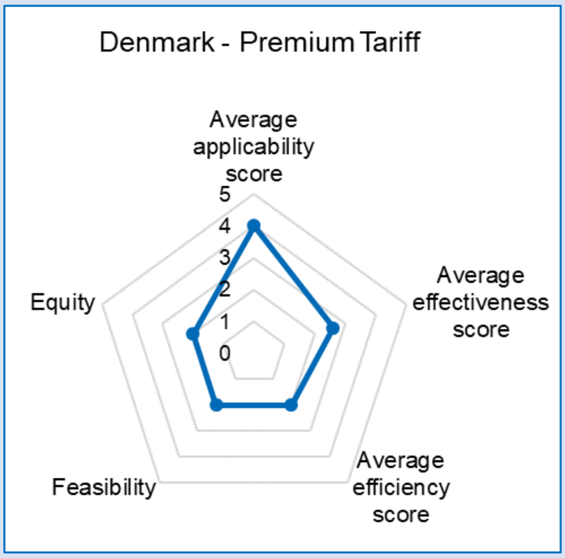
Denmark promotes renewable electricity generation through a premium tariff. Under this scheme, plant operators receive a variable bonus on top of the market price. The sum of the bonus and the market price shall not exceed a certain statutory maximum, which depends on the date of connection of a given installation and the source of energy used.

Systems that are eligible for the scheme are:

- Solar: non-commercial RES systems smaller than 6 kW
- Wind: capacities of up to 10kW and 10kW - 25kW that generate for the operators own use
- Hydro: capacity of up to 6kW (or over 6kW, although not considered for study)

Costs associated with the scheme are borne by the consumer although the scheme offers a good 'sliding' rate and encourages self-generation to offset market cost of electricity

To begin with, the premium tariff was made more attractive because of the possibility of annual net metering. This meant that for an average household, the annual electricity bill, excluding subscription, could be covered by the annual generation of the installation itself, with an average support level of around 25 ct/kWh for generated electricity.[49] Additionally, there were favourable tax conditions over and above this. Subsequently, the rules were changed to an hour-by-hour net metering scheme and the favourable tax conditions were reduced. This practically removed the incentive for installations in average types of household.



After an initial boom in residential PV installation, in 2012/13 the change in the net metering conditions practically eliminated this market, but common PV installations on the rooftops of apartment blocks and commercial buildings have continued to attract investment up to the 20 MW annual limit.

The scheme is considered to be fairly equitable as subsidies within the annual pool of 20 MW can be granted to commonly owned PV installations as well as household PV installations.

4.3 Identification of policy options

The UK Smart Export Guarantee was found to be most aligned with the objectives for the Irish microgeneration policy. The Austrian investment subsidy also scored highly, with the Danish premium tariff ranking third highest.

These highest scoring case studies were taken into consideration as a basis for the establishment of a set of policy options for a microgeneration scheme in Ireland as presented below.

[49] RES-Legal. N/D. Legal sources on renewable Energy – Premium Tariff Law on the Promotion of Renewable Energy. Available from: http://www.res-legal.eu/search-by-country/denmark/single/s/res-e/t/promotioN/Aid/premium-tariff-law-on-the-promotion-of-renewable-energy/lastp/96/

Figure 4-2 - Proposed policy options for a microgeneration support scheme in Ireland based on international experience

Policy options	1	2	3	4	5
Smart Export Guarantee for all installations (old and new) based on the UK example	✓	✓		✓	✓
Investment subsidy for new installations as a percentage of total investment costs		✓			✓
Feed-in-tariff based on exported electricity for new installations			✓		
Feed-in-premium for exported electricity for new installations only based on difference between viability gap and smart export guarantee rate				✓	
Different **eligibility criteria** for **increased accessibility**					✓

5 Policy review

The five identified policies from the review of international policies are investigated further in this chapter to assess their suitability for Ireland to incentivise microgeneration uptake.

5.1 Policy design

This chapter introduces a selection of policy options that have been defined and designed according to the outcomes of the above sections. The design takes into account the best practices identified by selected international schemes and caters for the individual Irish market position. Further emphasis has been given to how existing schemes (as listed under section 1.2.) can be used as building blocks and integrated into future policy support schemes for microgeneration up to 50kW beyond 2030. It is important to re-iterate that the basis for the microgeneration scheme design is the assumption that at least 70% of electricity generated is for self-consumption and only the periodic overgeneration is going to be fed into the grid. Hence the incentives of any policy are not driven by maximising output but rather a best fit for own consumption levels.

In addition, the objective of the support scheme is to be technology neutral and minimise cost. Therefore, while support rates have been calculated for exported electricity for different archetypes, DECC have focussed this study to assume that only the domestic rooftop solar rate, which is expected to have the highest uptake rate, will be paid out for all archetypes. This is both to ensure the support scheme is at lowest cost, as this archetype has one of the lowest viability gaps, is optimised for the archetype that is expected to have the largest uptake and so have the greatest impact on the policy cost, as well as to ensure the scheme is technology neutral and does not distinguish levels of support based on technology or sector.

The length of the subsidy life assumed in this study is 15 years to align the microgeneration support scheme with other Irish policies such as the Renewable Energy Feed-in-Tariff (REFIT), RESS and Support Scheme for Renewable Heat (SSRH) which were all defined for 15 years as well.

5.1.1 Level of support

The level of support provided by each policy option is dependent on the type of policy mechanism and each policy's parameters that are applied. In the case of the Smart Export Guarantee, the level of support will be set by the market and the rate offered may vary by supplier. In the UK, suppliers are obligated under rules set by the regulator Ofgem[50], to ensure that "*the remuneration offered for electricity fed into the grid reflects the market value of that electricity and* [takes] *into account its long-term value to the grid, the environment and society*", in line with the requirements set under the recast Renewable Energy Directive in the EU[51]. The rate offered will depend on the portfolio of generators that each supplier has and the price they can trade their generated electricity at. For the economic cost modelling exercise, it has been assumed that the smart export guarantee rate that is offered by suppliers will be equivalent to the expected wholesale electricity price, as forecasting any other level has too many associated uncertainties.

Alternatively, for the investment subsidy, feed-in-tariff and FiP policies the level of support has assumed that payments are made on exported electricity only. This could effectively work as an incentive to minimise the export as the payment is lower than the retail electricity price.

A summary of the way in which the level of support has been calculated for each policy option as well as the rates used is provided in the table below.

Table 5-1 - Level of support per policy option

Policy options	1	2	3	4	5	Level of support calculation
Smart Export Guarantee	✓	✓		✓	✓	One single rate for all technology types and capacity bands (and both existing and new installations). The modelled rate is derived from expected wholesale electricity prices, although in practice set by the suppliers.
Investment subsidy		✓			✓	Investment subsidies will be available for all qualifying new installations and these are defined as a percentage of total investment costs. To ensure the investment subsidy is technology neutral, only one rate (set as percentage of capital costs) for investment subsidy will be set for all technologies i.e. for domestic rooftop solar, as the highest uptake is expected here and lower levels of support are needed. This aligns with the policy objectives to be technology neutral and lowest cost.
Feed-in-tariff			✓			The feed-in-tariff is defined as a fixed export payment set at such a rate that the viability gap is met when the FiT is paid for exported electricity. While viability gaps may differ for each capacity band, the FiT will be set at the viability gap level for the domestic rooftop solar archetype, as this is expected to have the highest uptake levels. The FiT will be available for new installations only, while an export payment at the wholesale electricity price level will be made by the government in the form of a FiT payment for existing installations.
Feed-in-premium				✓		A FiP will be available for new installations only. It will be calculated based on the difference between the viability gap and the SEG. The FiP is thereby dynamic and varies according to the market rate of the SEG. Similar to the FiT, only one FiP rate will be set for all capacity bands, i.e. based on the viability gap level of the domestic rooftop solar archetype. Through its flexible nature, a FiP guarantees a certain income over the lifetime of a technology for all new

50 Ofgem. 2019. SEG: Guidance for Generators. Available from: https://www.ofgem.gov.uk/system/files/docs/2020/02/seg_generator_guidance_-_final_for_publication.pdf

51 DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Article 21(2)d.

						installations.
Different **eligibility criteria** for **increased accessibility**					✓	Additional supports/incentives may be required to increase accessibility to the schemes. For example, 10% of the budget available for investment subsidies could be reserved for special access schemes. This could include e.g. targeted groups at risk of fuel poverty, charities or community groups.

Table 5-2 below provides an overview of the level of the Smart Export Guarantee assumed in this study. As indicated above, the level of the SEG has been assumed to be equal to the projected wholesale electricity price and this has been modelled both for the high- and low-price forecast scenarios (further details can be found on the price forecast in A1.4.1). The SEG levels of the low scenario come close to current values of the SEG offered by suppliers in the UK and these have been used in the assessment of total policy costs as presented in chapter 5.3.2. In the UK the values vary from 0.5pkWh to 5.6p/kWh (compares to the modelled values of 0.56EURc/kWh – 6.26EURc/kWh) with an average closest to 3.5p/kWh (3.91 EURc/kWh)[52]. When the policy was first introduced, Shell had initially set a rate of 0.001p/kWh, but was quickly challenged by different environmental NGOs after which it raised its rate to 3.5p/kWh to reflect a 'fair market value'.

Table 5-2 - Level of smart export guarantee per year in the high and low scenario in EURc/kWh

Scenario	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SEG – High scenario	Real price EUR 2020 in EUR c/kWh	6.58	7.07	7.65	7.77	9.21	7.99	8.19	7.80	8.23	8.44
SEG - Low scenario		5.60	4.58	5.21	5.02	4.93	5.06	3.88	4.16	4.24	3.80

The investment subsidy figures are calculated from the net present value of the viability gap across the subsidy life. The investment subsidy levels have been presented as a percentage of total initial investment (i.e. the capital cost) across each of the technology bands in the table below. These investment subsidy percentages in each year vary due to the increasing electricity prices, therefore pushing down the viability gap and reducing capital costs. In the case where no investment subsidy level is presented, these technology bands either did not have a viability gap and therefore no investment subsidy is needed or no export is expected, so that this proposed policy option is not able to support this technology band. It should be noted that in these estimates no technical innovation has been considered. The rates below imply that for example for solar for the domestic sector an investment subsidy of 10% of the capital costs will be needed in 2021, while no further subsidy will be needed in 2030. However, for example for wind subsidies of 57-83% would still be needed in 2030 to make these technologies viable.

The levels of the investment subsidy for the domestic solar bands compare well to the lower range of rates provided in international examples such as Austria and Germany where 10-30% of investment costs grants were provided for solar PV. However, the rates for medium and large micro-wind and small micro-hydro seem to be higher than international estimates, as the viability gaps for these technologies are higher compared to the other technologies due to their higher CAPEX and therefore also high LCOE to meet a 70% self-consumption rate (see chapter 2 and 3).

As the aim of the new microgeneration support scheme is to be at lowest cost and technology neutral the assumed level of the investment subsidy for all capacity bands is the level as defined necessary to promote domestic rooftop solar (the bold figures in the table below). However, it should be noted

[52] SolarGuide. 2020. Compare Smart Export Guarantee Tariffs. Available from: https://www.solarguide.co.uk/smart-export-guarantee-comparison#/

that if the level of support is set at the domestic solar rooftop archetype, then this will possibly lead to overcompensation of the small and large rooftop solar archetypes.

Table 5-3 - Level of investment subsidy in each year as a percentage of total capital cost for technology band

Technology band	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic solar	**10%**	**7%**	**4%**	**1%**	**No further support provided as viability gap is met**					
Small rooftop solar	9%	7%	4%	0%	No further support provided as viability gap is met					
Medium rooftop solar	23%	20%	18%	15%	12%	12%	11%	10%	9%	7%
Large rooftop solar	12%	9%	6%	3%	No further support provided as viability gap is met					
Small ground solar	29%	27%	25%	22%	20%	19%	18%	17%	16%	15%
Large ground solar	Not sufficient uptake and export to calculate level of support required									
Small micro wind	Not sufficient uptake and export to calculate level of support required									
Medium micro wind	86%	85%	85%	85%	85%	85%	84%	84%	84%	83%
Large micro wind	71%	71%	70%	70%	70%	70%	69%	69%	68%	68%
Small micro hydro	55%	55%	55%	56%	56%	56%	56%	56%	57%	57%
Large micro hydro	Not sufficient uptake and export to calculate level of support required									
Small micro CHP	Not sufficient uptake and export to calculate level of support required									
Medium micro CHP	Not sufficient uptake and export to calculate level of support required									
Large micro CHP	Not sufficient uptake and export to calculate level of support required									

Two different feed-in-tariffs are calculated, one for existing installations, the other for new installations. For existing installations the feed-in-tariff is a payment for exported electricity, which has been assumed to be at the level of the wholesale electricity price. The level of this is therefore the same as the figures provided in Table 5-2. These levels are comparable to the export FiT provided in the UK from 2012-2019 at 5.5p/kWh.

The second part of the feed-in-tariff, for exported electricity for new installations, is calculated to meet the viability gaps as presented in the table below. These levels have been set in such a way so that the viability gap for each technology band is met in each year from 2021 to 2025. However, as for the other microgeneration support schemes, for this study we have assumed that the tariff as defined for the domestic rooftop solar archetype will be used for all archetypes.

The table shows that some of the technologies become economically viable without the need for the investment subsidy, for example domestic solar PV from 2025, but also that some of the technologies do not result in any export, so will not be eligible for an investment subsidy.

Table 5-4 - Level of feed-in-tariff for each year per technology band in EURc/kWh

Technology band	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic solar	**12.23**	**9.74**	**7.39**	**5.01**	**2.62**	**1.99**	**1.13**	**0.32**	**No further support provided as viability gap is met**	
Small rooftop solar	11.80	9.26	6.86	4.44	2.00	1.36	0.48	No further support provided as viability gap is met		
Medium rooftop	17.27	15.40	13.68	11.93	10.17	9.78	9.12	8.52	7.95	7.28

solar										
Large rooftop solar	9.58	8.08	6.73	5.34	3.95	3.65	3.13	2.65	2.20	1.66
Small ground solar	20.91	19.06	17.36	15.62	13.88	13.47	12.82	12.23	11.66	11.00
Large ground solar	Not sufficient uptake and export to calculate level of support required									
Small micro wind	Not sufficient uptake and export to calculate level of support required									
Medium micro wind	73.28	72.07	71.00	69.89	68.77	68.13	67.25	66.43	65.63	64.75
Large micro wind	48.95	48.03	47.25	46.43	45.61	45.16	44.48	43.85	43.25	42.55
Small micro hydro	45.20	45.30	45.52	45.71	45.90	46.11	46.11	46.15	46.22	46.20
Large micro hydro	Not sufficient uptake and export to calculate level of support required									
Small micro CHP	Not sufficient uptake and export to calculate level of support required									
Medium micro CHP	Not sufficient uptake and export to calculate level of support required									
Large micro CHP	Not sufficient uptake and export to calculate level of support required									

As indicated above, the level of the FiP for the modelling exercise is calculated through the difference between the required viability gap for each technology band and the SEG payment. The results of this calculation are presented in the table below. It should be noted that these are only estimates based on projected wholesale electricity prices, while in reality the FiP levels will fluctuate to ensure each technology will be guaranteed a level of income that will meet its viability gap. It is this guaranteed level of income that provides a level of certainty to those investing in microgeneration.

Similar to policy options 2, 3 and 5, as the aim of the new microgeneration support scheme is to be technology neutral, for policy option 4 the assumed rate of the FiP for all archetypes is the rate as defined necessary to optimise for domestic rooftop solar (the bold figures in the table below).

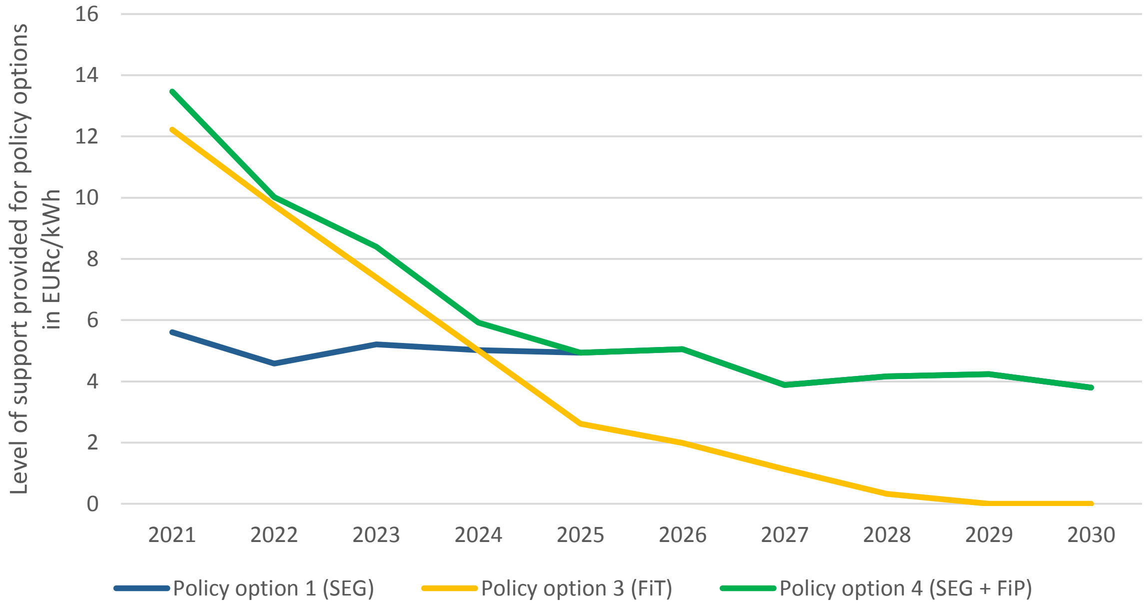
Table 5-5 Level of FiP for each year per technology band in EURc/kWh

Technology band	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Domestic solar	**7.87**	**5.44**	**3.19**	**0.90**	**No further support provided as viability gap is met**					
Small rooftop solar	7.44	4.96	2.66	0.32	No further support provided as viability gap is met					
Medium rooftop solar	12.91	11.09	9.48	7.82	6.15	5.86	5.20	4.63	4.09	3.42
Large rooftop solar	5.22	3.78	2.53	1.23	No further support provided as viability gap is met					
Small ground solar	16.55	14.76	13.16	11.51	9.85	9.55	8.90	8.34	7.80	7.14
Large ground solar	Not sufficient uptake and export to calculate level of support required									
Small micro wind	Not sufficient uptake and export to calculate level of support required									
Medium micro wind	68.94	67.78	66.81	65.78	64.75	64.21	63.34	62.54	61.77	60.88
Large micro wind	44.60	43.74	43.06	42.33	41.59	41.24	40.56	39.96	39.39	38.69
Small micro hydro	40.85	41.00	41.33	41.61	41.88	42.19	42.19	42.26	42.36	42.34
Large micro hydro	Not sufficient uptake and export to calculate level of support required									
Small micro CHP	Not sufficient uptake and export to calculate level of support required									
Medium micro CHP	Not sufficient uptake and export to calculate level of support required									
Large micro CHP	Not sufficient uptake and export to calculate level of support required									

In terms of subsidy provided, both the FiT and FiP would result in a payment of around 12-13 EURc/kWh in 2021 for exported electricity when assuming a 70% self-consumption rate. In comparison the average offer price for any type of project in the RESS was 74.08 EUR / MWh in the last round (2020). The RESS payments are defined on a contract for difference basis (strike price minus the wholesale price), which means that the estimated effective tariff is 40 EUR / MWh (or 4 EURc/kWh) generated. As the FiT and FiP payments are based on paying for 30% of generated electricity only, in theory the payment could be perceived as 12-13 EURc/kWh / 0.3 = 40-43 EUR c / kWh. Therefore, the level of support provided as assumed in this study compares well with the actual level of support provided under the RESS scheme in the 2020 auctioning round.

For comparison of the policy options that provide support based on exported electricity (rather than a one-off payment such as in policy options 2 and 5), the level of support provided in each year for all capacity bands is provided in the graph below.

Figure 5-1 Comparison of level of support provided in policy option 1 (SEG), 3 (FiT) and 4 (SEG + FiP)



The graph shows that in the first years the support provided by policy option 3 (FiT) and 4 (SEG + FiP) is similar, as both are based on filling the viability gap for the domestic rooftop solar capacity band, which is until 2025 still higher than the expected rates provided by the SEG[53]. However, from 2025 in options 1 and 5, a market value will still be provided to installations via the SEG, while in the FiT option support provided would be phased out over time. The FiT option may therefore need to be complemented by a SEG from 2025 onwards to ensure compliance with the RED II in the long-term.

5.1.2 Eligibility criteria and scope

Secondly, the policy options will be defined in terms of their eligibility criteria and scope. Table 5-6 shows five policy options that will be available for any of the four technologies (solar PV, wind, hydro and CHP) for up to 50kW and their parameters (i.e. type, scope, energy efficiency principles, and time scales).

All policy options will be accessible to applicants from all sectors such as domestic, SMEs, farming, social enterprise and public buildings. However, eligibility will be dependent on adherence of participants to energy efficiency principles and adherence to best practice guidance. The policy shall also focus on maximising self-consumption of the different sectors and ideally should target at least a 70% self-consumption minimum for the domestic solar PV generators who make up the majority of

[53] The slight difference between the two levels of support provided is due to the calculation of the level of support provided over the subsidy lifetime, which is different as policy option 4 will have a permanent SEG in place.

the program. For the commercial sector the policy program should be designed in a way that the funding only includes the self-consumption part of the business and the eligibility should be limited to that amount. However, these businesses may want to install higher volumes of RE on their site to further offset any carbon intense operations within their business. That differentiation must be picked up in the application process which is likely to increase the administrative costs.

The shape and structure of a potential microgeneration scheme has not been determined, and certainly a programme of work needs to be completed in that regard. Some of the matters to consider are:

- Who will manage and administer the scheme? This is very much a function of the complexity and requirements of the policies chosen. SEAI have managed the existing solar PV grant scheme and other similar programmes and would be the obvious candidate to manage any new scheme involving grant funding. An export guarantee scheme would require less administration and oversight (compared to a grant or FIT), and the network operator or regulators may be the appropriate body to manage this type of scheme.
- Is the existing guidance sufficient or will new or updated guidance be required to ensure high-quality installations that consumers can have confidence in? There is a body of existing guidance to draw on for example in relation to the SEAI Solar PV grant and the solar PV guidance within the TAMS. A range of matters covered under guidance would include building regs compliance, Safe Electric[54] certification of works, effective design of the microgenerator, energy efficiency principles and BER (Building Energy Rating) assessments. Grid code compliance and the impact of clustered microgenerators within the network is important. A body of work is ongoing to increase the current 6kW limit (or 11kW on 3-phase supply) and amend the connection procedures and related protocols to accommodate microgeneration up to 50kW.
- Necessity for on-going checks for compliance by the appointed manager of the scheme.

The only option with different eligibility criteria is policy option 5 where options for enhanced access can be included. Again, a number of different options can be pursued, depending on the overall policy chosen and the identified target group.

In a similar fashion to RESS1, a proportion of the overall consumers targeted by the scheme could be made available for enhanced access to the policy.

Alternately, higher levels of grant funding could be made available for groups identified for enhanced access.

A particular target is more equitable treatment of individuals at risk of fuel poverty. The target here may not be the individuals but their landlord, which could include housing agencies, local authorities or private landlords accommodating low-income tenants for example under the housing assistance programme (HAP). SEAI have also administered energy efficiency programmes and have experience in targeting those at risk of energy poverty, for example under the Better Energy Homes and the Warmer Homes schemes. The BEH scheme saw SEAI administer €255m in grants over the period 2009-2018[55].

A further group to consider are not-for-profits e.g. entities who demonstrate that they are not-for-profit community organisations which could include charities, co-operative societies, or limited companies created for people who want to conduct a business or other activity for community benefit. Such requirements were similarly applied in the UK FiT scheme[56]. Many communities have signed up the sustainable energy community programme run by SEAI and availed of grants under the better energy communities (BEC) which included microgeneration grants as part of overall grant funding.

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[54] Safe Electric and CRU. N.D. Completion Certificates. Available from: https://safeelectric.ie/help-advice/completion-certificates/
[55] SEAI. N.D. Better Energy Home Statistics. Available from: https://www.seai.ie/data-and-insights/seai-statistics/better-energy-home-statistics/
[56] Ofgem. 2020. Feed-in Tariffs: Guidance for community energy and school installations. Available from: https://www.ofgem.gov.uk/system/files/docs/2020/06/cs_guidance_version_5_062020.pdf

A further wide range of stakeholders could be considered for enhanced access, but at this stage it is recommended to focus on putting a broad-based microgeneration support in place and respond over time to obvious gaps in uptake of the scheme.

Table 5-6 - Eligibility criteria and scope of policy options

Policy parameters	Policy option 1	Policy option 2	Policy option 3	Policy option 4	Policy option 5
Technology eligibility	Solar, wind, CHP and hydro				
Size threshold	50 kW threshold				
Scope (Sectors)	All types of applicants such as domestic, SMEs, farming, social enterprise and public buildings.				All types of applicants including domestic, SMEs, farming, social enterprise and public buildings. Additional measures and criteria for enhanced access.
Energy efficiency principles	Minimum Energy Performance Certificate (EPC) or Building Energy Rating Certificate (BER) of C or higher for all sectors except for public buildings. Public buildings require a Display Energy Certificate (DEC) if the area is above 50m2 with a rating of C or higher. In case a DEC is not required for public buildings, no energy efficiency standards are required for public buildings.				

5.1.3 Alignment with existing policies

The intention is to introduce a new microgeneration support scheme in June 2021, and the alignment with existing policies needs to be considered, from both a funding perspective, but also in terms of continuity for sector stakeholders.

In particular, the risks around the introduction of a new policy to replace existing schemes include inter alia:

- It is unlikely that a new policy option exactly matches the remaining viability gap for each technology band, so it is likely there will be some variance from the existing situation to the new policy;
- There is typically an education and awareness lag when a new scheme is introduced, as a new policy has added layers of complexity and administration from the consumer perspective compared to the existing grant schemes;
- There may be delays in the introduction of a new scheme due to, for example, state aid clearance, delays in government approval, unforeseen regulatory steps and difficulties with procurement or recruitment.
- Others, such as a new policy is often combined with a reduction in the level of funding over time or parallel changes in other policies that can have impact on the industry.

Therefore, at a time where the supply chain needs to be scaling up and maintaining and enhancing skilled teams, it is potentially damaging to have a large sudden impact on the industry through withdrawal of programmes or stop/start periods. To the extent possible, continuity and consistency will better enable the sector to deliver on microgeneration targets.

The Accelerated Capital Allowances (ACA) Scheme is available to businesses and it is assumed that this scheme will be continued under all possible policy options.

The Targeted Agricultural Modernisation Scheme II (TAMS II) provides investment grants up to 60% of total installations costs for up to 6kWp solar PV systems on farms. TAMS II is co-funded by the National Exchequer and the European Union under Ireland's Rural Development Programme 2014–2020 (RDP). Solar PV is only one element within a large range of farm investments that are supported under TAMS II. TAMS is not available on a continuous basis but is administered in periodic tranches (the most recent tranche 18 closed to applications in August 2020). The continuity of any TAMS funding for microgeneration is not known beyond 2020 and co-ordination with the Department of Agriculture is recommended regarding the alignment of any new policies.

For domestic dwellings, the SEAI pilot programmes to support solar PV and micro-CHP covers around 30% of installation costs. However, as mentioned under section 1.2., this scheme does not include houses owned and occupied after 2011 and new-build houses.

The provisions relating to multi-unit new build in the Building Regulations are assumed to apply and will continue to act as an incentive for microgeneration, noting also the plans to ban oil boilers in new homes from 2022 and gas boilers from 2025 as indicated in the Climate Action Plan.

The targeted SEAI grants under Better Energy Community (BEC) and Community Housing Scheme (CHS) support microgeneration within an overall package of retrofit measures and it is assumed they can continue or be tailored to recognise any parallel microgeneration support scheme.

Policy options 2, 3, 4 and 5 all assume that the viability gaps of the major capacity bands considered in this study will be met when the new policies are introduced (i.e. June 2021). Provided the new scheme is operational and effective, then there should be no need for parallel schemes after June 2021. Therefore, in these cases it is recommended that these schemes are discontinued just before June 2021 to avoid having a period without support. However, in the case of policy options 2 and 5, as the new scheme includes an investment subsidy, it is recommended to only adjust the eligibility criteria of the existing subsidy schemes and the level of support provided to convert them into the new policy schemes and thereby ensure continuity. Under policy option 5 enhanced access for targeted groups is to be considered, and refinement or continuation of existing targeted schemes could be considered.

Under policy option 1 only a market value export payment will be provided by suppliers, which is not likely to bridge the viability gap for each technology and sector in the first years, however it will provide a secure level of support for the longer-term thereby de-risking investments for microgeneration.

The slow phasing out over time of the SEAI Solar PV programme would provide some level of continuity to bridge the viability gap for the domestic solar PV sector. Existing supports available for microgeneration within the BEC and CHS or other similar initiatives can be maintained, and modest levels of microgeneration can continue to be supported within these highly targeted schemes.

However, consideration would also need to be given to widening the scope and scale of existing schemes significantly to cover the viability gap. While there are niche and targeted supports available, there are no stand-alone or broadly accessible schemes that would support microgeneration in for example, the non-domestic sectors, installations above 6kW and other technologies beyond solar and micro-CHP.

An overview of these suggestions per policy option is provided in the table below.

Table 5-7 - Proposed alignment of policy options with existing policies

<table>
<tr><th>Existing policy</th><th>Policy option 1</th><th>Policy option 2</th><th>Policy option 3</th><th>Policy option 4</th><th>Policy option 5</th></tr>
<tr><td>ACA</td><td colspan="5">Continued in current form for all policy options</td></tr>
<tr><td>TAMS</td><td rowspan="2">Continue at least until June 2021, a slow phase out after that can be considered to avoid stop/start issues</td><td rowspan="2">Eligibility criteria of current schemes can be adjusted</td><td rowspan="2">Current schemes will be discontinued</td><td rowspan="2">Current schemes will be discontinued</td><td rowspan="2">Eligibility criteria of current schemes can be adjusted</td></tr>
<tr><td>SEAI PV pilot programme</td></tr>
<tr><td>Other existing schemes such</td><td colspan="5">Continue in current form as they work in a complementary way to a microgeneration support scheme and the objective to increase (micro) renewable</td></tr>
</table>

as building regulations and RESS	generation in Ireland.

When implementing the changes outlined above to existing policies alongside the introduction of a new policy scheme in Ireland, it is recommended that the following steps are taken to mitigate against the risks of a new policy introduction:

- Widespread consultation with all stakeholders in advance of the planned policy change to both existing and proposed scheme(s)
- Transparency on the timescales for implementation and ensuring these timescales are adhered to reduces any investment risk by suppliers and installers
- SEAI may wish to complete further research into the supply chain to ensure there are enough suppliers and installers on the market to meet the uptake scenarios projected in this study
- Wider engagement with international stakeholders, such as Renewable UK or UK Solar Trade Association to highlight the policy changes may stimulate investment within Ireland by companies in the UK looking to become a supplier in Ireland
- Ensuring responsibilities for all parties are clear early in the policy development process to allow the affected agency(ies) to prepare, resource and implement the scheme. This is because leaving open the responsibility through consultation phase can often lead to delays in implementation.
- Ensuring high quality of, and sufficient budget for, supporting material, information and marketing of support schemes to support a smoother transition.
- Any discussion around the scheme implementation should be target-led with either a defined budget or other suitable metric (e.g. MW/period, MWh/period) for management and adjusting where necessary. In particular for the investment subsidies a budget approach is recommended, while a MW/period is recommended for the other three policy options.
    - Such metric can be used for purposes of amending support levels (degression /appreciation as necessary). The amendment of support levels can have target-based triggers which give forward visibility on potential policy changes.
- It should also be possible in parallel to drive more innovation and encourage the market to move towards a subsidy-free environment, through e.g. development of know-how, innovations in finance, efficiencies in the installation supply chain, procurement efficiency, technical innovation, removal of procedural barriers (planning, networks) etc.

5.1.4 Summary of five policy options

Based on the above provided details, the five policy options proposed are:

Policy Option 1 proposes to provide a SEG only. This means the consumer (i.e. the microgenerator) is guaranteed a tariff by its energy supplier at variable market rate for all energy supplied in excess of its own consumption. The consumer is able to choose the energy supplier offering the highest rate.

Policy Option 2 proposes a combination of a new investment subsidy and a SEG. This is a scheme that combines a significant part of the CAPEX to be covered upfront through a grant and then any further viability gap being covered through the SEG. The uptake of such a scheme can be expected to have a large positive effect as initial costs for the consumer are significantly lower. Over time such schemes can be adjusted to reduce the investment subsidy which (a), incentivises the consumers to go ahead with the scheme early and (b), picks up the benefits of the SEG later in the scheme as the market environment is expected to mature over time and can naturally adjust pricewise with what else is happening in the market and/or with new policies.

Policy Option 3 proposes a Feed-in-Tariff which is a fixed tariff paid to the consumer for all electricity exported for the entire period of the scheme (15 years) at a level to meet the viability gap of domestic solar as well as an export payment for existing installations which is set at the wholesale electricity price. FIT schemes are easy to understand by consumers and are a solid basis for any bank loan the consumer may need to take out. As a trajectory of degression may occur over time with technology improvements), the level of support provided by this option to microgenerators may vary over time based on the wholesale electricity price.

Policy Option 4 is a combination of a SEG with a FiP and similar to Policy Option 1 except the viability gap is always overcome by an additional premium and only applies to new installations. This makes this a very risk-free option for the consumer as cost recovery is ensured at all times. Also, the premium changes based on the level of the SEG and natural increase or decrease of market prices by market forces will be reflected.

Policy Option 5 is a combination of a new investment subsidy and SEG. This policy is identical to Policy Option 2 in its mechanism, except that it will provide for additional incentives for target groups requiring enhanced access. Such target groups could include the residential category “Apartments” as described in SEAI’s 2018[57] as approximately half of their heating fuel type is electricity. Their self-consumption estimates are likely to be very high and the average tenant/owner could be classified as lower income households. There are challenges with solar PV on multi-occupancy buildings, as to who owns the roof, how the power is distributed to each occupant and how the distributed power is metered, but there are international case studies demonstrating how this has been managed. In this case a high investment subsidy would make sense to cover the upfront costs entirely, especially if this encourages further the electrification of heating systems and therefore savings on gas for heating fuel.

Please also see further mentioning of Policy 5 under section 5.1.2.

5.2 Scaling microgeneration uptake

5.2.1 Description of scenarios

Three scenarios of uptake rates of the proposed policy options have been considered; low, medium and high. As the uptake is likely to be dominated by domestic PV installations (see Box 5-11), and due to the complexity that would be involved in determining uptake forecasts and modelling all 33 archetypes (the figures in section 3 contain the full list of archetypes), a number of high priority archetypes have been selected for uptake scenarios and modelling. This selection of high priority archetypes was informed by the technologies and sectors that saw the most significant uptake for Microgeneration incentives seen in Great Britain and Northern Ireland. The high priority archetypes selected for this analysis are:

Table 5-8 - Priority archetypes selected for uptake forecast

	Technology	Sector
Archetype 1	Micro_solar	Domestic
Archetype 2	Small_rooftop_solar	Small agriculture
Archetype 3	Small_rooftop_solar	Large agriculture
Archetype 4	Small_rooftop_solar	School
Archetype 5	Large_rooftop_solar	SME-commercial
Archetype 6	Large_rooftop_solar	SME-industrial
Archetype 7	Large_rooftop_solar	Local authority
Archetype 9	Medium_ground_solar	Large agriculture
Archetype 14	Micro_wind	Large agriculture
Archetype 18	Large_ wind	SME-commercial
Archetype 22	Micro_hydro	Large agriculture

[57] SEAI 21018 Report “Energy in the Residential Sector – Figure21: Private households in permanent housing units by central heating fuel type and by type of dwelling.

Given the domination of domestic PV uptake in the international case studies, this is a key archetype for the scenarios and modelling.

The key assumptions for each of the scenarios is summarised below.

Table 5-9 - Key assumptions for the Low, Medium and High uptake scenarios

	Low	Medium	High
Domestic PV[58]	3% of domestic premises install solar PV (over 50,000), in line with rates seen in international case studies.[59]	14% of domestic premises install solar PV (250,000).	40% of domestic premises install solar PV (700,000), in line with the 2017 Micro-generation Support Scheme Bill targets.
Agriculture and SME (small agriculture, large agriculture, SME commercial, SME industrial)	2,500 installations distributed proportionately across four archetypes (around 3% of total installations cf GB 3.4% of installations in non-domestic commercial and industrial premises).	15,000 installations distributed proportionately across the four archetypes, as a mid-level between the Low and High scenarios.	55,000 installations distributed proportionately across the four archetypes, in line with the 2017 Micro-generation Support Scheme Bill targets.
School and Local Authorities	0.3% of schools install PV, in line with GB FIT uptake for schools. 1% of Local Authority buildings install PV.	1% of schools and 5% of Local Authority buildings install PV.	2% of schools install PV. 10% of Local Authority buildings install PV.
Ground mounted solar (large agriculture)	10% of large agriculture installations are ground mounted.		
Wind (large agriculture and SME commercial)	0.1% of domestic PV installations, in line with GB FIT uptake for commercial wind.	0.8% of domestic PV installations, as a mid-level between the Low and High scenarios.	1.5% of domestic PV installations (NI Micro NIRO total wind installations = 1.8% of domestic PV installations)
Hydro (large agriculture)	0.1% of domestic PV installations, in line with GB FIT uptake for Non Domestic Hydro.	0.15% of domestic PV installations, as a mid-level between the Low and High scenarios.	0.2% of domestic PV installations (NI Micro NIRO total Hydro installations = 0.23% of domestic PV installations)

With regard to public buildings, the high case scenario for schools and Local Authorities gives relatively high uptakes compared to the GB FIT comparison, where 0.3% of schools installed solar PV, community schemes accounted for 0.4% of all microgeneration installations, and non-domestic commercial (which could include local authority office buildings, but will also include the SME commercial and agricultural sectors in this analysis), accounted for 3.2% of all microgeneration installations. However, it is noted that in Ireland the Programme for Government includes specific

[58] The domestic PV installation target excludes installations that have been, and are forecast to be, installed prior to June 2021.
[59] The low case scenario for domestic PV installations is comparable to a forecast of uptake of the existing PV microgeneration pilot scheme: assuming linear growth to 2025 (based on uptake data provided to June 2020), and assuming that 75% of installations take place by 2025, the 2030 installation figure is 45,650 or 2.6% of homes.

targets for public sector decarbonisation, including a €750 million allocation from the National Development Plan (NDP) for public sector energy retrofits, with further funding for schools. This could lead to higher uptake rates than those forecast even in the high case scenario, although the translation from the Programme for Government targets into uptake figures would require further assumptions to be made.

To consider the sensitivity of the overall policy cost results, taking a more ambitious target for public sector buildings is considered, where it is assumed that 50% of schools and Local Authority office buildings install microgeneration by 2030 (that would be 1,848 school installations and 1,700 Local Authority office installations). The impact on the percentage of installed microgeneration capacity under this higher sensitivity case is shown in the table below. While this does increase the share of these two archetypes of the total installed microgeneration capacity by 2030, the uptake is still dominated by other sectors – notably domestic PV and SME commercial, which will have a larger impact on the total policy costs. Therefore, this sensitivity was not used for the assessment of the policy options.

Table 5-10 - Sensitivity for greater uptake in public buildings

	% uptake	% of installed microgeneration capacity	% uptake	
Schools	2%	0.02%	50%	0.5%
Local Authorities	10%	0.51%	50%	2.47%

Box 5-11 - Case studies on microgeneration policies by generation technology and sector

Case study: Microgeneration policy uptake by generation technology and sector

<u>Great Britain</u>

In April 2010 the UK government introduced a Feed-in Tariff (FIT) as a financial support scheme for small scale renewable generators (see section 4.2). It closed to new entrants in April 2019. Ofgem maintains a FIT installation report, with installation data available from when the FIT was introduced. This is a useful database on FIT installation statistics in Great Britain over nearly 10 years. The FIT supported generation up to 5 MW. For comparison the microgeneration policy support in Ireland will be limited to 50 kW installations. For this analysis, the FIT installation report data was refined by only considering those installations with a Declared Net Capacity of 50 kW or less.

On that basis, the total number of installations and Declared Net Capacity by generation technology are summarised in table below.

Generation technology	Declared Net Capacity (kW)		Number of installations		
	kW	%	Number	%	
Solar PV	3,310,720	98.066	854,572	99.228	
Wind	53,308	1.579		5,481	0.636
Hydro	11,132	0.330	630	0.073	
Micro-CHP	572	0.017	531	0.062	
AD	283	0.008		9	0.001
Total	3,376,015			861,223	

Solar PV makes up 99.2% of installations and 98% of capacity, clearly dominating the uptake.

The FIT installation data is categorised across four sectors:

Sector	Number of installations	Proportion of installations
Domestic	828,955	96.3%
ND Commercial	27,613	3.2%
ND Industrial	1,399	0.2%
Community	3,265	0.4%

The domestic sector dominates the FIT installations.

Around 3% of homes in Great Britain installed Microgeneration under the FIT scheme.

Northern Ireland

Ofgem also administered the Micro NIRO (Northern Ireland Renewable Obligation) scheme, which was a financial support scheme for microgeneration in Northern Ireland (see section 4.2). The NIRO opened in 2005 and closed to new entrants in 2017. Data is available on Micro NIRO installations via the Ofgem Renewables and CHP register. Again, for installations up to 50 kW, the installation statistics are as follows:

Generation technology	Declared Net Capacity (kW)		Number of installations	
	kW	%	Number	%
PV	116,454	96.0%	22,196	97.9%
Wind	3806	3.1%	412	1.8%
Hydro	886	0.7%	52	0.2%
Fuelled	164	0.1%	4	0.0%

Again, the uptake of the Micro NIRO scheme was dominated by PV. Unfortunately, data is not available on the sector associated with each installation.

Around 3% of homes installed generation under the Micro NIRO scheme.

It should be noted that in all the uptake scenarios, no consideration has been made of any technology breakthroughs such as bifacial modules, that might greatly increase the performance of panels or allowance for a step change in capital costs. This highlights the need to ensure the policy uptake is monitored closely and adjusted according to changes in the market.

5.2.2 Existing solar PV installations and building regulations

When considering domestic PV installations for the uptake scenarios, two additional factors need to be considered:

1. The number of installations that are forecast to have been installed prior to June 2021 (the earliest start date for the proposed policy options)

2. The number of installations from June 2021 that would have come forward regardless of a microgeneration policy, to support housing developers meet building regulations[60].

Domestic PV installations have been separated in the uptake forecasts according to existing (pre June 2021), new installation on new home and new installation retrofit. This is to allow adjustments to the uptake forecasts in the different categories, and to allow for different tariff rates to be applied to the different categories (i.e. existing and new).

It is assumed that just over 30,000 homes will have PV installations by June 2021, prior to the implementation of the microgeneration policy.[61] This is based on the assumption that the existing PV microgeneration pilot scheme operates until June 2021; the transition between the existing pilot scheme and the proposed policy options is discussed further in section 5.1.3.

In terms of the number of domestic PV installations that are assumed to result from housing developers installing solar PV to meet building regulations (new homes), rather than as a result of a microgeneration policy (retrofit), the following proportions are assumed through to 2030 (see Table 5-12), based on SEAI forecasts for microgeneration uptake and the indicated split between new home and retrofit installations. The decrease in this proportion is due to changes to building regulations in prohibiting the installation of oil and gas boilers[62]; this is forecast by SEAI to result in an increase in heat pump installations that will allow housing developers to meet building regulations, rather than installing solar PV installations. These figures are used to allocate the proportion of domestic PV installations between new builds and retrofits.

Table 5-12 - Proportion of domestic PV installations installed to meet building regulations

2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
75%	75%	65%	65%	65%	20%	20%	20%	20%	20%

5.2.3 Customer numbers per sector

To forecast uptake rates for the three scenarios, the number of customers per sector has been estimated. This is because some of the archetype forecasts are based on a percentage of customers installing generation (e.g. domestic, schools), but also gives a sense of proportions of uptake in other sectors. The following table shows the assumed number of customers or premises per sector.

Table 5-13 - Assumed number of customers / premises per sector

Sector	Number of customers / premises	Source / comment
Domestic	1,758,185	Source: SEAI Energy in the residential sector 2018 report (2016 data)[63]
Small agriculture	75,221	Source: NFS 2020/Teagasc sources Notes: Grouped into large and small agriculture according

[60] The building regulations (Technical Guidance Document L- Conservation of Fuel and Energy – Dwellings[60]) have been very effective in incentivising solar PV in new-build (since 2011), though at a smaller scale than a scale which might increase the amount of self-consumption. The schemes typically are less than 2kW, on average about 1.2kW, sized to comply with TGD L. On average 40% of newly built houses in 2019 have included solar PV installations and this is expected to rise to 50% this year.

[61] This is based on data from an ESB Networks report, *Assessment of potential implications for the distribution network of defined higher penetrations of distributed generators, December 2019* as well as data provided by DECC on the uptake of the PV microgeneration pilot scheme. The 30,000 figure assumes a forecast uptake of the microgeneration pilot scheme for the second half of 2020 and the first half of 2021, and that 75% of total PV installations come forward to support housing developers to meet building regulations (and are not part of the microgeneration pilot scheme).

[62] The Irish Climate Action Plans outline the objective to ban oil boilers in new homes from 2022 and gas boilers from 2025.

[63] SEAI. 2018. Energy in the residential sector. Available from: https://www.seai.ie/publications/Energy-in-the-Residential-Sector-2018-Final.pdf

		to energy demand analysis in WP2
Large agriculture	17,286	Source: NFS 2020/Teagasc sources Notes: Grouped into large and small agriculture according to energy demand analysis in WP2
Public buildings – Schools	3,696	Source: SEAI Annual Report 2019 on public sector energy efficiency performance[64]
SME-commercial	67,053	Source: CSO Business in Ireland, Small and Medium Enterprises[65] Notes: SMEs in the Services and Financial & Insurance categories. Assumed 0.5 premises per enterprise, as some smaller enterprises will share premises. This compares with SEAI data on the total number of commercial premises (109,353) some of which will be large enterprises.
SME-industrial	17,136	Source: CSO Business in Ireland, Small and Medium Enterprises Notes: For SMEs in the Industry category we have assumed one premises per enterprise.
Public buildings – Local Authority office	3,400	Source: SEAI Monitoring and reporting data

5.2.4 Uptake Scenarios

Based on the assumptions in Table 5-9 and the additional factors for domestic PV installations (existing installations, new homes and retrofit), a summary of the low / medium / high uptake scenarios are presented below.

Table 5-14 - Low / Medium / High uptake scenarios per priority archetype – total installations by 2030

Archetype	Archetype technology	Sector	Low	Medium	High
Archetype 1	Micro_solar	Domestic Pre 2021	30,754	30,754	30,754
Archetype 1	Domestic_solar	Domestic new build	29,669	140,625	393,750
Archetype 1	Domestic_solar	Domestic retrofit	23,076	109,375	306,250
Archetype 2	Small_rooftop_solar	Small agriculture	1,064	6,386	23,414
Archetype 3	Small_rooftop_solar	Large agriculture	220	1,321	4,843
Archetype 4	Small_rooftop_solar	School	11	37	74
Archetype 5	Large_rooftop_solar	SME-	949	5,692	20,872

[64] SEAI. 2019. Annual report 2019 on public sector energy efficiency performance. Avaialble from: https://www.seai.ie/publications/Public-Sector-Annual-Report-2019.pdf
[65] Central Statistics Office. 2015. Business in Ireland 2014. Available from: https://www.cso.ie/en/releasesandpublications/ep/p-bii/bii2014/sme/

		commercial			
Archetype 6	Large_rooftop_solar	SME-industrial	242	1,455	5,334
Archetype 7	Large_rooftop_solar	Local authority	34	170	340
Archetype 9	Medium_ground_solar	Large agriculture	24	147	538
Archetype 14	Micro_wind	Large agriculture	11	410	2,152
Archetype 18	Large_ wind	SME-commercial	42	1,590	8,348
Archetype 22	Small_micro_hydro	Large agriculture	53	375	1,400

The total installed capacity, electricity generated and electricity exported by 2030 is shown in the tables below for each scenario. Note that this includes the assumed existing domestic PV installations by June 2021.[66]

The forecast figures below are based on the assumption that the installed capacity for each archetype installation results in 70% self-consumption of the microgeneration, with the exception of domestic solar, where the upper limit of the capacity band is 3 kW, but it is known that the typical installed capacity in new build homes is around 1.2 kW; 1.5 kW has been assumed as the installed capacity of existing domestic PV installations (pre June 2021) and installations on new homes. For retrofit installations, the upper limit of 3 kW has been assumed.

There are a number of uncertainties over the course of the period being examined (2021 – 2030) in forecasting electricity demand. Key factors in this uncertainty are moves towards the electrification of heat and transport and the uptake of low carbon technologies, including Electric Vehicles (EV) and Heat Pumps (HP). If demand increases significantly, customers may consider increasing the size of their microgeneration installations, to maximise their self-consumption. However, it should be noted that the generation profile of PV is not well correlated with typical demand profiles that have been observed with EVs and HPs. In addition, including features in the policy design such as review periods for capacity bands would give an opportunity to take account of any significant developments, and make appropriate adjustments to capacity bands, among other parameters (see section 5.1).

To put this into context, currently three more rounds of RESS are planned to take place to support in total 12,000 GWh of generation through targeting of onshore wind, offshore wind, biomass and solar PV.

Table 5-15 - Low scenario – installed capacity, generation and export

Technology	Installed capacity (MW)	Annual generation (GWh)	Annual export (GWh)
Solar	220.36	163.62	29.39
Wind	1.68	3.05	0.91
Hydro	0.26	1.06	0.33

[66] Also note that for the purposes of modelling the total costs of each policy option (section 5.3.2), the generation and export from installations in a given year commence in the subsequent year. In reality, the installations will take place throughout the year, with small lead times for installations, which can start generating immediately. However, this assumption has been made to remove the need for month by month modelling.

Table 5-16 - Medium scenario – installed capacity, generation and export

Technology	Installed capacity (MW)	Annual generation (GWh)	Annual export (GWh)
Solar	946.21	705.09	146.27
Wind	63.70	115.51	34.66
Hydro	1.88	7.56	2.35

Table 5-17 - High scenario – installed capacity, generation and export

Technology	Installed capacity (MW)	Annual generation (GWh)	Annual export (GWh)
Solar	2,864.66	2,151.67	554.17
Wind	334.44	606.44	181.97
Hydro	7.00	28.21	8.78

Based on the assumptions of total number of customers per sector, uptake rates per sector and installed capacity per archetype, the results from this analysis show a higher proportion of installed capacity for SME commercial PV installations (and therefore a lower share of domestic PV) than has been seen in the GB FIT data. The GB FIT data showed that 96.3% of microgeneration installations were domestic, and that domestic installations account for 84% of installed capacity, compared to 3.2% of commercial installations, accounting for 13.5% of installed capacity.

This compares with the priority archetypes in the forecast uptake scenarios proportioned as follows (cumulative total by 2030)[67]:

- Low scenario: 96.9% of installations are domestic PV, accounting for 72% of installed capacity; 1.1% are SME commercial PV, accounting for 21% of installed capacity.
- Medium scenario: 94.1% of installations are domestic PV, accounting for 57% of installed capacity; 1.9% are SME commercial PV, accounting for 27% of installed capacity.
- High scenario: 91.6% of installations are domestic PV, accounting for 47% of installed capacity; 2.6% are SME commercial PV, accounting for 31% of installed capacity.

The high relative proportion of SME commercial installed capacity is determined by the forecast number of installations and the assumed installation capacity for this archetype. The assumed installation in this case is 49.5 kW, which is based on achieving around 70% self-consumption of the generation. This compares with an average installed capacity per installation for microgeneration in GB FIT installations of 17 kW for non-domestic commercial and 23 kW for non-domestic industrial.

To illustrate the impact of reducing the installed capacity for installations that are currently assumed to be close to the upper capacity band (to meet the 70% self-consumption figure), assuming that these installations are reduced to 20 kW, the proportions would be as follows:

- Low scenario: domestic PV installations account for 84% of installed capacity and SME commercial account for 10%.
- Medium scenario: domestic PV installations account for 74% of installed capacity and SME commercial account for 14%.

[67] Including pre-June 2021 installations.

- High scenario: domestic PV installations account for 65% of installed capacity and SME commercial account for 18%.

As the installed capacity per archetype has been assumed based on reaching around 70% self-consumption from generation, the 20 kW limited capacity for the larger priority archetypes has not been considered in the assessment of policy options.

5.3 Policy option assessment

Each of the policy options described in the previous section has been assessed based on:

- its potential effectiveness in promoting microgeneration, providing certainty to investors and promoting self-consumption,
- its costs and cost-effectiveness
- how policy costs can be recovered by suppliers or the public sector and the risk of overcompensation
- their feasibility for implementation and their administration costs

Our assessment is based both on a modelling exercise and a qualitative analysis. This chapter presents the results from this assessment.

5.3.1 Effectiveness to achieve microgeneration objectives

Each of the policy options considered have different associated opportunities for incentivising microgeneration and risks. This section outlines an assessment of these opportunities and risks of each option in terms of their ability to incentivise microgeneration.

Guarantee to meet viability gap

Firstly, while investment subsidies, FiT and FiP policies can be set at levels that guarantee the viability gap of different technologies and sectors is met, this cannot be guaranteed for a SEG policy. Within a SEG policy the rate offered for exported electricity will be set by the market and unless restrictions for suppliers are set by a regulator, this rate can be set at any level above zero. Although it is unlikely that a supplier would set the SEG at zero, increasing volumes of renewables could push the market price below the level needed to meet a viability gap.

Policy option 1 therefore carries the largest risk of all five options to not incentivise a significant amount of microgeneration as the viability gap might not be met, although its objectives do align closely with those outlined in the Climate Action Plan and Programme of Government. However, the viability gap assessment shows that from 2025 onwards it is expected that the forecast SEG rate will be able to meet the viability gap of domestic solar. Therefore, additional support on top of a SEG may only be needed for 4 years. In addition, because of the assumption that investment subsidies, FiT and FiP payments will be set at a level to meet the viability gap for domestic rooftop solar, the other policy options considered in this study may not achieve the expected uptake rate, as more expensive technologies such as wind will not be incentivised enough to bridge the viability gap.

Besides the inherent uncertainty of how the market will value exported electricity within a SEG, the rate set by suppliers may also be influenced by the selected policy option. For example, in option 4 the SEG is combined with a FiP for all new installations. The FiP will be varied on, for example, an annual basis, not on spot market prices, aiming to fill the remaining gap between the viability gap and the SEG. This will require clear rules on how the suppliers set the SEG, equally on an annual basis and submitted to DECC or the Commission for Regulation of Utilities. The FiP could be set with a floor price and a cap price which would set a range within which microgeneration owners could expect to receive a payment.

Transaction costs may be high for suppliers, especially for low volumes of export that are expected across the different archetypes, and this may have a downward pressure on SEG rates being offered.

Ability of different policy types to address barriers to microgeneration uptake and associated risk

Literature cites the main barriers to microgeneration uptake in other jurisdictions, such as the UK, are financial factors and that homeowners may lose their investment if they moved home post installation. There is some evidence to show that microgeneration adds value to a property, but the research is scant and other factors do influence price more considerably. On the other hand, self-sufficiency has been identified as a main motivator for the uptake of microgeneration technologies in the UK[68]. Policies such as feed-in-tariffs, FiPs would be well-placed to overcome financial barriers if set at appropriate levels. If the subsidy is only paid over 15 years, rather than the full life of the scheme, there is a risk that necessary maintenance (eg inverter replacement) beyond the incentive life is not completed. In particular, as a FiP guarantees a certain income even when wholesale prices (i.e. export payments) vary, these can be effective in overcoming issues and providing certainty to the market.

Investment grants would be well suited to overcome barriers related to the perception that money may be lost if homeowners move. However, as the FiT and FiP policies considered here will be paid to overcome the viability gap of different technology bands within 15 years, providing higher rates earlier on in the lifetime of installations, this goes some way to minimising the risk for homeowners in lost investment when moving home.

Policy risk

The way in which policies are set can impact significantly on their effectiveness. Policy design can either result in overcompensating the market, resulting in the inefficient deployment of technologies, impacting the policy cost. Alternatively, if the incentive level is set too low, the supply chain and finance required to support the development of the sector does not evolve. For solar PV, there are already clear signs in the market in Ireland that the supply chain is adapting to the current domestic grant scheme, offering innovative financing options.

Allowing a supply chain to develop and not overheat, is another risk to be considered in the development of the microgeneration policy. The rush to capitalise from an overgenerous support scheme can lead to poor quality installations and policy responses such as degression[69], if implemented too abruptly can result in significant job losses. Degression is a necessary mechanism that needs to be considered as it offers greater policy control.

For example, the UK FiT suffered from perceived policy uncertainty, in particular due to regular reviews and reductions to the FiT[70]. However, publishing when degression steps would be planned,, could take away some of these negative effects. Literature indicates that “the total effect of a FIT can be seven times larger if it is well designed”, for example by publishing review dates, providing certainty for longer time frames and acknowledging differences per sector and technology type[71].

There have been some examples of poor practice where microgeneration policies have been implemented, such as:

- The tariff is set at the wrong level, thereby providing too much support to generators. To mitigate this, a mechanism for degression should be included. This requires careful tracking of market costs for the installation of microgeneration and transparency in the market of the impact of the changing cost;
- Technology capacity banding impacted the efficiency of the scheme by incentivising developers to derate wind turbines to take advantage of higher tariffs, resulting in turbines operating at lower efficiencies than expected. This risk is managed in our proposed policy

[68] Balcombe, P., Rigby, D., Azapagic, A. 2014. Investigating the importance of motivations and barriers related to microgeneration uptake in the UK. https://doi.org/10.1016/j.apenergy.2014.05.047
[69] Degression refers to a gradual decrease of the level of support provided as part of a policy (e.g. level of tariff for a FiT) with the aim to both align with and incentivise technology cost reductions.
[70] Hanna, R., Leach, M., Torriti, J. 2018. Microgeneration: the installer perspective. https://doi.org/10.1016/j.renene.2017.09.023
[71] Dijkgraaf, E., van Dorp, T., Maasland, E. 2018. On the effectiveness of feed-in tariffs in the development of solar photovoltaics. The Energy Journal 39(1)81-99. 10.5547/01956574.39.1.edij

options as capacity bands have been defined in such a way that they align with available turbines on the market and their viability gaps. By setting guidelines for generator selection such that the installed technologies (wind, solar, hydro or micro-CHP) are optimised for performance efficiency, without any modifications limiting generation, this risk is managed.

- Developers implementing “rent a roof” schemes, offering householders free electricity for the use of their roof, so the developer retains the feed in tariff, but householders are burdened with long term agreements that make selling the house difficult. On the other hand, third party ownership of solar schemes on roofs has been successful across the social housing and schools in the UK. It is therefore proposed that this risk is managed in our policy options through the development of guidelines on rent-a-roof type schemes.
- Miss-selling resulted in rooftop solar PV installations that were shaded or oriented North. Guidelines on the design procedures to be followed for PV systems should be reviewed to take this into account, which may be an evolution of the guidelines produced by SEAI for the grant scheme.

Alternatively, investment grants could lead to high uptake rates of microgeneration as they can overcome some of the main barriers such as high upfront costs and long payback periods. However, a downside of investment grants is that they can be less effective in incentivising behaviour such as self-consumption[72]. This is however not expected to be an issue for the considered policy options 2 and 5, as these schemes and the investment levels are specifically designed to promote self-consumption.

Policy Options 2 through 5 address the financial barrier in different ways. Policy option 4, whereby a FiP is provided to always meet the viability gap provides the greatest level of certainty for investors. This is followed by the FiT (policy option 3) where a payment is always guaranteed, but this may fluctuate based on the export payment provided, which is dependent on the wholesale electricity price. Policy Option 3 and Policy Option 4 are expected to be very similar in practice.

Policy options 2 and 5 combine a variable SEG with a fixed investment subsidy. The effectiveness of any of these policies will ultimately be determined by the initial rates set, but all other things being equal, the more certainty on offer by any fixed element will improve uptake rates. Therefore, the changes to eligibility criteria for option 5 to make the scheme more accessible and guaranteeing these provisions will not change, will make this policy option more effective in addressing barriers to microgeneration uptake by these target groups.

Policy option 1 only provides a smart export guarantee, which is set by the market. The risk of not recovering costs if SEG is lower than any viability gap is clearly a disadvantage of the scheme from an incentive point of view. It can only be expected that under this policy option in the first years 2021-2024, it would be early adopters who would consider installing any microgeneration, not for financial reasons. Given there is currently a grant scheme in place to support solar PV, this policy option would have a significant detriment to the supply chain. This option can work well in a mature market, where the costs to install are significantly lower, however in Ireland the market is relatively modest with approximately 30,000 microgenerators installed to-date, and there is a case that additional incentives are required initially to stimulate the market and supply chain until sufficient scale and cost efficiencies are attained.

It can be anticipated that domestic solar installations will be the largest target sector in Ireland (see chapter 5.1). Policy Option 4 set at a rate that covers the viability gap is likely to be the most effective (but also the most costly) in increasing uptake.

Potential to promote self-consumption

The policy options considered in this study are also evaluated in terms of their potential to promote self-consumption. All options with a SEG incorporated align well with these objectives. This is

[72] Bergman, N., Hawkes, A., Brett, D., Baker, P., Barton, J., Blanchard, R., Brandon, N., Infield, D., Jardine, C., Kelly, N., Leach, M., Matian, M., Peacock, A., Staffell, I., Sudtharalingam, S and Woodman, B. Review of UK microgeneration. Part I: policy and behavioural aspects. Available from: https://pure.strath.ac.uk/ws/portalfiles/portal/67232828/strathprints018813.pdf

because a SEG promotes self-consumption as savings of paying the retail price on an energy bill may be higher than the payment of the wholesale electricity price in the form of a SEG, therefore schemes will be sized to optimise self consumption. Through this promotion of self-consumption, a SEG will also minimise the need for infrastructure development, as less upgrade of the grid will be required.

As a FiP can overcome some of the initial barriers of a SEG by supplementing SEG payments with an additional payment to meet the viability gap, while later transitioning into a SEG only, it is also well aligned with the Irish microgeneration objectives.

For example, the costs a typical domestic solar PV installation in 2021 are estimated to be around €6,344 with an associated €900 EUR O&M costs for the 15 year policy lifetime, largely to cover the cost of a replacement inverter. When the system is installed the viability gap is estimated to be 12.23 EURc/kWh. With these assumptions, with a 70% self-consumption level this household is expected to export 761 kWh in its first year and thereby receive a subsidy of €93 (from the combined from the SEG and FiP). Over the policy lifetime, the total subsidy expected for a typical household scheme would be €1329 with a payback of 17 years. Subsidy levels would in this case be lower than current grant levels, which are around €2100 for a domestic solar system.

In a scenario where there is 90% self-consumption, it is estimated that the payback period will only be 15 years, as the householder would benefit from greater savings in their energy bills. The subsidy that would be provided would be €419 over the lifetime of the policy, demonstrating that the policy is in line with the Irish objectives for high self-consumption and avoiding of over-compensation. The findings of this example are provided in the table below.

Table 5-18 Customer subsidy sensitivities on percentage of export

Archetype technology	Export level	CAPEX (2021)	15 year OPEX	Viability gap - 2021	Annual export	1st year subsidy - 2021	Total subsidy	Payback (incl. subsidy)
Unit	%	€	€	c/kWh	kWh	€	€	yr
Domestic small rooftop solar	32%	6,344	900	12.23	761	93	1,329	17.18
Domestic small rooftop solar	50%	6,344	900	12.23	1,199	147	2,094	20.74
Domestic small rooftop solar	10%	6,344	900	12.23	240	29	419	15.08

On the other hand, both investment subsidies and a FiT can risk overcompensating the installation of microgeneration as both are set as fixed rates over time. In particular, if the target of 70% self-consumption as set in this study is not met, the risks of having higher costs than anticipated in the options with a FiT and investment subsidies are very high.

Additional policy and regulatory factors

The building regulations (Technical Guidance Document L- Conservation of Fuel and Energy – Dwellings[73]) have been very effective in incentivising solar PV in new-build (since 2011), though at a smaller scale than a scale which might increase the amount of self-consumption. The schemes typically are less than 2kW, on average about 1.2kW, sized to comply with TGD L. On average 40% of newly built houses in 2019 have included solar PV installations and this is expected to rise to 50% this year.

[73] Department of Housing, Planning and Local Government. 2019. Technical Guidance Document L-Conservation of Fuel and Energy – Dwellings. Available from: https://www.housing.gov.ie/housing/building-standards/tgd-part-l-conservation-fuel-and-energy/technical-guidance-document-l-7

Part L of the building regulations does not apply to one-off homes, applying only where more than one home is constructed. The effectiveness of this measure is expected to reduce somewhat in 2022 when oil boilers are banned for new-build and in 2025 when gas boilers are banned and in light of the current coronavirus-crisis.

As indicated in section 5.1.3, the ACA is assumed to be continued in its current form for all policy options. In addition, policy options 3 and 4 assume that the viability gaps of each capacity band will be met when the new policies are introduced (i.e. June 2021) and therefore that the other policies such as the SEAI PV pilot programme will be discontinued when the new scheme is introduced. In the cases of policy options 2 and 5, a conversion of the current scheme could be envisioned where the eligibility criteria are broadened to include more sectors and technologies.

Under policy option 1 only a market value export payment will be provided by suppliers, which is not likely to bridge the viability gap for each technology and sector. Therefore, in this option the slow phasing out over time of the SEAI Solar PV programme would provide some level of continuity to bridge the viability gap for the domestic solar PV sector. Existing supports available for microgeneration within the BEC and CHS or other similar initiatives can be maintained, and modest levels of microgeneration can continue to be supported within these highly targeted schemes.

A summary table of each effectiveness indicator analysed above is provided below.

Table 5-19 - Summary table of effectiveness assessment of policy options

Policy options	Certainty measure will fill viability gap	Ability to address main barriers/risks for highest potential technologies/sectors in Ireland	Potential to promote self-consumption	Alignment with other policy and regulatory factors
Policy option 1: SEG	Low (in Irish context) as SEG will not meet viability gap for domestic solar from 2021-2024	Medium, payments over longer term help de-risk investments in non-domestic sectors	High, as SEG provides control over behavioural direction of self-consumption, energy efficiency, size of system targeted	Slow phase out of current scheme to provide some additional support
Policy option 2: SEG and investment subsidy	Medium, investment subsidy for domestic solar may not meet viability gap for all capacity bands.	Medium, addresses barriers related to loss of investment when moving home. Only pay back is via saving on energy bills though.	Medium, as there is a high risk costs are higher than anticipated if self-consumption target is not met.	Eligibility criteria of current schemes can be adjusted
Policy option 3: FiT	Medium, tariff fixed in advance with little flexibility in case wholesale electricity prices change	Medium, long-term payments provided but effectiveness dependent on policy design	Low, as this option provides highest risk for over-subsidizing while in later years the option may also not be aligned with requirements for export payment as outlined in RED II.	Current schemes will be discontinued
Policy option 4: SEG and FiP	High, subsidy flexible to ensure viability gap is	Medium, long-term payments provided but effectiveness dependent on policy design	High, similar to SEG less risk of oversubsidizing, while incentives for self-	Current schemes will be discontinued

	met		consumption are high	
Policy option 5: SEG, investment subsidy and equity aspects	Medium, investment subsidy for domestic solar may not meet viability gap for all capacity bands.	High, similar to option 2, but eligible criteria can be adjusted to address barriers of specific groups	Medium, as there is a high risk costs are higher than anticipated if self-consumption target is not met.	Eligibility criteria of current schemes can be adjusted

5.3.2 Policy costs under different uptake scenarios

The total costs per policy type under a low, medium and high uptake scenario as defined in chapter 5.1 have been assessed. The table below provides an overview of the costs (total both for SEG and additional support) for each policy option under different uptake scenarios and broken down for costs for export payments to pre-June 2021 installations, costs for new installations from 2021-2025 and costs for new installations 2025-2030. The details about the cost of support calculation methodology can be found in A1.4.1.

Table 5-20 - Estimated costs for each policy option under a low, medium and high uptake scenario in million EUR

Policy option	Description	Low uptake scenario €M	Medium uptake scenario €M	High uptake scenario €M
Policy option 1 (SEG)	Total costs for pre-June 2021 installations		18.19	
	Total costs for new installations 2021-2025	16.94	98.69	334.98
	Total costs for new installations 2025-2030	6.82	42.01	147.08
	Total costs for 2021-2030	**41.95**	**158.89**	**500.25**
Policy option 2 (SEG + Investment subsidy)	Total costs for pre-June 2021 installations		18.19	
	Total costs for new installations 2021-2025	25.71	148.88	503.12
	Total costs for new installations 2025-2030	6.82	42.01	147.08
	Total costs for 2021-2030	**50.72**	**209.09**	**668.39**
Policy option 3 (FiT)	Total costs for pre-June 2021 installations		18.19	
	Total costs for new installations 2021-2025 in million EUR	44.82	261.39	888.07
	Total costs for new installations 2025-2030 in million EUR	8.02	49.45	173.09
	Total costs for 2021-2030 in	**71.03**	**329.03**	**1,079.36**

	million EUR			
Policy option 4 (SEG + FiP)	Total costs for pre-June 2021 installations in million EUR	18.19		
	Total costs for new installations 2021-2025 in million EUR	28.97	169.03	574.44
	Total costs for new installations 2025-2030 in million EUR	6.82	42.01	147.08
	Total costs for 2021-2030 in million EUR	**53.98**	**229.24**	**739.71**
Policy option 5 (SEG + investment subsidy with equity aspects)	Total costs for pre-June 2021 installations in million EUR	18.19		
	Total costs for new installations 2021-2025 in million EUR	25.71	148.88	503.12
	Total costs for new installations 2025-2030 in million EUR	6.82	42.01	147.08
	Total costs for 2021-2030 in million EUR	**50.72**	**209.09**	**668.39**

The above table shows that the least cost option is policy option 1. However, under this policy option the remaining viability gap after subsidies in the discounted medium uptake scenario is still around 24 million EUR per year. The costs of this option are therefore not comparable to the other four options, as the microgeneration uptake rate should be expected to be low in the years 2021-2024.

Policy option 2 and 5 have similar costs, as the equity aspects under policy option 5 have been assumed not to add additional costs, but instead carve out a part of existing costs to support different consumers. However, in the case of a choice for a different mechanism (e.g. higher investment subsidies for certain consumers), it can be expected that these costs are higher than those estimated in the table above (e.g. estimated around ~10%).

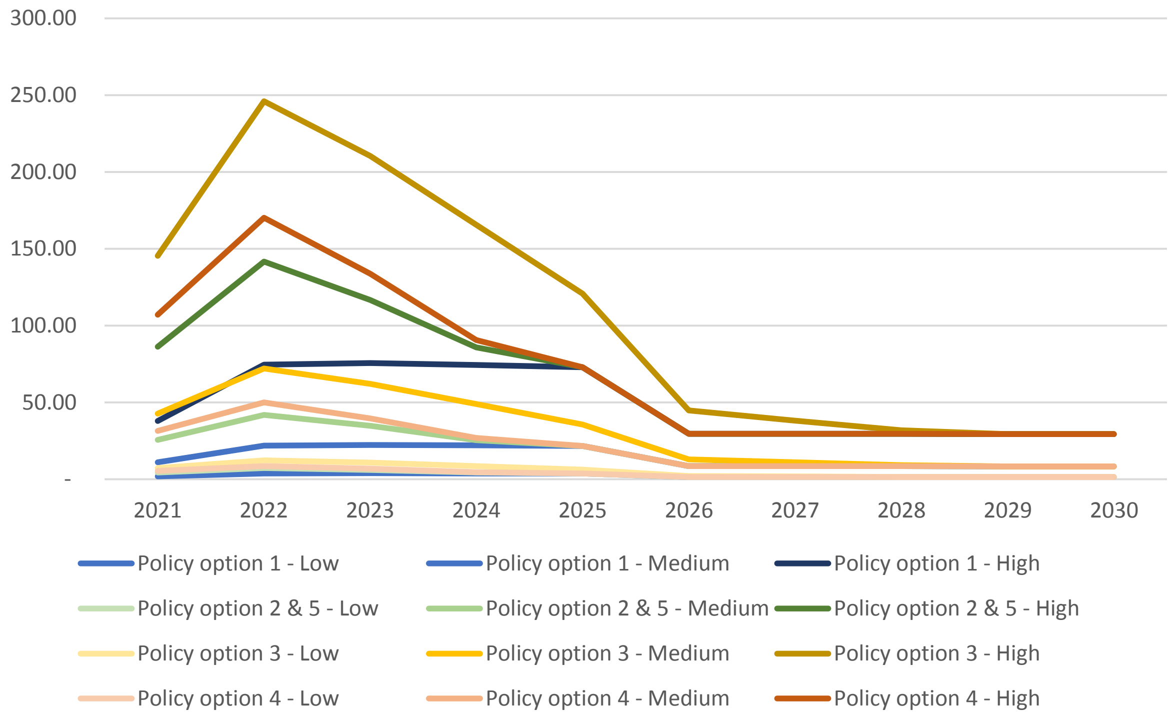
In the low scenario the policy costs for the investment subsidies + SEG option are around 5.7 million EUR per year. These estimates are substantially lower than the support currently provided, e.g. the Better Energy Communities retrofit scheme is currently provided by the public sector and amounts to up to 28 million EUR per year, whereas in policy option 2 part of the costs would be provided by suppliers via the SEG. Likewise, the FiP under a low and medium uptake scenario is estimated to amount to around 5.4 and 22.9 million EUR per year respectively.

Policy option 3 and 4 are the most costly options presented, with the FiT coming out as the most expensive option as it does not have the benefit of a permanent SEG incentivising microgeneration uptake over their lifetime. On the other hand, the FiP option has a higher risk of high costs, because it is set up in such a way that if the SEG rates are low, the remaining gap would be filled by the FiP. On the other hand, while the FiT costs will be borne exclusively by one actor (e.g. public sector either through a PSO or through recovery via ring-fencing of other revenues or taxes or suppliers with recovery through their rates (see section 5.3.3), policy option 4 will split the costs to be paid by suppliers for the SEG and the public sector for the FiP.

The UK FiT scheme is estimated to have costed 30 billion GBP from 2010-2019 (on average around 3 billion GBP/year or EUR 5,275 / kWp installed (1.1607 EUR/GBP exchange rate for March 31, 2019))[74]. These costs in the UK were mostly borne by suppliers and paid for through higher retail rates. This amounted to about 9 GBP per year for the average household in 2014[75] and was expected and did rise to 14 GBP per household in 2020. The estimated costs of the FiT (policy option 3) is lower than these costs for all three uptake scenarios with an average cost of 32.9 million EUR per year under the medium uptake scenario or around 325.20 EUR / installed kW. The FiP would come out with lower costs with an estimated cost of 22.9 million per year under the medium uptake scenario (including SEG costs) or 226.57 EUR / installed kW.

The figure below shows the cost development of each policy option over time. This shows that costs are generally higher in the years 2021-2025 as uptake rates are expected to be increasing more significantly during these years while viability gaps are still high and they smoothen out over time after 2026, as capital cost reductions reduce the viability gap.

Figure 5-2 - Total cost per policy option per year in million EUR



The costs of the policy options are split between the costs of the export payments through a smart export guarantee and payments in the form of an investment subsidy, FiT and FiP in the table below. Typically, it is assumed that suppliers who provide the SEG procure energy from microgenerators through this SEG which they can recover through balancing of wholesale volumes. On the other, the other payments of an investment subsidy, FiT and FiP can be provided either by suppliers with recovery through their unit rates or by the public sector (e.g. through ring-fencing of revenues or through the PSO levy). A more detailed discussion of funding mechanisms for each policy option is included in section 5.3.3.

[74] Ofgem. 2019. Feed-in Tariff Annual Report 2018-2019. Available from: https://www.ofgem.gov.uk/system/files/docs/2019/12/feed-in_tariff_annual_report_2018-19.pdf
[75] DECC. 2015. Performance and Impact of the Feed in Tariff Scheme: Review of Evidence.

Table 5-21 - Breakdown of costs of SEG and other support policies for each policy option under the low, medium and high uptake scenarios

Policy option	Description	Low uptake scenario	Medium uptake scenario	High uptake scenario
Policy option 1 (SEG)	Total costs of SEG for 2021-2030 in million EUR	41.95 (100%)	158.89 (100%)	500.25 (100%)
Policy option 2 (SEG + Investment subsidy)	Total costs of SEG for 2021-2030 in million EUR	41.95 (83%)	158.89 (76%)	500.25 (75%)
	Total costs of investment subsidy for new installations 2021-2030 in million EUR	8.77 (17%)	50.19 (24%)	168.14 (25%)
Policy option 3 (FiT)	Total costs of FiT (both export and generation payment) for new installations 2021-2030 in million EUR	71.03 (100%)	329.03 (100%)	1,079.36 (100%)
Policy option 4 (SEG + FiP)	Total costs of SEG for 2021-2030 in million EUR	41.95 (78%)	158.89 (69%)	500.25 (68%)
	Total costs of FiP for new installations 2021-2030 in million EUR	12.03 (22%)	70.35 (31%)	239.46 (32%)
Policy option 5 (SEG + investment subsidy with equity aspects)	Total costs of SEG for 2021-2030 in million EUR	41.95 (83%)	158.89 (76%)	500.25 (75%)
	Total costs for new installations 2021-2030 in million EUR	8.77 (17%)	50.19 (24%)	168.14 (25%)

A summary of the cost assessment of the five policy options considered in this study is provided in the table below.

Table 5-22 - Cost assessment of five policy options

Policy options	Level of costs in million EUR / year under medium scenario when viability gap is met	Risks of costs to public sector increasing when export payments are low
Policy option 1: SEG	N/A as viability gap is not met for 2021-2024. For 2025-2030 costs are 8.4 million EUR per year while viability gap is met.	No, 100% of costs are SEG.
Policy option 2: SEG and investment subsidy	20.9	No, investment subsidy will be fixed. SEG estimated to cover 75-83% of costs.
Policy option 3: FiT	32.9	No, although 0% covered by SEG.

Policy option 4: SEG and FiP	22.9	Yes, when SEG payment is low, public sector costs may increase. SEG estimated to cover 68-78% of costs.
Policy option 5: SEG, investment subsidy and equity aspects	20.9	No, although additional support may be provided for vulnerable consumers. SEG estimated to cover 75-83% of costs.

5.3.3 Policy option funding mechanisms

There are a range of options available for each of the policy options discussed for how incurred costs can be recovered. In the case where costs are incurred by suppliers, such as for the Smart Export Guarantee (or possibly the other policies), suppliers can recover the costs based on one of the following mechanisms:

- **Socialise costs through unit rates (the price per kWh rate).** Suppliers can increase their overall unit rates for all of their customers to recover the costs of the Smart Export Guarantee tariff paid for customers exporting self-generated electricity (or other policies if paid out via suppliers if relevant). However, unit rates are regulated in Ireland to remain constant for the duration of a electricity supply contract. Therefore, for a supplier to pass through additional costs in its unit rates it will need approval from the regulator (CRU). In addition, to remain competitive, suppliers may choose to set a Smart Export Guarantee that minimises the increase needed on their unit rates.
- **Recover costs based on market value.** In this option the supplier will sell the electricity gained via the SEG again at market value, thereby recovering the costs of providing a tariff for exported electricity as well as providing the grid with clean energy. The UK government impact assessment of the Smart Export Guarantee even outlines that "*the aim of SEG is that over time suppliers offer smart export tariffs where the price paid varies on a half-hourly basis to reflect the wider electricity system conditions and maximise the benefits available to energy consumers. However, it's recognised that some suppliers will not be ready to move to this type of tariff immediately.*"

In the case where the policy incurs costs for the government, such as might be the case of the FiT, FiP and investment subsidies, costs can be covered either:

- **Via a voted grant scheme or by ring-fencing other revenue.** In practice, therefore, when costs fall to the government, if covered via this option it will be paid for by all taxpayers.
- **Recover costs through a (Public Service Obligation) PSO levy or equivalent.** This is a levy that all electricity consumers in Ireland pay to their suppliers. The level of the levy is calculated by the regulator, CRU, and the rate is typically shown separately on the electricity bill. The income from this levy is transferred to the wholesale power providers and used to cover costs related to increasing the share of renewable energy in Ireland (previously also security of supply and peat fuel objectives). The CRU has recently announced that a PSO levy of 480.11 EUR million will be charged in 2020/2021 which is a significant increase compared to financial year 2019/2020 where 179.46 EUR million was charged[76]. This may be a consequence of wholesale electricity market prices being lower and also new renewable generators coming on stream, thereby more need for the PSO levy to provide additional support to renewable generators and the higher costs incurred. It should also be noted that

[76] CRU. 2020. CRU Publishes Proposed 2020/21 Public Service Obligation Levy. Available from: CRU Publishes Proposed 2020/21 Public Service Obligation Levy

the increasing penetration of wind on the system is driving down the wholesale price of electricity so the impact on the net cost to the consumer (combined PSO + electricity cost) is less pronounced.

The table below provides an overview of the main advantages and disadvantages of the different cost recovery mechanisms considered here.

Table 5-23 - Advantages and disadvantages of cost recovery mechanisms

Cost recovery mechanism	Socialise costs through unit rates	Recover costs based on market value	Costs to government covered via voted grant scheme or ring-fenced revenue from other schemes	Recover costs through PSO levy
Agency recovering their costs	Suppliers		Public sector	
Main group affected	All electricity consumers of a specific supplier, different rates per supplier	Suppliers may incur additional admin costs, no other group affected	All taxpayers	All electricity consumers will be affected equally
Advantages	Scaled by amount of electricity consumed	No impact on consumer bills	Possibility to use revenue from specific other policies, e.g. carbon tax, thereby using polluter pays principle	Relatively easy to implement as costs for renewable electricity are already considered in the current calculations of a PSO levy
Disadvantages	Competition between suppliers may lead to offering of low SEG, impacting on the effectiveness of the policy .	May take time (and admin costs for suppliers) for suppliers to be able to offer half-hourly rates in line with wholesale prices	In case no revenues will be ring-fenced, all taxpayers will be affected.	Some consumers may be impacted disproportionally as it is not determined by unit
Additional considerations	To avoid low SEG rates due to competition, regulators may impose restrictions on the SEG such as minimum levels. However, in the case of such restrictions it	As this option may place additional admin burden on suppliers, so it may be considered that other admin requirements for suppliers are decreased such	Ring-fencing may be politically and legally difficult to realise This option may be combined with a possible carbon tax and revenue collected for this.	PSO levy has recently already increased significantly, therefore additional increase may lead to industry opposition

	should be accompanied by other measures such as a price cap on unit rates to avoid socially regressive outcomes[1].	as registrations of Meter Point Administration Numbers (MPAN) etc.		

The above table demonstrates that to allow suppliers to recover costs based on their market value would impact the least on consumer bills. However, it may take time before this is possible and in the meantime suppliers may recover the costs through unit rates, which could lead to either lower rates of the SEG offered (and thus lower effectiveness) or disproportionate impacts on low-income households that have fewer means to invest in microgeneration.

However, both of the options of suppliers recovering costs are preferable to options where costs fall to the public sector. This is because options where the public sector recovers costs do typically have higher impacts on all electricity consumers or taxpayers. However, by ring-fencing of carbon tax revenues or other income streams, this impact may be adjusted to follow more of a polluter-pay principle.

Moreover, the timing of payments may also need to be considered. For example, investment subsidies will likely be paid early on in the scheme, thereby posing a high risk for the government to have this funding available and possible risking over-compensation if later self-consumption rates turn out to be different than expected. In turn, FiT or FiP payments have lower risk for the government, as payments are spread out over longer timeframes.

In addition, it is proposed that a mix of approaches may also be used for recovery of costs for the different policy options. For example, investment subsidies offered to schools or community schemes could be covered by the central government, while those for domestic use can be mandated to be covered by suppliers instead.

5.3.4 Feasibility for implementation and administration costs

The feasibility of a policy can be assessed based on a number of criteria. These include:

- Complexity of implementation including potential for required changes in policy over lifetime
- Administrative costs required

The case studies identified in Section 4.2 can be broadly grouped into four groups—Smart Export Guarantee, Feed-in-tariff and FiP and Investment Subsidy—which will now be assessed in terms of their general feasibility. Aspects relating to the equity of schemes will also be discussed as they can also impact the feasibility of a scheme.

It should be noted that for policy option 4, a combination of a SEG with a FiP, it is assumed that additional regulation would be put in place that requires suppliers to agree to a SEG rate a year in advance. This regulation facilitates thereby a calculation to take place what the level of the FiP payment needs to be for the period ahead. This additional regulation, however, does indicate additional administration costs and complexity for policy option 4 on top of those listed by measure in the table below. A disadvantage of asking suppliers to fix their SEGs for a year in advance is also that this brings additional risk for suppliers. In case wholesale prices fluctuate, their SEG payment may be higher than the actual wholesale prices, although they may also be lower. To adjust for this risk, it may be expected that suppliers set lower SEG rates than in a system where they are not expected to fix their rates for a year in advance.

Table 5-24 - Assessment of complexity and administration costs for different policy types

Measure	Complexity for implementation	Administration costs estimate
Smart Export	**Low**- the market-based approach of the SEG means complexity of	**Low**- in the UK SEG, it is expected that the scheme administrator will face some

Guarantee	implementation is low for governing bodies although administrative burden is passed on to energy suppliers	administration costs although these are expected to be significantly less than the costs of administering a Feed-in-Tariff scheme. It is expected that suppliers will set tariffs so that any administration costs incurred are offset and that a surplus can be made in the retail market.[77]
Feed-in-tariff	**Moderate**- FITs require an up-front and continuous administrative commitment to set the payments accurately although the fixed nature of feed-in-tariff means it is less complex to implement than a variable premium tariff scheme	**Moderate**- administrative costs as a percentage of total scheme cost start high but drop over the lifetime of the scheme. Costs for the UK FIT have typically been in the region of £2-5-4 million per year, dropping from almost 4% of the scheme's cost in Year 1 to 0.23% of the total value of the scheme in Year 9[78]
Feed-in-premium	**High**- the need for premium tariffs to adjust in response to market prices results in increased complexity.	**High**- FIP schemes come with additional costs for example, associated with the procurement of balancing services
Investment Subsidy	**Low**- subsidy schemes typically change little over the course of their lifetime and are relatively simple to implement. Investment schemes are often outsourced, for example in Austria the investment subsidy scheme is run by Kommunalkredit Public Consulting GmbH	**Low**- administrative costs associated with investment subsidies are expected to be relatively low, especially if the scheme is outsourced.[79]
Equity aspects	Consideration of equity can lead to greater administrative complexity. For example, the additional tax deductions available as part of the French scheme lead to an additional layer of administrative complexity.	As in the cases above, increased complexity typically leads to increased administrative costs.

The policy options outlined in Section 5.2 are assessed on their potential feasibility based on the above considerations, However, it is important to first consider the existing support schemes in Ireland as continuity with current policy can lead to reduced administrative complexity.

As outlined in Section 1.2, the most notable scheme in Ireland is the pilot programme launched in July 2018 by the Sustainable Energy Authority of Ireland (SEAI) to support solar PV. Some changes have already had to be made to the scheme following a review of the first 16 months the scheme was in operation.[80] However, as an investment subsidy, the scheme is generally not expected to result in a

[77] UK BEIS. 2019. Impact assessment for Smart Export Guarantee. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/807422/smart-export-guarantee-impact-assessment.pdf
[78] Ofgem. 2019. Feed-in Tariff Annual Report 2018-2019. Available from: https://www.ofgem.gov.uk/system/files/docs/2019/12/feed-in_tariff_annual_report_2018-19.pdf
[79] World Bank – Climate Investment Funds. 2011. Information note on subsidies for renewable energy technologies under SREP. Available from: https://www.climateinvestmentfunds.org/sites/cif_enc/files/meeting-documents/srep_inf_3_subsidy_paper_0.pdf
[80] SEAI. 2019. Changes to domestic solar PV scheme. Available from: https://www.seai.ie/news-and-media/changes-to-domestic-solar/

significant administrative burden and continuation of the scheme as part of a future microgeneration support scheme may be a desirable option.

Under some policy options, particularly feed in tariffs, market caps can be introduced, or effectively a deemed payment be regulated for exported electricity. In the UK, for FiT installations below 50kW, domestic and non-domestic consumers were fitted with a generation meter upon which a generation tariff was paid. A deemed figure of 50% of the generated electricity was paid, as this was assumed to be exported, at a separate fixed price similar to the wholesale price. No metering of exported electricity was completed, thereby reducing the complexity and costs for the scheme. While this cuts down potentially on admin or complexity of administering a policy, it is not certain that this approach would comply with the RED II requirement to pay renewable self-consumers fair market value for exported electricity. It is also difficult to distinguish a deemed payment from an investment grant. This also did not emerge as a beneficial feature of international case studies considered in section 4.

Further, it may be more cost effective to deliver a grant equivalent to an export tariff in total cost over the policy lifetime. However, the implementation of such an idea would mean further costs upfront that would obviously benefit the generator and could incentivise the installation uptake. If there were enough funding available at the beginning of the policy program, then this may be considered, and certain sectors could be incentivised further.

Table 5-25 provides an assessment of the proposed policy options, considering this information.

Table 5-25 - Assessment of complexity and administration costs for different policy types

Policy Option	Feasibility assessment
Policy Option 1	The market-based approach of an SEG system is eminently feasible and should not result in a significant administrative burden, with decisions related to the setting of tariffs passed onto energy suppliers. Furthermore, continuation of existing grant schemes should not lead to added complications.
Policy Option 2	The combination of new investment subsidies with the SEG will result in some additional administrative complexity in comparison to Policy Option 1.
Policy Option 3	A Feed-in-Tariff which is a fixed tariff paid to the consumer for all electricity generated for the entire period of the scheme (10 years) as well as an export payment for both existing and new installations Although administrative costs may be expected to decrease over the lifetime of the scheme, the need to administer variable export payments means this is likely to be a complex and costly option.
Policy Option 4	The combination of a SEG with a FiP provides additional complexity as the premium will need to be recalculated for every year (or quarter) to adjust for changes in the smart export guarantee rates provided.
Policy Option 5	This option is identical to Policy Option 2 in its mechanism, except for the additional consideration of equity aspects. As a result, implementation is likely to be marginally more complex and costly than Policy Option 2.

Based on the assessment above, Policy Option 4 (FiP + SEG) represents the most complex option, while Policy Option 1 (only SEG) is the most straightforward.

6 Conclusion - Policy options

Table 6-1 provides a summary of the policy option assessment presented in chapter 5.3, showing the trade-offs of each option. For example, while the Smart Export Guarantee combined with a FiP (policy option 4) provides long-term certainty to the microgeneration market that the viability gap for the main targeted capacity bands will be closed, it also comes with high administrative costs due to the complexity of recalculating FiP rates regularly. Alternatively, the smart export guarantee (policy option 1) has low overall and administrative costs, but also has the highest risk of all policy options that it will not be able to meet the viability gap for the domestic solar rooftop sector up to 2024.

Alternatively, both options that combine a Smart Export Guarantee with an investment subsidy (policy options 2 and 5) provide opportunities to address barriers to the uptake of microgeneration, especially those relating to high upfront costs. They may however be less effective in providing long-term investment certainty to the market compared to the FiT and FiP, as investment subsidy payback rates after the initial investment are only based on savings on the energy bill. While the investment subsidy options are less costly than the feed-in-tariff option, the risk for high costs to the government in the first years of the scheme and potential overcompensation are high in these options. Policy option 5 provides the additional benefit that eligibility criteria can be adjusted to ensure that barriers to microgeneration uptake for certain consumer groups are addressed, although this may also bring higher administrative costs and complexity to implementation. On the other hand, policy option 3 (FiT) provides the highest risk for over-subsidizing as it does not have an inherent mechanism to promote self-consumption or a mechanism adjust its rates based on market values.

Based on this assessment, the recommended policy option for Ireland is an option that includes a Smart Export Guarantee. The advantages of a Smart Export Guarantee is that it can be provided at near cost-neutrality as the rates are provided by suppliers based on wholesale electricity prices, which also aligns with the European objectives of the Renewable Energy Directive. Moreover, a SEG is inherently able to provide incentives for self-consumption, energy efficiency and avoids the risk of overcompensation, which are all objectives set under the Irish Climate Action Plan. However, as the SEG will not be able to meet the viability gap for domestic rooftop solar (and other technologies and sectors) from 2021-2024, it is recommended that the option is supplemented by a FiP in the first years. The advantage of this mechanism (policy option 4) is that certainty is provided in the short-term that the viability gap is met in any scenario (independent of the rate of SEG provided), while also providing the long-term benefit of compensating exported electricity at market value. As the FiP is defined as bridging the difference between the viability gap and the SEG provided, there is also a natural phase-out of this subsidy over time, thereby reducing the risk of policy uncertainty or overcompensation.

Table 6-1 - Summary of policy assessments

Assessment indicator	Policy option 1 (SEG)	Policy option 2 (SEG + Investment Subsidy)	Policy option 3 (FiT)	Policy option 4 (SEG + FiP)	Policy option 5 (SEG + Investment subsidy + equity aspects)
Effectiveness	SEG will not meet viability gap for domestic solar from 2021-2024. Payments over longer term help de-risk investments in	Addresses main barrier of upfront costs. SEG provides longer-term certainty.	Recognised and understood by the market, provides bankable revenue stream for investment and thereby addresses	Provides bankable revenue stream for investment and certainty that viability gap is met in any scenario (high or low	Similar to option 2, with the added benefit that eligibility criteria can be adjusted to address barriers for certain consumer groups to align with CAP objectives. However, it

	non-domestic sectors. SEG is effective in promoting self-consumption and energy efficiency.		finance barrier, but effectiveness heavily dependent on design of FiT and degression profile. The option does not promote self-consumption.	export levels). Natural phase-out of FiP over time while support from SEG remains, providing long-term certainty to investors.	may be difficult to target most vulnerable consumers as fuel poor households may not consider any investment in microgeneration
Cost assessment	While costs are low, there is a high risk that the viability gap will not be met for 2021-2024. For 2025-2030 costs are 8.4 million EUR per year when the viability gap is met.	Medium uptake scenario costs are 20.9 million EUR per year.	Medium uptake scenario costs are 32.9 million EUR per year	Medium scenario costs are 22.9 million EUR per year, but could be significantly higher if SEG payments are lower than expected	Medium uptake scenario costs are 20.9 million EUR per year, but additional support may be provided for vulnerable consumers
Ability to minimize costs to vulnerable consumers)	Costs only borne by suppliers and potential to be near cost-neutrality	Costs can be recovered either through unit rates or through ring-fenced revenues. Risk that there are high costs upfront for government with risk of overcompensation.	None of the costs covered by suppliers, costs likely to either pass through in unit rates or to taxpayers	SEG offered by suppliers, but remaining gap will be assumed to be covered by public sector through PSO levy or ring-fenced revenues	Costs can be recovered either through unit rates or through ring-fenced revenues. Risk that there are high costs upfront for government with risk of overcompensation.
Administrative costs and complexity for implementation	Low administrative costs as suppliers set SEG rates	Eligibility for investment grants need to be calculated and level degression over time. Easy to align with existing investment schemes (e.g. SEAI pilot) through small adjustments	FiT need to be adjusted year-on-year and it requires certification of eligible participants	Most complex as FiP needs to be regularly recalculated as suppliers vary SEG although could be paid by the supplier	Similar to option 2, but more complex due to equity aspects for eligibility criteria. Easy to align with existing investment schemes (e.g. SEAI pilot) through small adjustments

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A1 Appendices

A1.1 Data collection for case studies

A1.1.1 UK – Feed-in-tariff

Data point	UK - Feed-in-tariff
Name of scheme	Feed-In Tariffs (FIT)
Year of implementation	2010
Year scheme ended	2019
Main objective of the microgeneration support policy	The FIT was designed to promote the uptake of renewable and low-carbon electricity generation technologies. More specifically, it was intended to a subsidy framework for small-scale low carbon technologies which is easily understood, offers more certain returns and covers a wide range of technologies The introduction of the FIT marked a new approach to the deployment of renewable energy technologies in the UK as it was explicitly not technologically neutral, in the sense that specific, less mature technologies, as well as smaller installations, enjoyed a higher tariff compared to larger installations or technologies that are closer to grid parity.
Type	Feed-in tariff
Scope	The technologies covered by this policy were hydro, anaerobic digestion, wind and solar PV. In addition, a pilot scheme for micro-CHP was also added under this policy. Specific rates were set for different technologies and at different scales of installation for those technologies.
Historical background	The first scheme developed to encouraging the deployment of renewables in the UK was the Renewables Obligation (RO) in 2002. This was a fairly complicated system, primarily aimed at large scale projects and was not successful in encouraging small scale domestic generators. To address this the Government put in place the FIT scheme for smaller generators only - shortly after the creation of the new Department of Energy and Climate Change.
Description of regulatory landscape	Energy supliers with over 250,000 domestic electricity supply customers are required to offer mandatory FIT licenses. The suppliers process applications submitted for small installations and make FIT payments to all installations. Suppliers with proportionally fewer FIT customers make cross-payments to those with more, to spread the costs of running the FIT scheme fairly. FIT payments are made quarterly (at least) for the electricity generated and exported. Payments are made based on the meter reading submitted to the FIT licensee.
Description of mechanism	Under this policy, producers of small-scale renewable electricity (under 5MW) can receive a feed-in-tariff for 10 to 25 years for the electricity that is fed back into the grid, depending upon the technology type. Owners of generators received both an export tariff (for energy supplied to the grid) and a generation tariff (for all generated energy regardless of use). The scheme assumes that generators export 50% of the electricity they produce and are paid even when they export less than 50%. Generators are highest in the merit order are given priority market access as there is no control on the export of excess generation
Installation capacity limit	5MW
Implementing agency	Electricity regulator Ofgem

Funding mechanism	FITs is one of the renewable schemes funded through the Levy Control Framework (LCF) which is designed to control the costs of supporting low carbon electricity, paid for through consumers' energy bills. Costs for the programme are socialised and borne by all British electricity consumers proportionally: all consumers will bear a slight increase in their annual bill, thus allowing electricity utilities to pay the FIT for renewable electricity generated at the rates set by the government. Annual reconciliations and periodic redistributions within the year took place to minimise the financial exposure of suppliers.
Policy outcomes	The FIT scheme is generally considered to have been successful, despite the high costs to consumers. The scheme has supported the installation of over 850,000 installations by 2020 —far more than the 750,000 installations expected in the original impact assessment—equivalent to over 6.6GW of UK generation capacity. The 8.45 TWh of electricity generated by FIT installations in Year 9 of the scheme therefore equates to slightly over 8% of final household energy consumption in the UK.
Overall size of support provided	30 billion
Units	£
Explanation	N/A
Uptake per technology and sector	99% of installations accredited under the FIT scheme are solar, or 80% capacity. By capacity: wind is 12%, hydro is 3%, AD is 5% and mCHP is 0.01%
Emission reductions estimated	1.3 million
Units	tCO2e in 2013 and 2014 only
Explanation	The 2010 Impact Assessment projected that 7m tonnes of carbon would be saved by 2020. The FIT surpassed this figure, saving 10.4 million tonnes of CO2e emissions were saved by Year 7
Cost-effectiveness of policy overall for government	Poor- the scheme assumes that generators export 50% of the electricity they produce and are paid for it-even when the electricity is not needed by the grid or they export less than 50%.
Costs to end-use consumer / impact on electricity prices	The scheme was considered to be costly for consumers- with generation payments rising year-on-year, costing £1.4 billion in the scheme's final year. However, the average cost per tonne of CO2e saved as a result of the scheme decreased over time, reflecting the increased cost effectiveness of the scheme as a greenhouse gas emissions saving instrument. This reduced marginal cost of emissions can be attributed largely to tariff degression.
Avoided costs for end-use consumers	The high uptake through FITs, particularly for Solar PV, has resulted in the Feed-in Tariffs being cut several times since their introduction. The Government also attempted to cut tariffs for Solar PV retrospectively but this was ruled unlawful in court.
Co-benefits	The scheme was successful in creating a supply chain, creating a significant amount of jobs transfer to support renewable installation.
Impacts on specific	Cost to consumers was high while generators benefited, especially in the early years of the scheme. Administrative burden placed on energy suppliers. The solar industry

stakeholders	benefited from the scheme, with uptake dominated by the solar sector. Some found it difficult to enter into the market through the FIT scheme, e.g. listed buildings.
Key issues and changes	Tariffs were set to give rates of return between 5-8%, encouraging investment but preventing overcompensation. This only partly succeeded in the case of solar PV and a fast-track review took place in 2011. The main change following this review was the introduced of a degression rate for the scheme, with new levels of tariffs dependent on the level of uptake in previous months. The stepped degression resulted in reduced return to investors, but also resulted in the tendency of developers to rush to complete projects before the dates rates are reduced. The Government also attempted to reduce rates retrospectively for solar PV, but this was ruled inadmissible by the courts. Following consultation in 2015, tariffs were reduced (although not as much as initially intended) and a quarterly cap introduced, resulting in a quarterly rush for developers to register for accreditation as soon as the new tariffs were available. The UK government took the decision to close the scheme to new entrants in March 2019 in the context of a steady fall in the cost of low-carbon generation, a move towards cost-reflective pricing, and a continued desire to minimise the costs of support schemes to consumers.
Overlaps with other policies	FIT was designed for small-scales, fitting in with the Renewables Obligation and the Contracts for Difference scheme.
Main lessons learned	The UK FIT scheme has over-achieved its targets and has therefore been regarded as successful. However, it has also resulted in high costs to consumers leading to the decision to phase out the scheme and to replace it with the Smart Export Guarantee. In particular, tariffs were set as part of the policy to give rates of return between 5-8%, encouraging investment but preventing overcompensation. This only partly succeeded in the case of solar PV. Therefore, after a review of the policy in 2011 a degression rate was introduced to the scheme which was dependent on the level of uptake in previous months. The stepped degression resulted in reduced return to investors, but also resulted in the tendency of developers to rush to complete projects before the dates rates are reduced. The UK government took the decision to close the scheme to new entrants in March 2019 in the context of a steady fall in the cost of low-carbon generation, a move towards cost-reflective pricing, and a continued desire to minimise the costs of support schemes to consumers.
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A1.1.2 UK – Smart Export Guarantee

Data point	UK - Smart export guarantee
Name of scheme	Smart Export Guarantee (SEG)
Year of implementation	2020
Year scheme ended	N/A

Main objective of the microgeneration support policy	The SEG was intended to: • Ensure small-scale generators are compensated by the market for the value of their exported electricity; • Establish a framework for the sector which provides room for the market to develop options, promoting innovation and competition, in particular the growth of aggregators and a digital marketplace; • Enhance the role small-scale generators play in driving a smarter energy system, using smart meters and time-of-use tariffs, which will allow more consumers to benefit from location and time-specific electricity prices
Type	Minimum export price guarantee
Scope	Smart Export Guarantee ensures anaerobic digestion, hydro, micro-combined heat and power (with an electrical capacity of 50kW or less), onshore wind, and solar photovoltaic exporters with up to 5MW capacity receive payment for exported electricity.
Historical background	The SEG is not a direct replacement of the feed-in tariff scheme. Announcing its decision to close the FIT scheme, the Government argued that “growth in the small-scale low-carbon generation sector must be sustainable; driven by competition and innovation, not direct subsidies”. It also explained that the feed-in tariff scheme’s “fixed and flat rate export tariff does not align with the wider government objectives to move towards market-based solutions, cost reflective pricing and the continued drive to minimise support costs on consumers.”
Description of regulatory landscape	SEG is introduced to replace the FiT scheme in the UK.
Description of mechanism	Licensed electricity suppliers with more than 150,000 customers are required to offer at least one SEG compliant export tariff to any generator with an eligible installation.. The SEG licensees decide exactly how they want their SEG export tariff to work in terms of its rate, type and length. However, the tariff must be greater than zero pence per kilowatt hour exported at all times. As with tariffs for the purchase of electricity, there could be a variety of different SEG export tariffs available. Suppliers can compete to offer attractive terms and, if the tariff becomes uncompetitive, generators may consider switching to another supplier.
Installation capacity limit	5MW
Implementing agency	Electricity regulator Ofgem
Funding mechanism	Suppliers offering tariffs make payments to eligible SEG generators based on verified export meter readings. Suppliers cover the cost of these payments.
Policy outcomes	Some suppliers are offering or trialling export tariffs, either in line with the wholesale price or at levels comparable with the feed-in tariff export tariff rate. The government believes that these encouraging signals show that suppliers are keen to engage in this market and meaningful and competitive offerings will come through, without government taking the role of price setting. The SEG impact assessment predicts it will deliver only 12.5 MW per year until 2026.
Overall size of support provided	TBC
Units	N/A
Explanation	N/A
Uptake per technology and sector	Solar is expected to have highest uptake in all modelled scenarios according to the Impact Assessment carried out prior to implementation.
Emission reductions	Displacement figures from Impact Assessment available only

estimated	
Units	"Expected displacement of marginal grid plants that are more carbon intensive, valued at £5m to 19m"
Explanation	Impact Assessment reports discounted carbon savings of £5m and £19m for two modelled SEG scenarios
Cost-effectiveness of policy overall for government	High. The scheme administrator will face some administration costs although these are expected to be significantly less than the costs of administering the FITs scheme, given the light touch nature of the Authority's role, in line with the market based approach of SEG.
Costs to end-use consumer / impact on electricity prices	The overall impact on consumer bills is uncertain however there is not expected to be a direct impact on consumer bills from the introduction of the SEG. As suppliers under the SEG set their own tariff for exported electricity, tariffs can be set so that net costs to suppliers are avoided. The SEG is therefore unlikely to carry any policy costs which are typically paid for by final consumers. In fact, there are two avenues through which the SEG could lead to reduced consumer prices. Firstly, if suppliers offer a tariff lower than the wholesale price, this would represent a cost saving which could be passed on to consumers. Secondly, increased small-scale generation may decrease demand in the wholesale market in turn reducing the wholesale price.
Avoided costs for end-use consumers	It is expected that suppliers will set tariffs so that any administration costs incurred through the SEG are offset and that a surplus can be made in the retail market. As a result, there is a minimal risk that consumers could face any direct policy costs passed on to bills from the SEG.
Co-benefits	The assumed increase in deployment of small-scale generators will likely result in increased employment in the small-scale sector. As the SEG is not dealing with public monies, Ofgem will not be involved in counter fraud activities in the same way that it is for other government funded environmental and social schemes.
Impacts on specific stakeholders	The introduction of the SEG is expected to result in an administration cost for suppliers. These have not been estimated as it is expected that the costs facing mandated suppliers will vary widely dependent on their approach for implementing the SEG and is therefore highly uncertain. The scheme administrator will also face administration costs. There is not sufficient evidence to estimate these costs at this stage, although we expect them to be significantly less than the costs of administering the FITs scheme, given the light touch nature of the Authority's role, in line with the market based approach of SEG.
Key issues and changes	In response to the consultation on the Smart Export Guarantee scheme, the Solar Trade Association highlighted the vulnerability of households operating small-scale generation or storage systems compared to large-scale operators, as well as the potentially limited number of households with smart meters capable of fulfilling the requirements of the Smart Export Guarantee scheme. In addition to advocating a minimum export price, Dr Nina Skorupska, Chief Executive of the Renewable Energy Association, has also said that "minimum contract lengths should be required to give future generators certainty". The Durham Energy Institute also argued that the new scheme should be "guaranteed over a sufficiently long time frame to ensure that continuity, consistency and clarity releases private investment".
Overlaps with other policies	The May Government amended the Climate Change Act 2008 to include a target for net-zero emissions by 2050. When recommending this target, the Committee on Climate Change said that decarbonising electricity would require increasing the share of low-carbon power from 50% today to 95% in 2050. The SEG impact

	assessment predicts it will deliver only 12.5 MW per year until 2026. While the SEG is not the only Government support for low carbon power, there may be calls for more support for renewable power in light of the net-zero target.
Main lessons learned	No lessons learned yet.
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A1.1.3 Germany – Subsidy for solar PV and storage

Data point	Germany subsidy for PV and storage
Name of scheme	Energy Storage Funding Initiative (KfW 275)
Year of implementation	2013, renewed 2016
Year scheme ended	2018
Main objective of the microgeneration support policy	Encourage the uptake of energy storage with solar PV and to incentivise manufacturers to pass on the technology/production-related cost reductions to the customers.
Type	Investment grant
Scope	Germans with solar storage systems below 30 kilowatts received subsidies that could cover 30 percent of their battery system's cost (2013-2015). Renewal for 2016-2018 covered 25% of costs gradually dropping to 10% over time depending on when application was submitted.The scheme is available for SMEs, public sector buildings, farmers and households.
Historical background	State owned KfW bank has long history with regards to German development - serves as a promotional bank for individuals/cities, enterprises etc. Aims to provide low interest loans for German development. Feed-in tariffs for PV dropped below the average electricity price for households, with self-consumed electricity exempt from network tariffs.charges encouraging the use of batteries. High cost of batteries means this isnt economic = KfW bank investing EUR25m in 2013 to batteries - investment grant of 30% of battery system cost with remaing 70% covered by low interest loan.
Description of regulatory landscape	Applications can be submitted for projects whose capacity does not exceed 30 kWp. These can get a rebate of up to 25% for the system and installation cost, and they can also apply for a low-interest loan from German development bank KfW.
Description of mechanism	Germany's current storage incentive scheme, which was renewed in March 2016 after an initial implementation in 2013, consists of a low-interest loan of up to €2/W for the PV system and a direct payment for up to 22% of the eligible costs of the system (not to exceed €0.50/W of the PV capacity). The portion of eligible costs to which the grant can be applied will decrease by three percentage points every six months until it reaches 10% in the second half of 2018, at which time the program will expire
Installation capacity limit	30kWp
Implementing agency	Administered through the national development bank KfW,

Funding mechanism	Offer of low-interest KfW loans and repayment bonuses from BMWI funds. The repayment bonus is degressive covering 25 to later 10% of cost.
Policy outcomes	In the coming years, additional revenue options may arise for EEG-eligible investments in other markets. Flexible taxable installations which do not qualify for EEG feed-in tariffs may, in particular, participate in the balancing market. In addition, as of 2021, the first years of plant production that have been phased out will leave the EEG and will be actively integrated into the energy markets without funding. Different business models will be established here, e.g. funded through PPAs.
Overall size of support provided	30m
Units	EUR
Explanation	N/A
Uptake per technology and sector	The monitoring of the support programme showed that out of the 40 000 home storage facilities newly built in 2018, only 5 % used the support programme. Therefore, it does not seem necessary at present to further promote home storage facilities by the Federal Government.
Emission reductions estimated	Not available
Units	N/A
Explanation	
Cost-effectiveness of policy overall for government	Results from an evaluation study show that the investment in a battery storage system does not pay off even when government subsidies are taken into account. Regardless of the size of the selected battery storage system and all other influencing variables, the financial advantages of such a system do not materialise, although a battery storage system does substantially increase the self-sufficiency rate.
Costs to end-use consumer / impact on electricity prices	Rebate only up to 25% of the system and installation costs. Studies have shown that, in most cases, the average profit of a standalone PV system is much higher compared to a PV battery storage system. Only if the governmental investment subsidies are taken into account and optimistic assumptions are made about future estimated electricity prices, could storage systems with capacities between 5 and 10 kWh be a viable option for consumers.
Avoided costs for end-use consumers	Incentivises manufacturers to pass on the technology/production-related cost reductions to the customers. Manufacturer must provide 10-year warranty for replacement of batteries (previously 7 years)
Co-benefits	Reduced pressure on grid by only allowing a maximum of 50% of installed capacity into the power grid. This has been reduced from 60% when the scheme started.
Impacts on specific stakeholders	Incentivises manufacturers to pass on the technology/production-related cost reductions to the customers. This outcome is different to the information that some suppliers provide to potential customers. For example, the calculations often include the full electricity price for self-consumption but neglect lost remunerations for fed-in electricity. This omission leads to too favourable economic results for additional storage capacity. Such simplified calculations and the frequently observed non-economic factors can explain how investors are misled when they consider the economic consequences of their decisions.

Key issues and changes	Little change since introduction - decreased the capacity of plant available to export to grid and battery guarantee time has increased. Finally, the battery price has a huge impact on the annuity of the system and can make the difference as to whether it is profitable or not. Assuming falling battery prices, some scenarios will become more profitable than others. However, if there is no focus on autarchy (self consumption), investing only in PV panels without installing a battery the most profitable investment in all considered scenarios. This could change if the BES is used more flexibly, e.g. by adding a heating pump or a smart charging wall box for EVs to the system. With an increasing use of storage, its value will increase potentially. However, the financial attractiveness of battery systems changes significantly if the feed-in tariffs exceed a critical value. For small households, this is the case at just under 0.40 €/kWh and for large households it is already the case at less than 0.20 €/kWh. With the historical feed-in tariffs of over 0.507 €/kWh, an investment in such a battery system would always make sense financially.
Overlaps with other policies	The combination of financing storage from the KfW Renewable Energy Program subsidised systems with other KfW or ERP programs is not possible
Main lessons learned	The scheme has not been regarded as successful. A review showed that only 5% of all installed home storage facilities in 2018 made use of the scheme, indicating that it did not provide adequate support for storage and self-consumption.
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	Ofgem. 2016. Electricity storage – Comparative Case studies. Available from: https://www.ofgem.gov.uk/ofgem-publications/101908

A1.1.4 Austria – Investment subsidies for small solar PV installations

Data point	Investment subsidies for small solar PV installations in Austria
Name of scheme	"Photovoltaic systems 2018" (Photovoltaik-Anlagen)
Year of implementation	2008
Year scheme ended	N/A
Main objective of the microgeneration support policy	By promoting photovoltaic systems up to a maximum of 5 kWp, the climate and energy fund wants to create attractive incentives for environmentally and climate-friendly electricity supply.

Type	Investment grant
Scope	Subsidies are granted for maximally 5 kWp of a PV installation (PV Subsidy Guidelines 2018). However, the installation's size is irrelevant for eligibility, except in the forestry and agriculture sector (maximum capacity allowed is 5 kWp under this scheme). Alternatively, also joint PV installations ('Gemeinschaftsanlagen') are eligible for subsidies, whereas the funds can be accessed for max. 5 kWp per capita and 30 kWp in total (PV Subsidy Guidelines 2018).
Historical background	By establishing the Climate Fund, the Austrian Federal Government created a strategically important tool designed to drive the transition from a central, fossil energy supply system towards a smart regional energy mix. At the end of May 2018, the Austrian Government approved the new Climate and Energy Strategy – "mission 2030" – for Austria. This included measures aimed at increasing the uptake of renewable technologies. Since 2018 there exists for the first time an official government target of 100% green electricity by 2030. Out of that, PV targets were derived leading to additional 12-15 GW PV (from currently 1.4 GW) until 2030. Note, a feed-in-tariff has also been in operation in Austria since 2012.
Description of regulatory landscape	Photovoltaic systems must be grid-connected. Eligible investment costs include: • PV modules • Inverters • Elevations, tracking systems(both single and biaxial) • installation, assembly, cable connections, Control cabinet conversion • Lightning protection, data logger• necessary conversion of the meter box • Planning (to a maximum of 10% of the recognizable net investment costs)
Description of mechanism	PV installations under 5kWp in private households and commercial buildings are eligible for investment subsidies from the Austrian Climate and Energy Fund. The subsidies support max. 5 kWp of a PV system, whereas double funding is not possible. The promotion budget – annually announced in spring – is only granted for new projects and can be claimed by private individuals, companies, associations and confessional facilities. Since 2015, private individuals can build a PV system conjointly by accessing the funds for max. 5 kWp per capita and 30 kWp in total. Furthermore, it is also possible to apply for the funding more than once if the applicant aims to build another unit at a different site.
Installation capacity limit	5kWp
Implementing agency	Kommunalkredit Public Consulting GmbH
Funding mechanism	Funding provided by Austrian Climate and Energy Fund (Klima- und Energiefonds) For single installations • € 275 per kWp for roof-top or ground-mounted installations for maximally 5 kWp. • € 375 per kWp for building integrated installations for maximally 5 kWp (PV Subsidy Guidelines 2018). For joint PV installations • € 200 per kWp for roof-top or ground-mounted installations for maximally 5 kWp per applicant (but not more than 30 kWp in total) • € 300 per kWp for building integrated installations for maximally 5 kWp per applicant (but not more than 30 kWp in total, PV Subsidy Guidelines 2018) The overall budget amounts up to € 4.5 million for 2018 and was increased by another € 360,000 in June 2018 (PV Subsidy Guidelines 2018).
Policy outcomes	This support has led to about 3 600 new PV systems with a total capacity of 20.2 MWp in 2018.
Overall size of support provided	4.5 million-10million
Units	€/yr

Explanation	2018: The overall budget amounts up to € 4.5 million for 2018 and was increased by another € 360,000 in June 2018 2020: budget doubled to 10 million EUR
Uptake per technology and sector	PV-only (3,600 new systems, with a total capacity of 20.2 MWp up to 2018) Subsidies were different for free-standing systems / rooftop systems and for building-integrated systems
Emission reductions estimated	Not available
Units	N/A
Explanation	Figure has not been estimated. Capacity of 20.2 MWp installed under scheme.
Cost-effectiveness of policy overall for government	Medium- although the prices for PV have decreased, investment in PV systems in Austria is still a subject of subsidisation. Currently, around 98% of all installed PV systems in Austria are subject to some kind of public co-funding. A recent paper suggests that significant inefficiencies occur as a result of incentives to install relatively small PV systems. (Hartner M, Mayr D, Kollmann A, et al. (2017) Optimal sizing of residential PV-systems from a household and social cost perspective. Sol Energ 141: 49–58.) They argue that deployment of larger PV systems in the residential sector would allow costs to be decreased. For instance, they model that an increase of minimum system sizes to 10 kWp would reduce the total investment costs by 10%.
Costs to end-use consumer / impact on electricity prices	Minimal impact on electricity prices. Indirect costs to consumers.
Avoided costs for end-use consumers	Reduction in capital costs for energy consumers developing the system
Co-benefits	None identified
Impacts on specific stakeholders	beneficial for small-scale solar installers. PV-specific subsidy.
Key issues and changes	Scheme has seemingly changed little since its introduction. Size of funding has increased over time.
Overlaps with other policies	This additional support scheme is well-co-ordinated with the feed-in-tariff scheme Also "Photovoltaic and storage systems in agriculture and forestry" (Promotion of photovoltaic systems in agriculture and forestry in the size of 5 kW to 50 kW and electricity storage systems up to 3 kWh / kW)
Main lessons learned	The scheme distinguishes its level of support by type of system, e.g. free-standing, rooftop and for building-integrated systems, which it is believed has impacted positively on its effectiveness and uptake rate. In addition, the scheme is believed to work in a complementary manner to the existing FiT scheme in Austria, thereby making both policies more effective in incentivising renewable energy deployment.
Key Sources	Klima Energie Fonds. 2019. Leitfaden Photovoltaik-Anlagen in der Land- und Forstwirtschaft. Available from: https://www.klimafonds.gv.at/wp-

	content/uploads/sites/6/Leitfaden-PV-in-LW-FW-2018-1.pdf
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	Fechner, H. 2018. PVPS. National Survey Report of PV Power Applications in Austria. Available from: https://iea-pvps.org/wp-content/uploads/2020/01/NSR_Austria_2018.pdf

A1.1.5 Denmark – Premium tariff

Data point	Denmark: Premium tariff (Law on the Promotion of Renewable Energy)
Name of scheme	Law on the Promotion of Renewable Energy
Year of implementation	2014
Year scheme ended	N/A
Main objective of the microgeneration support policy	Plant operators receive a variable bonus on top of the market price (technology/capacity dependent). The sum of the bonus and market price shall not exceed a certain statutory maximum, which depends on the date of the connection of given plant/source of energy used. In some cases, plant operators are granted a guaranteed bonus on top of market price, negating the statutory maximum. This is known as a **'sliding premium'**
Type	Feed-in premium
Scope	Eligibility: Solar = Non-commercial RES systems <6 kW Wind = capacities of up to 10kW and >10kW - 25kW that generate for the operators own use Hydro = capacity of up to 6kW (or over 6kW, although not considered for study)
Historical background	In recent years, Denmark has gained considerable international attention as one of the first movers in implementing a green energy transition – the so-called grøn omstilling. In order to achieve an energy system independent from fossil fuels by 2050, Denmark is pursuing an integrated policy approach that takes all energy sectors into account. Denmark use a combination of FiT and premium tariffs. However, PV support schemes are much less favourable in Denmark than they traditionally have been in Germany and elsewhere in Europe.
Description of regulatory landscape	Renewable energy is given priority with access to the grid.
Description of mechanism	**Solar**: Installations with an installed capacity of max. **6 kW per household and connected to self-consumption** installation: maximum subsidy (bonus plus market price) of 1.30 DKK (approx. €ct 17) per kWh, applicable for 10 years after the grid connection. For plants connected on or after 01.01.2014 the bonus will be reduced annually by 0.14 DKK (€ct 2) (§47 par. 7 No. 1 VE-Lov). The maximum subsidy in 2018 is 0.60 DKK/kWh (approx. €ct 8) and in 2019 0.46 DKK/kWh (approx. €ct 6). **Wind:** For plants with total installed capacity **up to 10 kW**: 2.12 DKK/kWh (approx. €ct 28) for 12 years from the date of grid connection of the plant (§ 41 par. 4 no. 1 VE Lov). The plant has to be connected to the grid no more than 2 years after grant of the aid (§ 41 par. 5 VE Lov). For plants with total installed capacity **> 10 kW and up to 25 kW**: 1.32 DKK/kWh

	(approx. €ct 18) for 12 years from the date of grid connection of the plant (§ 41 par. 4 no. 2 VE Lov). The plant has to be connected to the grid no more than 2 years after grant of the aid (§ 41 par. 5 VE Lov). **Hydro:** with an installed capacity of **up to 6 kW**: maximum subsidy (bonus plus market price) of 1.30 DKK (approx. €ct 17) per kWh, applicable for 10 years after the grid connection. For plants connected on or after 01.01.2014 the bonus will be reduced annually by 0.14 DKK (€ct 2) until 01.01.2018 (§ 47 par. 9 No. 1 VE-Lov). The maximum subsidy in 2018 is 0.60 DKK/kWh (approx. €ct 8). ***note that there is a tariff for more than 6kW but has no defined upper boundary**
Installation capacity limit	Variable per technology as indicated above.
Implementing agency	Ministry of Energy, Utilities and Climate
Funding mechanism	Fixed or sliding payment to generator for every unit of power generated. Fixed tariff = tariff determined through a tendering procedure more in line with market conditions whereas as sliding premium tariff is reduced when electricity price exceeds a certain threshold - reduces cost to grid. The Premium tariffs or feed-in Premiums (FIPs) is a system of support for RES-E that establishes a premium on the existing market electricity price. Thus, it generates two sources of income for the producers: one with the sale of energy in the electrical market and the other with the receipt of the premium. In a similar way to the FITs, the premium differs based on the criteria applied in each country (energy source or technology used, size of the plant, electricity generation costs, etc). The FIPs can be classified as fixed or sliding premiums. In fixed premiums, applied in the case of biogas by Denmark, Italy and Slovenia, a constant amount is added to the existing market price. However, in the case of elevated prices in the market, this model can grant an excess of income with the supplement of the premium. In the same way, the possible fall of the prices does not assure minimum income to the producers, which could drive away potential investors. For that reason, some countries resort to the system of sliding premiums with the intention of controlling how price fluctuations fix the limits of the premium. In the case of biogas, this modality is applied by Germany, Finland and the Netherlands, which apply a variant called the “spot market gap model” consisting of guaranteeing a minimum level of payment, granting a premium equal to the difference between a fixed minimum payment and the price of the electricity. In the case that the market electricity price is higher than the guaranteed minimum, the premium is zero, with the producer receiving only the market price. Denmark uses a combination of fixed and sliding premiums for RES-E. A maximum remuneration level (electricity price plus fixed premium) is defined for most technologies to avoid windfall profits. For offshore wind, the premium level is defined via a tender process
Policy outcomes	Feed-in premiums with a cap to regulate the support for onshore wind power. Central and long-term planning has ensured timely and relevant investments in the power grid and system. Thus the grid and system have been developed incrementally in order to handle the steady increase in fluctuating renewable energy production.
Overall size of support provided	N/A
Units	N/A
Explanation	N/A
Uptake per	After an initial boom in residential PV installation, in 2012/13 the change in the net metering conditions practically eliminated this market, but common PV installations on

technology and sector	the rooftops of apartment blocks and commercial buildings have continued to attract investment up to the 20 MW annual limit.
Emission reductions estimated	Not available
Units	N/A
Explanation	N/A
Cost-effectiveness of policy overall for government	Medium - e.g. payments guaranteed for 10 years for solar, 12 years for wind, although premiums decrease over time
Costs to end-use consumer / impact on electricity prices	The conditions were made more favourable because annual net metering was allowed. This means that for an average household, the annual electricity bill, excluding subscription, could be covered by the annual generation of the installation itself. As electricity taxes are very high, in total the average support level was around 25 ct/kWh. Additionally, there were favourable tax conditions over and above this. Subsequently, the rules were changed to an hour-by-hour net metering scheme and the favourable tax conditions were reduced. This practically removed the incentive for installations in average types of household.
Avoided costs for end-use consumers	All subsidy costs are passed on to consumers as an equal Public Service Obligation.
Co-benefits	Caps and floors can also be introduced on the total allowable payment amount. This provides flexibility within a range of electricity price variability, and limits windfall profits while protecting RE developers against unanticipated drops in spot market prices.
Impacts on specific stakeholders	Allows an income with the sliding premium - fixed premiums don't offer assurance on income if market price is falls.
Key issues and changes	For a short time in 2003 and 2004, Denmark used a cap on the total payment amount for onshore wind. A premium was offered to plants that were connected to the grid after December 31, 2002, which decreased based on market price so that the sum of the market price and the premium did not exceed €0.0483/kWh. This made the policy effectively a sliding premium policy with a cap on the total allowable payment amount. In 2005, this cap was abolished and the policy reverted to a premium structure in which operators received a constant premium of €0.0134/kWh.
Overlaps with other policies	N/A
Main lessons learned	After the phase out of the net metering scheme, the premium tariff has been more successful for larger installations for the commercial and public sector building sectors than for domestic dwellings.
Key Sources	RES – Legal. Premium Tariff Law on the Promotion of Renewable Energy. Available from: http://www.res-legal.eu/search-by-country /denmark/single/s/res-e/t/promotioN/Aid/premium-tariff-law-on-the-promotion-of-renewable-energy/lastp/96/
	Energy Industry Challenges. Available from: http://www.i15.p.lodz.pl/strony/EIC/res/Denmark.html
	Elfeky, A. 2015. The effects of the renewable energy policies in the EU on investment: an empirical

	analysis. Available from: https://www.researchgate.net/publication/286042013_The_Effects_of_the_Renewable_Energy_Policies_in_the_EU_on_Investment_an_Empirical_Analysis
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	Danish Energy Agency. 2017. Memo on the Danish support scheme for electricity generation based on renewables and other environmentally benign electricity production. Available from: https://ens.dk/sites/ens.dk/files/contents/service/file/memo_on_the_danish_support_scheme_for_electricity_generation_based_on_re.pdf
	Agora Energiewende. 2015. A snapshot of the Danish Energy Transition. Available from: https://www.agora-energiewende.de/fileadmin2/Projekte/2015/integration-variabler-erneuerbarer-energien-daenemark/Agora_Snapshot_of_the_Danish_Energy_Transition_WEB.pdf

A1.1.6 Northern Ireland – Micro-Renewable Obligations

Data point	Northern Ireland Renewables Obligation
Name of scheme	Microgenerators in Northern Ireland (Micro-NIRO)
Year of implementation	2005
Year scheme ended	2017
Main objective of the microgeneration support policy	The Northern Ireland Renewables Obligation (NIRO) is an environmental scheme to encourage the use of renewable electricity in Northern Ireland. The micro-NIRO scheme is specifically aimed at encouraging microgeneration.
Type	Obligation scheme
Scope	To be eligible, stations must: - generate electricity from a renewable source (Solar photo-voltaic (PV), wind, hydro or fuelled) - have a declared net capacity (DNC) below 50kW (to be a Micro-generator) - be accurately measured by an NMO/MID approved meter - have a valid MCS Certificate.
Historical background	The Renewables Obligation (RO) is one of the main support mechanisms for large-scale renewable electricity projects in the UK. Smaller scale generation is supported through the Feed-In Tariffs (FIT scheme) in Great Britain but not Northern Ireland. The legislation under which the tariff was introduced was the Energy Act 2008, which applies to Great Britain but not to Northern Ireland. In Northern Ireland, energy policies are a devolved power, so the decisions about schemes, policies and incentives come from Stormont rather than Westminster.
Description of regulatory landscape	When a business or householder starts generating their own energy, they are issued with ROCs based on the technology they are using and the amount of energy they produce. These ROCs are tradable and are of value to the energy suppliers, meaning they can be sold for additional income. Altogether this mechanism makes up the NIRO scheme.
Description of mechanism	Ofgem provide Northern Ireland Renewables Obligation Certificates (NIROCs) for eligible generation from an accredited station. NIROCs can be traded with third parties, or sold to electricity suppliers directly, who use them to meet their Renewables Obligation.
Installation capacity limit	50 kW
Implementing agency	Ofgem
Funding mechanism	The NIRO is set independently of the wholesale electricity price, and unlike a support mechanism such as a FIT, which takes revenue volatility away from the investor and converts two uncertain revenue streams (the wholesale electricity and the subsidy price) into one fixed revenue stream, the NIRO exposes investors

	in renewable generation to volatility in Single Electricity Market prices. NIROCs can be traded with third parties, or sold to electricity suppliers directly, who use them to meet their Renewables Obligation. Where energy suppliers do not present a sufficient number of ROCs to meet their obligation in the reporting period (one year), they must pay an equivalent amount into a buy-out fund. The administration cost of the scheme is recovered from the fund and the rest is distributed back to suppliers in proportion to the number of ROCs they produced in meeting their individual obligation.
Policy outcomes	Boosted renewable energy generation in NI from 4 per cent in 2005 to 14 per cent in 2012. 22,665 micro NIRO stations accredited under the RO - 85.8% of the total-combined capacity of 120.7MW.
Overall size of support provided	N/A
Units	N/A
Explanation	Expected to only cover administrative costs
Uptake per technology and sector	Majority of stations accredited were solar PV, just under 98% were small solar photovoltaic (PV) stations installed on domestic properties in 2016-17.
Emission reductions estimated	Not available
Units	N/A
Explanation	Figure has not been estimated. Capacity of 120.7MW installed under scheme.
Cost-effectiveness of policy overall for government	Cost-effective- the cost of the NIRO is passed on to consumers by suppliers:
Costs to end-use consumer / impact on electricity prices	The cost of the NIRO is passed on to consumers by suppliers: it does not involve DfE paying grant assistance but instead provides a revenue support based on the amount of electricity generated. A number of government consultations on the RO have, in the past, suggested that for certain types of investor in renewable generation, in particular very small-scale commercial and domestic investors, there exist a number of administrative barriers under the RO which may act as a deterrent to investment. The uncertainty resulting from fluctuation in the value of ROCs can also have a detrimental effect on incentives to invest. The NIRO (and therefore subsidising renewable electricity generation in NI) was projected to cost NI electricity consumers around £65m annually by 2020.
Avoided costs for end-use consumers	The cost of the NIRO is passed on to consumers by suppliers.
Co-benefits	None identified
Impacts on specific stakeholders	The Micro-NIRO helped rooftop solar PV become one of the most prominent forms of microgeneration, leading to an installed capacity of around 100 MW in Northern Ireland.
Key issues and changes	A number of government consultations on the RO have, in the past, suggested that for certain types of investor in renewable generation, in particular very small-scale commercial and domestic investors, there exist a number of administrative barriers under the RO which may act as a deterrent to investment. The uncertainty resulting from fluctuation in the value of ROCs can also have a detrimental effect on incentives to invest. The fact that the cost of the NIRO was passed on to consumers by suppliers also remained an issue throughout the period it was effective.
Overlaps with	The Northern Ireland Renewables Obligation (NIRO) has been the main support

other policies	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 generators under the Obligations.
Main lessons learned	The market-type mechanism poses barriers for smaller entities to make use of the offerings of the scheme as it increases the administrative burden; and increases uncertainty regarding return on investment. In addition, the scheme can also be costly to consumers as all costs are passed through.
Key Sources	Ofgem. 2017. Northern Ireland Renewables Obligation. Available from: https://www.ofgem.gov.uk/system/files/docs/2017/02/applying_under_the_northern_ireland_renewables_obligation_niro_-_a_step-by-step_guide_feb_2017.pdf
	Ofgem. 2017. Microgenerators in Northern Ireland. Available from: https://www.ofgem.gov.uk/environmental-programmes/ro/applicants/microgenerators-northern-ireland-micro-niro
	The Department for Enterprise, Trade and Investment and Northern Ireland Authority for Utility Regulation. 2010. Cambridge Economic Policy Associates Ltd in association with Parsons Brinkerhoff . Available from: https://www.uregni.gov.uk/sites/uregni.gov.uk/files/media-files/CEPA_PB_Incentivising_Renewable_Electricity_Generation_in_NI_Final_Report__Volume_A__13_08_10.pdf
	Ofgem. 2019. Renewables Obligation. Annual report. Available from: https://www.ofgem.gov.uk/system/files/docs/2019/03/ro_annual_report_2017-18_final.pdf

A1.2 Assessment of international case studies

A1.2.1 Assessment grid

Assessment grid				
Assessment criteria	**Description**	**Low score (0-1)**	**Medium score (2-3)**	**High score (4-5)**
Eligibility criteria are applicable to Ireland	The technology scope is aligned with Irish objectives to target micro-solar mainly, supported by micro-wind, micro-CHP and micro-hydro.	Micro-solar is not included or only to a limited extent.	Micro-solar is included, but the other technology types are not.	The technology scope focuses mostly on micro-solar with also inclusion of micro-wind, micro-CHP and micro-hydro.
	The size threshold is aligned with Irish objectives of <50kW.	The size threshold is above 50kW.	The size threshold is 30kW or lower as per the RED II.	The size threshold is up to 50 kW.
	The sectoral scope is aligned with Irish objectives to cover domestic, SMEs, farming, social enterprise and public buildings.	Only one of the sectors of interest for Ireland is covered by the policy.	Only two sectors of interest for Ireland is covered.	More than two sectors of interest for Ireland are covered
	Eligibility criteria include energy efficiency principles.	No reference to energy efficiency principles in elgibility criteria.	Reference to energy efficiency principles in eligibility criteria, but no documentation required or it only applies to certain sectors.	Eligibility criteria include strict requirements for energy efficiency certificates (e.g. EPC) for all sectors.
Effectiveness	Effectiveness at promoting microgeneration in terms of installed capacity realised (MW) or electricity generated (MWh) (per year)	Installed capacity below 0.01% of country's electricity generation capacity per year, when possible to calculate	Installed capacity between 0.01% and 0.5% of country's electricity generation capacity per year, when possible to calculate	Installed capacity above 0.5% of country's electricity generation capacity per year, when possible to calculate
	Effectiveness at promoting self-consumption in terms of % of generated energy through scheme (per year)	No specific effectiveness related to self-consumption measured.	Intention or realised self-consumption up to 75%	Intention or realised self-consumption of 75% or higher.
	If relevant, effectiveness in terms of meeting pre-determined target	Target has only been met up to 80%.	Target achievement is between 80 to 100%	Target has been over-achieved.

Efficiency	Cost to public sector in terms of overall costs of scheme per year	Costs to public sector are high (over EUR 1,000 per kWp installed, when possible to calculate)	Costs are moderate (ranging from EUR 100 to EUR 1,000 per kWp installed, when possible to calculate)	Administrative costs only or below EUR 100 per kWp installed, when possible to calculate)
	Cost to consumer	All costs added to electricity bill and are over EUR 1 per person per year of project (when possible to calculate)	Costs to consumers in electricity bill or other charge below EUR 1 per person per year of project (when possible to calculate)	No additional costs to consumers observed or expected.
Feasibility	Complexity of implementation in terms of institutional capacity and administrative costs required	High complexity expected to implement policy, either because new institutional capacity is required or high administrative costs.	Medium complexity expected to implement policy and medium adminsitrative costs due to documentation required or changes in policy.	Low administrative costs expected with little or no changes required in policy over the lifetime and therefore low institutional capacity required.
Equity	Provisions for lower income and fuel-poor households	No elements are included in the policy that promote participation of different sectors/generators.	Some elements are included to increase the diversity of beneficiaries of the policy.	Benefits of policy are linked to income levels.

A1.2.2 Assessment scores – Table 1

Assessment criteria	Description	UK - Feed-in-tariff		UK - Smart Export Guarantee		Germany - Subsidy scheme for solar PV and storage		
		Value	Score	Value	Score	Value	Score	Weighting
Eligibility criteria are applicable to Ireland	The technology scope is aligned with Irish objectives to target micro-solar mainly, supported by micro-wind, micro-CHP and micro-hydro.	The technologies covered by this policy were hydro, anaerobic digestion, wind and solar PV. In addition, a pilot scheme for micro-CHP was also added under this policy. 99% of installations accredited under the FIT scheme are solar, or 80% capacity. By capacity: wind is 12%, hydro is 3%, AD is 5% and mCHP is 0.01%	5	The technology scope of the SEG targets anaerobic digestion, hydro, micro-combined heat and power onshore wind, and solar photovoltaic exporters.	5	Only applicable to solar PV in combination with storage. Subsidy applicable to cost of battery only.	3	40%
	The size threshold is aligned with Irish	Under this policy, producers of small-scale renewable electricity	2	The electricity capacity threshold for micro-CHP is up to 50kW, for	2	Battery storage limit is 30 kW.	4	10%

	objectives of <50kW.	(under 5MW) can receive a feed-in-tariff for 10 to 25 years for the electricity that is fed back into the grid.		all other technologies it is up to 5MW.				
	The sectoral scope is aligned with Irish objectives to cover domestic, SMEs, farming, social enterprise and public buildings.	All sectors are covered. Different tariff bands for each technology meant that smaller installations received significantly more per kWh of electricity generated than larger installations, in recognition of the greater proportional cost of installation. Initially, most installations were domestic but, from the end of Year 6 there was a sharp decline in the amount of new domestic capacity registered, possibility as a result of changes to degression mechanisms which reduce generation tariff rates, while the proportion of new commercial capacity increased. The increase in commercial and industrial installations during scheme, likely to be the result of commercial property owners becoming more aware of the long-term investment opportunities of FITs. Farming: the growth in smaller anaerobic digestion installations (smallest tariff band <=250kW) compared to larger waste-fed plants is attributed by Ofgem to the increasing awareness among commercial property owners (farmers) of the long-term benefits of the FIT. The FIT was also considered to be favourable for community generatoin projects due to the certainty it provided.	**5**	All sectors are covered. The SEG is likely to be of interest primarily to domestic scale solar projects. For community-led projects, the government acknowledge that the SEG "may not necessarily offer the same degree of both predictable and long-term income needed that was available under the FIT scheme."	**4**	The policy applies to domestic/foreign commercial companies, companies in which municipalities, churches, charitable organisations participate, freelancers, farmers, people and non-profit applicants who have a PV system.	**4**	40%
	Eligibility criteria include energy efficiency principles.	For solar PV, applicants must demonstrate that the building that the solar PV is wired to provide electricity has achieved an Energy Performance Certificate (EPC) rating of level D or above to receive the higher tariff. Exemptions apply	**4**	No requirements known.	**0**	No requirements known.	**0**	10%

		for public sector buildings and schools.						
		Average applicability score:	**4.60**	**Average applicability score:**	**3.80**	**Average applicability score:**	**3.20**	**20%**
Effectiveness	Effectiveness at promoting microgeneration in terms of installed capacity realised (MW) or electricity generated (MWh) (per year)	The scheme has supported the installation of over 6.6GW of UK generation capacity and has supported the installation of over 850,000 installations. This is equivalent to **7.8%** of UK's electricity capacity (based on 85 GW total capacity in 2014) or **0.9% per year**	**5**	The SEG impact assessment predicts it will deliver 12.5 MW per year until 2026. This is equivalent to **0.09%** of UK's electricity capacity (based on 85 GW total capacity in 2014) or **0.015% per year**	**2**	The initial round of the battery program (2013-16) saw some 19,000 systems installed, according to BMWi figures, resulting in an investment by consumers of some EUR 450 million. However, the monitoring of the support programme showed that out of the 40 000 home storage facilities newly built in 2018, only 5 % used this support programme. No info found regarding installed capacity so percentages could not be calculated.	**2**	40%
	Effectiveness at promoting self-consumption in terms of % of generated energy through scheme (per year)	No data on actual self-consumption rates. The scheme assumes that generators export 50% of the electricity they produce and are paid for it-even when the electricity is not needed by the grid or they export less than 50%.	**3**	No data available yet.	**N/A**	Expected that the majority of electricity generated will be self-consumed within household. A co-benefit of the scheme is reduced pressure on grid by only allowing a maximum of 50% of installed capacity into the power grid. Previously this was 60%.	**3**	40%
	If relevant, effectiveness in terms of meeting pre-determined target	The scheme has supported the installation of over 850,000 installations—far more than the 750,000 installations by 2020 expected in the original impact assessment.	**5**	No data available yet.	**N/A**	No target known.	**N/A**	20%
		Average effectiveness score:	**4.20**	**Average effectiveness score:**	**2.00**	**Average effectiveness score:**	**2.5**	**25%**
Efficiency	Cost to public sector in terms of overall costs of scheme per year	Expected cost of £30 billion, including expected payments after the end of the scheme. Equivalent to £4,545 / kWp	**0**	Overall costs are expected to include administrative costs only, so low overall.	**5**	Overall costs estimated to be 60 million EUR between 2013 and 2016 and 30 million EUR thereafter.	**4**	50%

		installed, or **EUR 5,275 / kWp** installed (1.1607 EUR/GBP exchange rate for March 31, 2019)				Cost per capacity installed could not be calculated as scheme is for battery systems only.		
	Cost to consumer	The scheme was considered to be costly for consumers with generation payments rising year-on-year. Overall cost is EUR 570 / person or **EUR 64 / person / year of project** (using total population = 61.1 million)	**1**	The overall impact on consumer bills is uncertain however there is not expected to be a direct impact on consumer bills from the introduction of the SEG. As suppliers under the SEG set their own tariff for exported electricity, tariffs can be set so that net costs to suppliers are avoided. The SEG is therefore unlikely to carry any policy costs which are typically paid for by final consumers.	**4**	Direct reduction of consumer bills due to offset electricity. Uncertain on specific impact although offset of peak electricity demand from grid at peak times could be offset to the customer. Cost between 2013 and 2018 of **EUR 0.09 / person / year of project** (using total population = 82.2 million)	**3**	50%
		Average efficiency score:	**0.50**	**Average efficiency score:**	**4.50**	**Average efficiency score:**	**3.50**	**15%**
Feasibility	Complexity of implementation in terms of institutional capacity and administrative costs required	Tariffs have changed over the course of the policy. FIT payments are made quarterly (at least) for the electricity generated and exported. Payments are made based on the meter reading submitted to the FIT licensee.	**1**	The scheme administrator will face some administration costs although these are expected to be significantly less than the costs of administering the FITs scheme, given the light touch nature of the Authority's role, in line with the market based approach of SEG.	**4**	Studies indicate relatively low administrative costs	**3**	**25%**
Equity	Provisions for lower income and fuel-poor households	No specific elements regarding equal access.	**0**	No specific elements regarding equal access.	**0**	No specific elements regarding equal access.	**0**	**15%**
		Overall average:	**2.30**	**Overall average:**	**2.94**	**Overall average:**	**2.54**	
		Rank	**6**	**Rank**	**1**	**Rank**	**4**	

A1.2.3 Assessment scores – Table 2

Assessment criteria	**Description**	**Austria - Investment subsidies for small solar systems**		**Denmark - Premium Tariff**		**Northern Ireland - Micro-Renewable Obligations**		**France - Investment bonus for solar PV**		
		Value	**Score**	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**	**Weighting**
Eligibility	The	Only applicable to solar	**3**	The	**4**	The technology scope consists of solar-PV,	**4**	The	**3**	40%

criteria are applicable to Ireland	technology scope is aligned with Irish objectives to target micro-solar mainly, supported by micro-wind, micro-CHP and micro-hydro.	PV.		technology scope includes micro-solar, micro-wind, micro-hydro.		micro-wind, micro-hydro or fuelled. The majority of stations accredited were solar PV, just under 98% were small solar photovoltaic (PV) stations installed on domestic properties in 2016-17.		technology scope is solar PV only.		
	The size threshold is aligned with Irish objectives of <50kW.	Subsidies are granted for maximally 5 kWp of a PV installation. However, the installation's size is irrelevant for eligibility, except in the forestry and agriculture sector (maximum capacity allowed is 5 kWp under this scheme). Alternatively, also joint PV installations ('Gemeinschaftsanlagen') are eligible for subsidies, whereas the funds can be accessed for max. 5 kWp per capita and 30 kWp in total (PV Subsidy Guidelines 2018).	**3**	Eligibility: Solar = Non-commercial RES systems <6 kW Wind = capacities of up to 10kW and >10kW - 25kW that generate for the operators own use Hydro = capacity of up to 6kW (or over 6kW, although not considered for study)	**4**	Eligible stations must have a declared net capacity below 50kW.	**5**	The installation must have a power less than or equal to 100 kWp. However, for the tax credit component the eligible plant shall not exceed 3 kWp.	**4**	10%
	The sectoral scope is aligned with Irish objectives to cover domestic, SMEs, farming, social enterprise and public buildings.	Policy applies to all sectors, with size thresholds for forestry and agriculture sectors. The additional offer for the agricultural sector was that systems from 5 kWp to 50 kWp, owned by farmers, obtained the same incentive per kWp (275/375 EUR) as other private owners,	**5**	All sectors are covered. After an initial boom in residential PV installation, in 2012/13 a change in the net metering conditions practically	**5**	All sectors are covered. Biomass and anaerobic digestion specifically considered as agriculture makes a significant contribution to the NI economy. As such the potential to develop technologies which create energy from agricultural bi-products is likely to be beneficial.	**5**	Tax credits are targeted at domestic installations mainly.	**3**	40%

		which might have led to approx. 4,3 MWp installed in 2018.		eliminated this market, but common PV installations on the rooftops of apartment blocks and commercial buildings have continued to attract investment up to the 20 MW annual limit.						
	Eligibility criteria include energy efficiency principles.	No requirements known.	**0**	No requirements known.	**0**	No requirements known.	**0**	The solar PV panels must be installed mainly for self-consumption.	**3**	10%
		Average applicability score:	**3.50**	**Average applicability score:**	**4.00**	**Average applicability score:**	**4.10**	**Average applicability score:**	**3.10**	**20%**
Effectiveness	Effectiveness at promoting microgeneration in terms of installed capacity realised (MW) or electricity generated (MWh) (per year)	A value for total installed capcity could not be obtained. However, the scheme led to about 3 600 new PV systems with a total capacity of 20.2 MWp in 2018 alone. This is equivalent to **0.09% per year** (based on 22.98 GW total capacity in 2012)	**3**	Assuming 20 MW per year solar installed under scheme (2013-2017). This is equivalent to **0.71%** of Denmark's electricity capacity (based on 14.05 GW total capacity in 2012) or **0.14% per year**	**3**	The Micro-NIRO helped rooftop solar PV become one of the most prominent forms of microgeneration, leading to an installed capacity of around ~4000 GW in Northern Ireland. 22,665 micro NIRO stations were accredited under the RO - 85.8% of the total- combined capacity of 120.7 MW (between 2005 and 2017)= 103.6 MW. This is equivalent to **2.6%** of Northern Ireland's electricity capacity (based on 4.04 GW capacity in Northern Ireland- from data in http://www.soni.ltd.uk/media/documents/EirGrid-Group-All-Island-Generation-Capacity-Statement-2019-2028.pdf) or **0.2% per year**	**3**	No data available.	**N/A**	40%

	Effectiveness at promoting self-consumption in terms of % of generated energy through scheme (per year)	No data available.	**N/A**	Incentives are given to promote self-generation by offering a maximum price	**2**	No data available.	**N/A**	Based on survey analysis it was estimated that about a third of participants use all electricity from self-consumption, while 85% of participants are still connected to the grid.	**2**	40%
	If relevant, effectiveness in terms of meeting pre-determined target	No target known.	**N/A**	Targets were achieved by 2010.	**3**	No known target for microgeneration.	**N/A**	No known target for this policy.	**N/A**	20%
		Average effectiveness score:	**3.00**	**Average effectiveness score:**	**2.60**	**Average effectiveness score:**	**3**	**Average effectiveness score:**	**2**	**25%**
Efficiency	Cost to public sector in terms of overall costs of scheme per year	In 2018, the overall budget amounted to € 4.5 million for the year, which was increased by another € 360,000 in June 2018 In 2020, the budget doubled to 10 million EUR. Taking 2018 as a represntative year, cost to public sector was **EUR 241 / kWp** installed	**3**	No data available	**N/A**	Expected to be low, as it is mainly administrative costs.	**3**	No data available	**N/A**	50%
	Cost to consumer	Minimal impact on electricity prices. Indirect costs to consumers. Cost in 2018 of	**3**	Costs are borne by the consumer although FiP offers a good	**2**	Expected to be low. In total NIRO (including large-scale renewable electricity generation in NI) was projected to cost NI electricity consumers around £65m annually by 2020 but it was	**3**	No data available.	**N/A**	50%

		EUR 0.05 / person / year of project (using total population = 8.86 million)		'sliding' rate as well as encouraging self generation to offset market cost of electricity		not possible to isolate micro-NIRO costs from this figure.				
		Average efficiency score:	**3.00**	**Average efficiency score:**	**2.00**	**Average efficiency score:**	**3.00**	**Average efficiency score:**	**0.00**	**15%**
Feasibility	Complexity of implementation in terms of institutional capacity and administrative costs required	Relatively low administrative costs to operate scheme. The scheme has not changed since its introduction.	**3**	Studies indicate relatively low administrative costs. However, policy has been adjusted over time.	**2**	Studies indicate relatively low administrative costs although certification system has fairly high administrative complexity.	**2**	No data available.	**N/A**	**25%**
Equity	Provisions for lower income and fuel-poor households	No specific elements regarding equal access.	**0**	This subsidy within the annual pool of 20 MW can be granted household PV installations as well as commonly owned PV installations.	**2**	No specific elements regarding equal access.	**0**	Persons that install renewable energy plants at their principal residence may deduce 30 % of the net hardware costs from income tax	**3**	**15%**
		Overall average:	**2.65**	**Overall average:**	**2.55**	**Overall average:**	**2.52**	**Overall average:**	**2.09**	
		Rank	**2**	**Rank**	**3**	**Rank**	**5**	**Rank**	**7**	

A1.2.4 Summary – assessment scores

Case study	Average applicability score	Average effectiveness score	Average efficiency score	Feasibility	Equity

UK - Feed-in-tariff	4.60	4.20	0.50	1.00	0.00
UK - Smart Export Guarantee	3.80	2.00	4.50	4.00	0.00
Germany - Subsidy scheme for solar PV and storage	3.20	2.50	3.50	3.00	0.00
Austria - Investment subsidies for small solar systems	3.50	3.00	3.00	3.00	0.00
Denmark - Premium Tariff	4.00	2.60	2.00	2.00	2.00
Northern Ireland - Micro-Renewable Obligations	4.10	3.00	3.00	2.00	0.00
France - Investment bonus for solar PV	3.10	2.00	0.00	N/A	3.00

Summary- weighted averages

Case study	Average applicability score	Average effectiveness score	Average efficiency score	Feasibility	Equity	Overall averages
UK - Feed-in-tariff	0.92	1.05	0.08	0.25	0.00	2.30
UK - Smart Export Guarantee	0.76	0.50	0.68	1.00	0.00	2.94
Germany - Subsidy scheme for solar PV and storage	0.64	0.63	0.53	0.75	0.00	2.54
Austria - Investment subsidies for small solar systems	0.70	0.75	0.45	0.75	0.00	2.65
Denmark - Premium Tariff	0.80	0.65	0.30	0.50	0.30	2.55
Northern Ireland - Micro-Renewable Obligations	0.82	0.75	0.45	0.50	0.00	2.52
France - Investment bonus for solar PV	0.83	0.67	0.00	#VALUE!	0.60	2.09

A1.3 Technology cost and capacity banding data

A1.3.1 Sector analysis

Table 7-1 - Suitability of solar PV by sector

Sector	Electricity load	Installation requirements	O&M requirements
Domestic	Medium	High	High
SME (commercial)	High	High	High
SME (industrial)	High	High	High
Agriculture	High	High	High
Community/social enterprises	High	High	High
Citizen energy communities	High	High	High
Public buildings (local authorities)	High	High	High
Public buildings (schools)	High	High	High

Table 7-2 - Suitability of micro-wind by sector

Sector	Electricity load	Installation requirements	O&M requirements
Domestic	High	Low	High
SME (commercial)	High	Medium	High
SME (industrial)	High	Medium	High
Agriculture	High	Medium	High
Community/social enterprises	High	Medium	High
Citizen energy communities	High	Medium	High
Public buildings (local authorities)	High	Medium	High
Public buildings (schools)	High	Medium	High

Table 7-3 - Suitability of micro-hydro by sector

Sector	Electricity load	Installation requirements	O&M requirements

Domestic	Medium	Low	Medium
SME (commercial)	Medium	Low	Medium
SME (industrial)	Medium	Low	Medium
Agriculture	Medium	Medium	Medium
Community/social enterprises	High	Low	High
Citizen energy communities	High	Low	Medium
Public buildings (local authorities)	Medium	Low	Medium
Public buildings (schools)	Medium	Low	Medium

Table 7-4 - Suitability of micro-CHP by sector

Sector	Electricity load	Installation requirements	O&M requirements
Domestic	High	High	High
SME (commercial)	High	High	High
SME (industrial)	High	High	High
Agriculture	High	High	High
Community/social enterprises	Medium	High	High
Citizen energy communities	Medium	High	High
Public buildings (local authorities)	Medium	High	High
Public buildings (schools)	Medium	High	High

A1.3.2 Capacity banding

Historical domestic energy data was obtained from SEAI[81], assuming an annual power demand of 4,700kWh and annual heat demand of 13,500kWh. They represent an approximation of energy demand in the sector over the last 3-5 years. Future domestic demand data was provided by SEAI to account for a more representative demand scenario, demonstrated below. These figures were used in

[81] SEAI. 2019. Key statistics - Residential. Available from: https://www.seai.ie/data-and-insights/seai-statistics/key-statistics/residential/

the evaluation of different capacities for each technology that would meet a 70% self-consumption threshold.

Table 7-5 – 2020-2030 annual domestic power demand

Year	Annual domestic power demand (kWh)
2020	5152
2021	5132
2022	5140
2023	5167
2024	5198
2025	5252
2026	5426
2027	5600
2028	5838
2029	6123
2030	6480

The target implementation date for the microgeneration scheme is mid-2021. It is forecast that the use of EV's and electrification of heat begins to increase demand at a more rapid rate later in the decade, which is particularly present from 2025 onwards. As a result, the average demand of 2021-2026 is used in this study for the assumed annual domestic demand of 5,219kWh.

Total agricultural demand data was provided by The Department of Agriculture, Food and the Marine, based on figures provided by farms across Ireland. Note that electricity consumption was provided in ktoe and then converted to kWh using a conversion of:

1ktoe = 11,630,000kWh

Table 7-6 - Annual electricity consumption by farm type

Farm type	Annual sector electricity consumption (ktoe)	Annual sector electricity consumption (kWh)	Annual sector fuel consumption (kWh)
Dairy	26	301,883,000	1,038,652,948
Sheep	4	41,116,704	321,697,705
Tillage	2	21,085,687	347,761,240
Cattle rearing	6	72,229,674	493,281,328
Cattle other	8	87,747,308	674,551,822
Mixed livestock	4	43,349,570	126,450,382
Pigs	4	44,021,600	676,757,600
Poultry	9	104,184,759	118,512,722

Horticulture (Mushroom)	2	18,724,300	14,913,172

To determine the average power/heat demand of each farm, the number of farms by type was obtained from the 2020 NFS[82].

Table 7-7 - Number of farms by type

Farm type	Total number of farms
Dairy	16,146
Cattle Rearing	25,781
Cattle Other	28,239
Sheep	14,322
Tillage	6,879
Mixed livestock	1,140

Note that pigs, poultry and horticulture farm types are not captured by the NFS 2020 data and show some inconsistency with the provided energy consumption data. Mixed livestock farms were described in both the energy consumption data provided as well as the NFS data yet because the pigs and poultry categories were not distinguished from the mixed livestock category, mixed livestock was also omitted from the analysis. Further, when the number of farms was divided by total sector demand, mixed livestock had an average annual power demand per farm nearly twice that of dairy. This is unlikely given the high-power demand of dairy and given that the consumption of individual cattle, pig and poultry farms is lower than dairy, so this was considered an outlier. As a result, the farms types considered are Dairy, Sheep, Tillage, Cattle rearing and Cattle other. This is likely to be representative of the actual range of power demands, particularly given that dairy farms typically have the highest power consumption by farm type[83].

The average typical farm type demand is calculated by dividing total farm type annual consumption by the total number of farms. The table below demonstrates the typical annual energy demands of each farm type.

Table 7-8 - Average annual electricity and heat consumption by farm type

Farm type	Average annual electricity consumption per farm (kWh)	Average annual heating demand per farm (kWh)
Dairy	18,697	64,329
Sheep	2,871	22,462
Tillage	3,065	50,554
Cattle rearing	2,802	19,134
Cattle other	3,107	23,887

[82] Donnellan, T., Moran, B., Lennon, J., Dillon, E. 2019. Teagasc National Farm Survey 2019 Preliminary Results. Available from: https://www.teagasc.ie/media/website/publications/2020/TeagascNFS2019-Preliminary-Results.pdf
[83] Teagasc. 2010. Dairy Farm Energy Consumption. Teagasc National Dairy Conference. Available from: https://www.teagasc.ie/media/website/rural-economy/farm-management/DairyFarmEnergyCoonsumption.pdf

From this, it is assumed that there would be two types of farm considered (small and large). Based on the above data, this can be summarised as the following:

Table 7-9 - Average annual electricity and heat consumption by size of farm

Farm type	Average annual electricity consumption per farm (kWh)	Average annual heating demand per farm (kWh)
Small	3,000	20,000
Large	19,000	65,000

Public building demand was obtained from the technical appendices of CIBSE Guide F 2012 building standards[84], using an average of scenarios for each sector and sub-category. This is summarised in the table below. Whilst this is based on UK figures, it is expected they are representative in Ireland too.

Table 7-10 - Energy demand by building category

Building category/sub category	Electricity demand (kWh/m^2/year)	Gas/oil demand (heating) (kWh/m^2/year)
Office – cellular naturally ventilated	43.5	115
Office – open plan naturally ventilated	69.5	115
Office – standard air conditioned	177	137.5
Office – prestige air conditioned	296	162
Office - average	147	132
Mixed use/industrial building – distribution and storage	31.5	132.5
Mixed use/industrial building – light manufacturing	50.5	195
Mixed use/industrial building – factory office	77.5	162.5
Mixed use/industrial building – general manufacturing	67.5	225
Mixed use/industrial building - average	57	179
Education – primary school	27	138.5
Education – secondary school	29	126
Education - average	28	132.25

The CIBSE building standards only assume energy consumption on per m^2 basis. Due to large variations in building size and no other data available for Ireland, these energy use intensities are

[84] CIBSE (2012) Guide F: Energy efficiency in buildings: https://www.cibse.org/Knowledge/knowledge-items/detail?id=a0q20000008I7oTAAS

used as a proxy for a typical 100m x 100m (1,000m^2) building for a fair comparison between the building sectors. The 'Office' category is used as a proxy for local authority and SME-commercial buildings, the mixed use/industrial was used as a proxy for 'SME – industrial' whilst the schools was used a proxy for the 'Schools' sector. As a result, the following annual energy consumptions for a typical building type are calculated.

Table 7-11 - Annual energy demand by building category

Building category	Annual electricity demand (kWh)	Gas/oil demand (heating) (kWh/m^2/year)
Office (1,000m^2)	146,500	132,375
Mixed use/industrial (1,000m^2)	56,750	178,750
School (1,000m^2)	28,000	132,250

From the above demand data, the finalised annual sector demands are categorised in the following table.

Table 7-12 - Annual energy demand by sector category

Sector category/sub category	Annual electricity demand (kWh)	Gas/oil demand (heating) (kWh/m^2/year)
Domestic	4,700	13,500
Small agriculture	3,000	20,000
Large agriculture	19.000	65,000
SME – commercial	146,500	132,375
SME – industrial	56,750	178,750
Public buildings – local authority	146,500	132,375
Public buildings - schools	28,000	132,250

This section also details the profiling of the large agriculture, SME-commercial/industrial, schools and local authority buildings.

A1.3.2.1 Profiling demands

The domestic/small agricultural profile is detailed in section A1.3.2.2 in conjunction with the small rooftop sizing.

The profiling of the SME commercial/industrial and local authority sector demand assumes the following, with the SME-commercial demand used as an example:

Table 7-13 - SME commercial Autumn/Winter hourly demand profiling

Consumption description	Value (%)	Consumption (kWh)
Annual consumption		146,500

Aut/Win consumption	60% of year	87,900
Aut/win week consumption (kWh)		3,381
Aut/win weekday consumption (kWh per day)	90% of week	609
Aut/win weekend consumption (kWh per day)	10% of week	169
Weekday 9-5 consumption	80% of day	487
Weekday 9-5 hourly consumption	487kWh/8hours	61
Weekday 5-9 consumption	20% of day	122
Weekday 5-9 hourly consumption	122kWh/16 hours	8
Weekend hourly consumption	169kWh/24 hours	7.04

Using the same method for Spring/Summer, the following annual demand profile is used for scaling to the annual demand of 146,500kWh for the SME-commercial/local authority buildings.

Table 7-14 - Seasonal/daily SME commercial/local authority demand profile

Hour	Aut/Win weekday consumption (kWh)	Aut/Win weekend consumption (kWh)	Spr/Sum weekday consumption (kWh)	Spr/Sum weekend consumption (kWh)
0	7.61	7.04	5.07	4.70
1	7.61	7.04	5.07	4.70
2	7.61	7.04	5.07	4.70
3	7.61	7.04	5.07	4.70
4	7.61	7.04	5.07	4.70
5	7.61	7.04	5.07	4.70
6	7.61	7.04	5.07	4.70
7	7.61	7.04	5.07	4.70
8	7.61	7.04	5.07	4.70
9	60.85	7.04	40.57	4.70
10	60.85	7.04	40.57	4.70
11	60.85	7.04	40.57	4.70
12	60.85	7.04	40.57	4.70
13	60.85	7.04	40.57	4.70
14	60.85	7.04	40.57	4.70
15	60.85	7.04	40.57	4.70
16	60.85	7.04	40.57	4.70

17	60.85	7.04	40.57	4.70
18	7.61	7.04	5.07	4.70
19	7.61	7.04	5.07	4.70
20	7.61	7.04	5.07	4.70
21	7.61	7.04	5.07	4.70
22	7.61	7.04	5.07	4.70
23	7.61	7.04	5.07	4.70

Applying the same method for the SME-industrial sector but scaled to the annual demand for the SME-industrial sector provides the following demand profile.

Table 7-15 - SME industrial seasonal/daily demand profile

Hour	Aut/Win weekday consumption (kWh)	Aut/Win weekend consumption (kWh)	Spr/Sum weekday consumption (kWh)	Spr/Sum weekend consumption (kWh)
0	2.70	2.50	1.80	1.67
1	2.70	2.50	1.80	1.67
2	2.70	2.50	1.80	1.67
3	2.70	2.50	1.80	1.67
4	2.70	2.50	1.80	1.67
5	2.70	2.50	1.80	1.67
6	2.70	2.50	1.80	1.67
7	2.70	2.50	1.80	1.67
8	2.70	2.50	1.80	1.67
9	21.62	2.50	14.41	1.67
10	21.62	2.50	14.41	1.67
11	21.62	2.50	14.41	1.67
12	21.62	2.50	14.41	1.67
13	21.62	2.50	14.41	1.67
14	21.62	2.50	14.41	1.67
15	21.62	2.50	14.41	1.67
16	21.62	2.50	14.41	1.67
17	21.62	2.50	14.41	1.67
18	2.70	2.50	1.80	1.67

19	2.70	2.50	1.80	1.67
20	2.70	2.50	1.80	1.67
21	2.70	2.50	1.80	1.67
22	2.70	2.50	1.80	1.67
23	2.70	2.50	1.80	1.67

Large agriculture was profiled using the following assumptions.

Table 7-16 - Large agriculture demand profiling assumptions

Consumption description	Value (%)	Consumption (kWh)
Annual consumption		19,000
Aut/Win consumption	60% of year	11,400
Aut/win week consumption (kWh)		438
Aut/win daily consumption (kWh per day)		63
Aut/win daytime consumption	70% of total day demand	44
Aut/win night time consumption	30% of total day demand	19
Aut/win hourly daytime demand	Assume 10 hour day 8am-6pm	4
Aut/win hourly night time demand		1

This provided the following demand profile, which is then scaled up to the annual 19,000kWh demand.

Table 7-17 - Large agriculture seasonal/daily demand profiles

Hour	Aut/Win daily consumption (kWh)	Spr/Sum daily consumption (kWh)
0	1.34	0.89
1	1.34	0.89
2	1.34	0.89
3	1.34	0.89
4	1.34	0.89
5	1.34	0.89
6	1.34	0.89
7	1.34	0.89
8	4.38	2.92

9	4.38	2.92
10	4.38	2.92
11	4.38	2.92
12	4.38	2.92
13	4.38	2.92
14	4.38	2.92
15	4.38	2.92
16	4.38	2.92
17	4.38	2.92
18	4.38	2.92
19	1.34	0.89
20	1.34	0.89
21	1.34	0.89
22	1.34	0.89
23	1.34	0.89

The school is profiled using data published by the UK regulator OFGEM, for a typical school load profile[85], demonstrated below. Note that the units are arbitrary values to represent a proportion of load. There is a total of 22.20 units of load in the example, therefore a unit of 0.01 within the 28,000kWh annual consumption represents 12.61kWh (28,000kWh/22.20 arbitrary units). The load profile is detailed below.

Hour	Spring load	Summer load	High summer load	Autumn load	Winter load
0 (weekday)	0.06	0.05	0.04	0.05	0.06
1	0.06	0.05	0.04	0.05	0.07
2	0.06	0.05	0.04	0.05	0.07
3	0.06	0.05	0.04	0.05	0.07
4	0.07	0.05	0.04	0.06	0.07
5	0.09	0.07	0.04	0.08	0.08
6	0.11	0.09	0.05	0.11	0.11
7	0.19	0.15	0.06	0.18	0.14

85 Downloadable spreadsheet from google search or https://www.ofgem.gov.uk/about-us

8	0.29	0.24	0.07	0.28	0.22
9	0.33	0.28	0.07	0.32	0.33
10	0.34	0.30	0.08	0.34	0.37
11	0.35	0.31	0.08	0.34	0.38
12	0.33	0.30	0.08	0.33	0.39
13	0.29	0.26	0.07	0.29	0.37
14	0.25	0.23	0.06	0.26	0.33
15	0.21	0.20	0.06	0.22	0.30
16	0.16	0.15	0.05	0.16	0.25
17	0.10	0.10	0.04	0.10	0.20
18	0.07	0.07	0.04	0.07	0.13
19	0.07	0.06	0.04	0.07	0.10
20	0.06	0.06	0.04	0.07	0.09
21	0.06	0.05	0.04	0.06	0.07
22	0.06	0.05	0.04	0.05	0.06
23	0.05	0.05	0.04	0.05	0.06
0 (weekend day)	0.05	0.05	0.04	0.05	0.06
1	0.05	0.05	0.04	0.05	0.06
2	0.05	0.05	0.04	0.05	0.06
3	0.06	0.05	0.04	0.05	0.06
4	0.05	0.05	0.04	0.05	0.06
5	0.06	0.04	0.04	0.05	0.06
6	0.06	0.04	0.04	0.05	0.07
7	0.06	0.04	0.04	0.05	0.07
8	0.06	0.05	0.04	0.05	0.07
9	0.06	0.05	0.04	0.05	0.07
10	0.06	0.05	0.04	0.05	0.07
11	0.06	0.05	0.04	0.05	0.07
12	0.06	0.05	0.04	0.05	0.06
13	0.06	0.05	0.04	0.05	0.06
14	0.05	0.05	0.04	0.05	0.06
15	0.05	0.05	0.04	0.05	0.06
16	0.05	0.04	0.04	0.04	0.06

17	0.05	0.04	0.03	0.04	0.06
18	0.05	0.04	0.03	0.05	0.06
19	0.05	0.04	0.04	0.05	0.06
20	0.05	0.04	0.04	0.05	0.06
21	0.05	0.05	0.04	0.05	0.06
22	0.06	0.05	0.04	0.05	0.06
23	0.06	0.05	0.04	0.05	0.06

Applying the value of 12.61kWh per arbitrary unit and accounting for the number of days in the year generates the following load profile when adjusted to the annual 28,000kWh.

Hour	Spring load (kWh)	Summer load (kWh)	High summer load (kWh)	Autumn load (kWh)	Winter load (kWh)
0 (weekday)	1.59	1.40	1.10	1.45	1.93
1	1.67	1.39	1.11	1.46	2.07
2	1.70	1.43	1.15	1.48	2.17
3	1.77	1.44	1.12	1.49	2.32
4	1.86	1.48	1.16	1.61	2.33
5	2.39	1.96	1.18	2.24	2.32
6	3.05	2.59	1.30	2.99	2.95
7	5.13	4.21	1.54	4.92	3.95
8	7.84	6.44	1.78	7.56	6.29
9	9.05	7.55	1.98	8.72	9.48
10	9.41	8.13	2.06	9.17	10.47
11	9.53	8.43	2.11	9.39	10.56
12	8.99	8.09	2.06	8.88	10.71
13	7.80	7.10	1.94	7.91	9.95
14	6.94	6.41	1.76	7.22	8.63
15	5.77	5.44	1.53	5.97	7.86
16	4.31	4.10	1.30	4.44	6.66
17	2.66	2.61	1.15	2.76	5.28
18	1.89	1.83	1.11	2.04	3.40
19	1.79	1.58	1.14	1.91	2.48
20	1.77	1.53	1.23	1.79	2.37

21	1.63	1.48	1.21	1.56	2.11
22	1.51	1.43	1.15	1.46	1.80
23	1.50	1.40	1.11	1.43	1.76
0 (weekend day)	1.48	1.31	1.09	1.31	1.61
1	1.48	1.31	1.08	1.31	1.65
2	1.47	1.31	1.11	1.33	1.65
3	1.51	1.30	1.07	1.32	1.61
4	1.47	1.28	1.11	1.35	1.63
5	1.53	1.23	1.03	1.36	1.70
6	1.51	1.20	1.00	1.35	1.79
7	1.51	1.21	1.01	1.30	1.86
8	1.61	1.27	1.03	1.33	1.86
9	1.62	1.34	1.04	1.35	1.86
10	1.66	1.37	1.04	1.39	1.85
11	1.60	1.38	1.03	1.40	1.86
12	1.59	1.33	1.04	1.37	1.75
13	1.53	1.28	1.03	1.34	1.66
14	1.47	1.25	1.02	1.29	1.67
15	1.37	1.24	0.99	1.24	1.59
16	1.30	1.17	0.96	1.18	1.54
17	1.25	1.16	0.93	1.19	1.57
18	1.26	1.15	0.95	1.25	1.63
19	1.34	1.15	0.96	1.31	1.67
20	1.49	1.19	1.05	1.34	1.68
21	1.46	1.28	1.11	1.34	1.65
22	1.51	1.31	1.12	1.32	1.60
23	1.51	1.30	1.09	1.31	1.63

A1.3.2.2 Sizing of generators

Research aimed to determine potential small-wind turbines available on the market and found a large range of potential options detailed in the table below.

Table 7-18 - Micro-wind turbine sizes believed to be available up to 50kW

Wind turbine model	Size (kW)
Aeolos-H 500W	0.5
Aeolos-H 1000W	1
Passat 1.4kW	1.4
Windspot 1.5 kW	1.5
Aeolos-H 2000W	2
Xzeres skystream 3.7	2.25
SD3	3
Aeolos-H 3000W	3
Windspot 3.5 kW	3.5
Montana 5kW	5
5 kW	5
R9000	5
Aeolos-H 5000W	5
QR6	5
SD6	6
Windspot 7.5 kW	7.5
TUGE10	9.9
Aircon 10s	10
Excel 10	10
Alize 10kW	10
Osiris10	10
Aeolos-H 10kW	10
Xzeres 442SR	10.4
Gaia Wind 133-11kW	11
CF11	11
Excel 15	15
CF15	15

H15	16
SWP-19.8	19.8
CF20	20
Phoenix 20kW (PHX-20)	20
Aeolos-H 20kW	20
EO-25/12	25
Viking-vs	25
SWP-25 kW	25
WindEn30	30
Aeolos-H 30kW	30
WindEn45	45
TUGE 50	50
Aeolos-H 50kW	50
Xzeres 50	51

The wind profile assumes the following:

- 60% of annual generation is in autumn/winter, 40% in spring/summer.
- 40% of daily generation is during the day (6am-6pm) whilst 60% is during the night (6pm-6am)
- Daily/night-time hourly generation is linear

Using a 15kW turbine with a capacity factor of 22.5% at 5m/s wind speed assumes an annual generation of 29,565kWh. From this, the following generation profile is assumed:

Table 7-19 - Assumed wind generation profiles for 15kW turbine at 5m/s wind speed

Hour	Aut/win daily generation (kWh)	Spr/sum daily generation (kWh)
0	4.87	3.25
1	4.87	3.25
2	4.87	3.25
3	4.87	3.25
4	4.87	3.25
5	4.87	3.25
6	3.25	2.17
7	3.25	2.17
8	3.25	2.17

9	3.25	2.17
10	3.25	2.17
11	3.25	2.17
12	3.25	2.17
13	3.25	2.17
14	3.25	2.17
15	3.25	2.17
16	3.25	2.17
17	3.25	2.17
18	3.25	3.25
19	4.87	3.25
20	4.87	3.25
21	4.87	3.25
22	4.87	3.25
23	4.87	3.25

The hydro generation profile is determined similarly to wind, using the following assumptions for a 1kW scheme with 50% capacity factor and an annual generation of 4,380kWh:

- 40% Summer/Winter generation (lower rainfall in summer, snow in winter), 60% Spring/Autumn
- Linear generation throughout the day

Using these assumptions, the following generation profile is assumed:

Table 7-20 - 1kW hydro seasonal/daily generation profile

Hour	Sum/win daily generation (kWh)	Spr/aut daily generation (kWh)
0	0.40	0.60
1	0.40	0.60
2	0.40	0.60
3	0.40	0.60
4	0.40	0.60
5	0.40	0.60
6	0.40	0.60
7	0.40	0.60

8	0.40	0.60
9	0.40	0.60
10	0.40	0.60
11	0.40	0.60
12	0.40	0.60
13	0.40	0.60
14	0.40	0.60
15	0.40	0.60
16	0.40	0.60
17	0.40	0.60
18	0.40	0.60
19	0.40	0.60
20	0.40	0.60
21	0.40	0.60
22	0.40	0.60
23	0.40	0.60

The capacity factors, output and total fuel use for CHP are obtained from figures published by the UK Government in their annual energy statistics publication, DUKES table 7.8[86], which detail these criteria by sector. Using agriculture as an example to determine full load hours:

Full load hours = Electrical output GWh *x* 1000/electrical capacity (MWe)

= 3,303GWh *x* 1000/ 795MWe

= 4,152.1372 hours

Therefore, the capacity factor is calculated as:

4,152.1372 hours/ 8,760 annual hours = 47.4%.

The heat:power (H:P) ratios are derived from a range of sources[87]. The peak heat load is determined with the closest capacity engine selected from the UK's CHPQA list of engines along with the heat efficiencies. To determine H:P ratios the following calculation is used:

[86] UK Government. 2020. National Statistics – Digest of UK Energy Statistics (DUKES): combined heat and power. Available from: https://www.gov.uk/government/statistics/combined-heat-and-power-chapter-7-digest-of-united-kingdom-energy-statistics-dukes

H:P ratio = heat efficiency/power efficiency

Using the 1kWe system as an example, using peak heat load/capacities of machine data[88], the H:P ratio is determined:

76.5% heat efficiency / 7.9% power efficiency = 9.68

From the above method using a range of data to determine capacity factors, peak heat load and H:P ratios, a range of CHP sizes are determined and summarised below.

Note that the threshold of 5.5kWp is used rather than the 6kWp for the single phase-limit for other technologies. This is because domestic settings typically require 5.5kW[89].

Table 7-21 - Micro-CHP assumptions

Sector	Capacity range (kW)	Electrical efficiency (%)	System efficiency (%)	Heat efficiency	H:P ratio
Domestic	1-1	7.9%	84.40%	76.50%	9.68
SME-commercial	5.5-19	31.7%	83.42%	51.70%	1.63
SME-industrial	5.5-30	26.9%	69.24%	42.30%	1.57
Small agriculture	1-1	7.9%	84.40%	76.50%	9.68
Large agriculture	1-5.5	22.8%	74.48%	51.70%	2.27

A1.3.2.3 Generator sizing optimisation

This section details the sizing of the solar, wind and hydro for self-consuming 70% of generation.

The sizing of the domestic/small agricultural PV scheme required demand profiles to investigate supply vs demand. Half hourly UK demand data was obtained[90] and converted into hourly data to align with the hourly outputs created by Helioscope. The data provides data broken down into

[87] https://www.chpqa.com/guidance_notes/CHPQA_UNIT_LIST.pdf, https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1054&context=engschcivart and https://www.mytub.co.uk/baxi-senertec-dachs-g-5-5-mini-chp-unit-product-465447
[88] Conroy, G., Duffy, A., Ayompe, L. 2015. Economic, Energy and GHG Emissions Performance Evaluation of a Whispergen Mk IV Stirling engine m-CHP unit in a domestic dwelling. Technological University Dublin. Available from: https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1054&context=engschcivart
[89] Multiple sources such as https://www.osti.gov/servlets/purl/921640 and the CHP QA list https://www.chpqa.com/guidance_notes/CHPQA_UNIT_LIST.pdf
[90] UKERC. 1997. Electricity user load profiles by profile class. Available from: https://ukerc.rl.ac.uk/DC/cgi-bin/edc_search.pl?GoButton=Detail&WantComp=42&&RELATED=1

weekday/weekends (Saturday and Sunday are modelled separately) for Spring, Summer, Autumn, Winter, peak Summer and Peak Winter. This analysis uses the following data:

- Autumn/Spring/Summer/Winter weekdays;
- Saturdays and Sundays are averaged to produce a 'Weekend' demand;
- Autumn = September - November
- Winter = December – February
- Spring = March – May
- Summer = June – August

From the data, the following hourly demand profiles are presented:

Table 7-22 - Hourly demand profiles for Autumn and Winter

Hour	Autumn weekday hourly demand (kW)	Autumn weekend hourly demand (kW)	Winter weekday hourly demand (kW)	Winter weekend hourly demand (kW)
00	0.62	0.70	0.74	0.84
01	0.45	0.53	0.53	0.62
02	0.39	0.43	0.45	0.5
03	0.37	0.39	0.42	0.44
04	0.37	0.38	0.4	0.42
05	0.38	0.38	0.43	0.425
06	0.47	0.42	0.55	0.48
07	0.77	0.55	0.91	0.645
08	0.99	0.77	1.25	0.895
09	0.87	0.94	1.09	1.12
10	0.82	1.03	0.99	1.22
11	0.77	1.02	0.95	1.28
12	0.8	1.09	0.96	1.33
13	0.79	1.10	0.96	1.34
14	0.73	0.94	0.89	1.185
15	0.73	0.88	0.93	1.165
16	0.85	0.93	1.17	1.28
17	1.16	1.08	1.67	1.605
18	1.26	1.20	1.84	1.8
19	1.37	1.38	1.79	1.785
20	1.37	1.37	1.64	1.655
21	1.33	1.29	1.55	1.51

22	1.2	1.16	1.39	1.36
23	0.93	0.96	1.08	1.105

Table 7-23 - Hourly demand profiles for spring and summer

Hour	Spring weekday hourly demand (kW)	Spring weekend hourly demand (kW)	Summer weekday hourly demand (kW)	Summer weekend hourly demand (kW)
00	0.65	0.705	0.61	0.67
01	0.47	0.555	0.44	0.51
02	0.41	0.455	0.39	0.42
03	0.38	0.4	0.37	0.385
04	0.38	0.38	0.36	0.38
05	0.38	0.395	0.37	0.38
06	0.48	0.42	0.45	0.405
07	0.77	0.57	0.72	0.545
08	0.97	0.79	0.87	0.72
09	0.87	0.95	0.81	0.88
10	0.83	1.035	0.77	0.965
11	0.77	1.075	0.74	0.985
12	0.8	1.175	0.76	1.055
13	0.8	1.11	0.74	1.03
14	0.73	0.94	0.69	0.9
15	0.74	0.9	0.7	0.855
16	0.87	0.95	0.83	0.875
17	1.14	1.085	1.08	0.98
18	1.17	1.185	1.09	1.025
19	1.14	1.15	1.02	1.01
20	1.18	1.2	0.95	0.955
21	1.31	1.295	1	0.96
22	1.25	1.195	1.08	1.04
23	0.98	0.99	0.9	0.915

Although the data is old (1997) and does not represent domestic annual consumption (over 7,564kWh annually when compared to an assumed 4,700kWh for a present-day typical Irish dwelling), the profile for times of demand allowed a scaling to represent an Irish dwelling. This is done via the following method:

Irish dwelling hourly demand of given timestamp (kW) =

Hourly demand of 1997 model data (kW) *x* (Irish dwelling annual consumption (kWh)/1997 model annual consumption (kWh))

For clarity, the 1997 model hour of 12pm – 1pm has a demand of 0.96kW. Therefore, using the above equation to generate an Irish demand for this timestamp produces the following:

0.96kW *x* (4700kWh/7,564kWh) = 0.60kW

This method was then applied across the year to produce an annual hourly demand profile for an Irish dwelling.

A basic 3kW roof-mounted array was then drawn up in Helioscope to generate an annual hourly generation profile. Similarly to the demand profile, the generation profile was then scaled to ensure that generation was 799kWh/kWp/year from the pre-determined outputs using PVGIS data. The 2.8kW array in Helioscope generated a total of 2080kWh and every hourly output for the 2.8kW array was then scaled to match the 2,397kWh annual output determined for a 3kWp system. For example, the Helioscope hourly generation for an autumn day 9am – 10am is 0.22kW. Therefore, this was scaled using the following calculation:

Hourly generation (kWh) =

Helioscope hourly generation (kWh) *x* (3kW system annual generation (kWh)/Helioscope 2.8kW system annual generation (kWh))

9am – 10am autumn weekday hourly generation (kWh)=

0.22kW *x* (2,397kWh/2080kWh)

= 0.25kWh

This method was also used for the sizing of the small-agriculture system as it was assumed the demand profile is the same as the domestic sector. Using this method, the small-agriculture sizing for 70% self-consumption is a 1.7kW rooftop scheme/1.4kW ground-mount scheme.

Figure 7-1 – Array details of 2.8kW rooftop scheme design using Helioscope

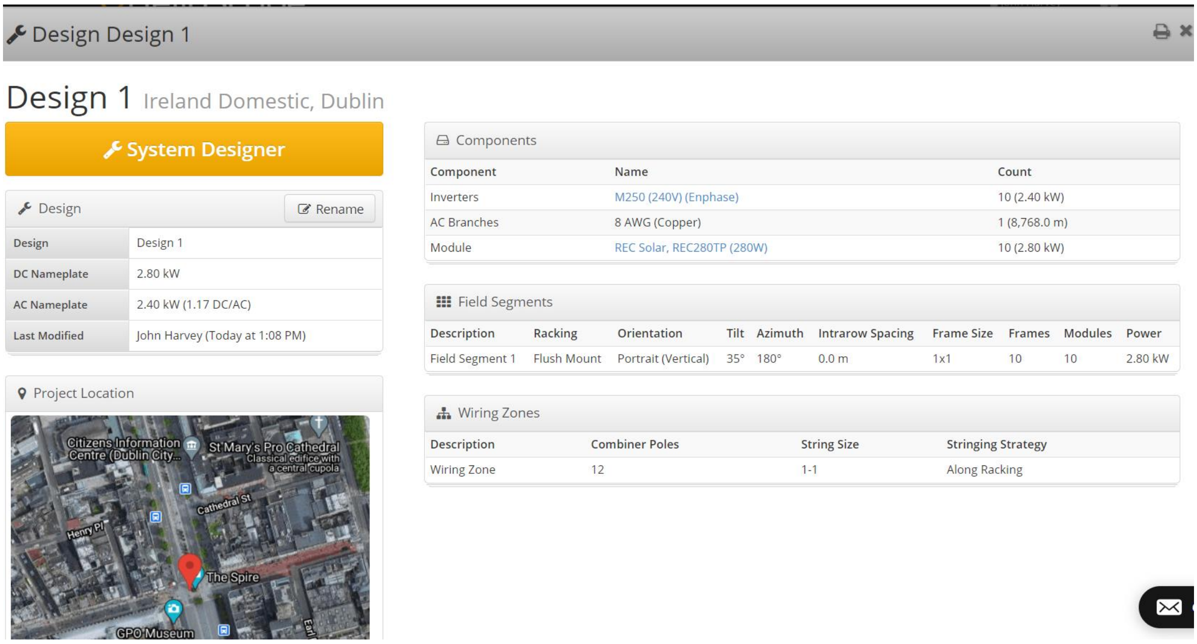
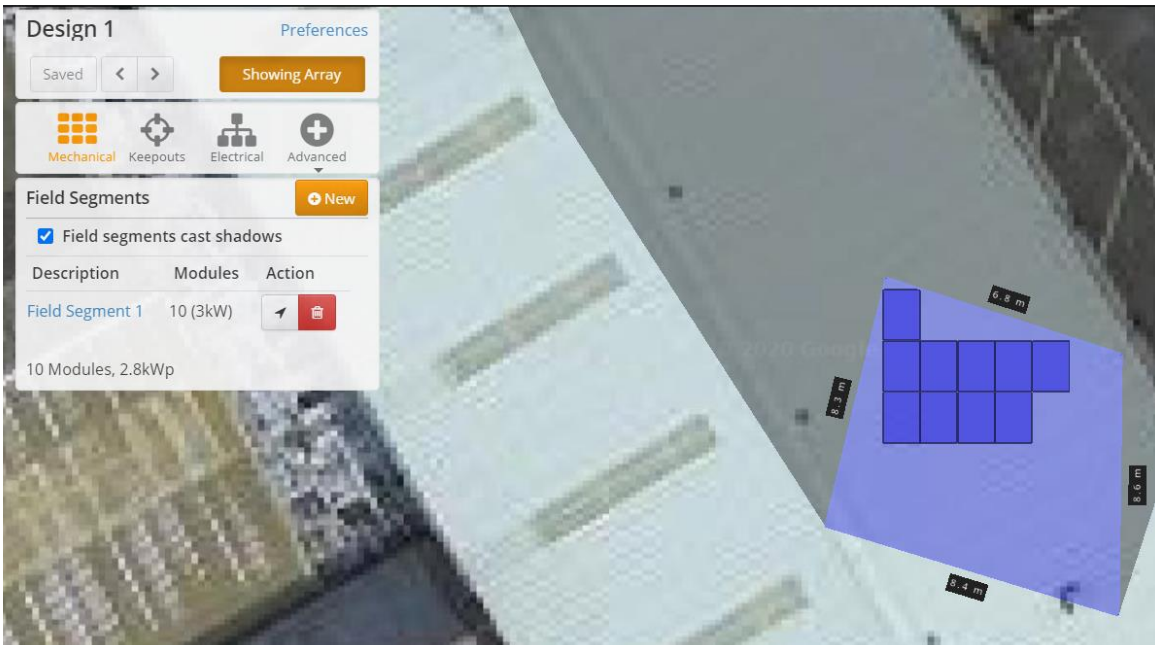


Figure 7-2 – Outline of 2.8kW rooftop scheme design using Helioscope



The solar PV design tool, PV-Sol, was also used to determine the required capacity for approximately 70% self-consumption for each sector, with the results highlighted below along with data assumptions.

Table 7-24 – PV-Sol demand profile assumptions

Sector	PV-sol monthly load profile
Large agriculture	BDEW L0 blended Agri monthly load profile

School	School profile
SME-commercial	BDEW G1 commercial load profile (weekdays 8am-6pm, offices workshops, administrative units) applied to annual usage
SME-industrial	BDEW G3 continuous load (e.g. refrigeration, pumping) applied to SME industrial annual usage
Local authority	BDEW G1 commercial load profile (weekdays 8am-6pm, offices workshops, administrative units) applied to annual usage

Table 7-25 – Size of rooftop-PV arrays required for 70% self-consumption in sectors

Sector	PV-sol capacity factor (%)	Capacity required for 70% self-consumption	% self-consumption
Large agriculture	9.56%	9.24	71.4
School	9.56%	9.24	72
SME-commercial	9.53%	49.5	81
SME-industrial	9.53%	31.68	69.1
Local authority	9.53%	49.50	81.00

Table 7-26 - Size of ground-mount PV arrays required for 70% self-consumption in sectors

Sector	PV-sol capacity factor (%)	Capacity required for 70% self-consumption	% self-consumption
Large agriculture	10.60%	9.24	69.1
School	10.60%	9.24	69.5
SME-commercial	10.58%	49.5	80.9
SME-industrial	10.62%	27.06	71.5
Local authority	10.58%	49.50	80.90

Note that due to the large annual demand of local authorities and SME-commercial sites, a 50kW array would be able to self-consume around 80% of its generation. This is also justifies the capacity bands as there is a large increment between the schools/large-agriculture to industrial SME's, then to commercial SME's/local authorities regarding required capacities for the 70% self-consumption threshold.

Below highlights the assumptions and results for each of the PV-Sol simulations.

A1.3.2.4 Ground mount large agriculture

Climate Data

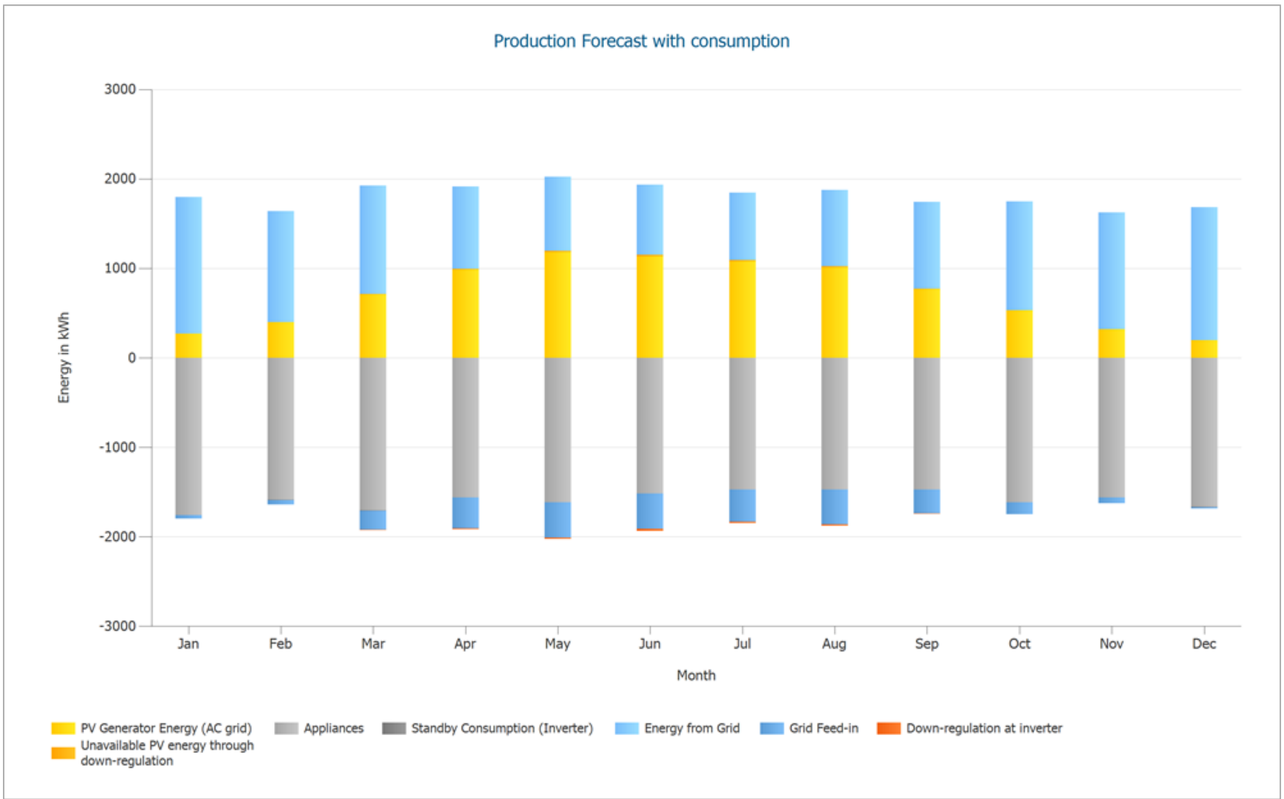
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

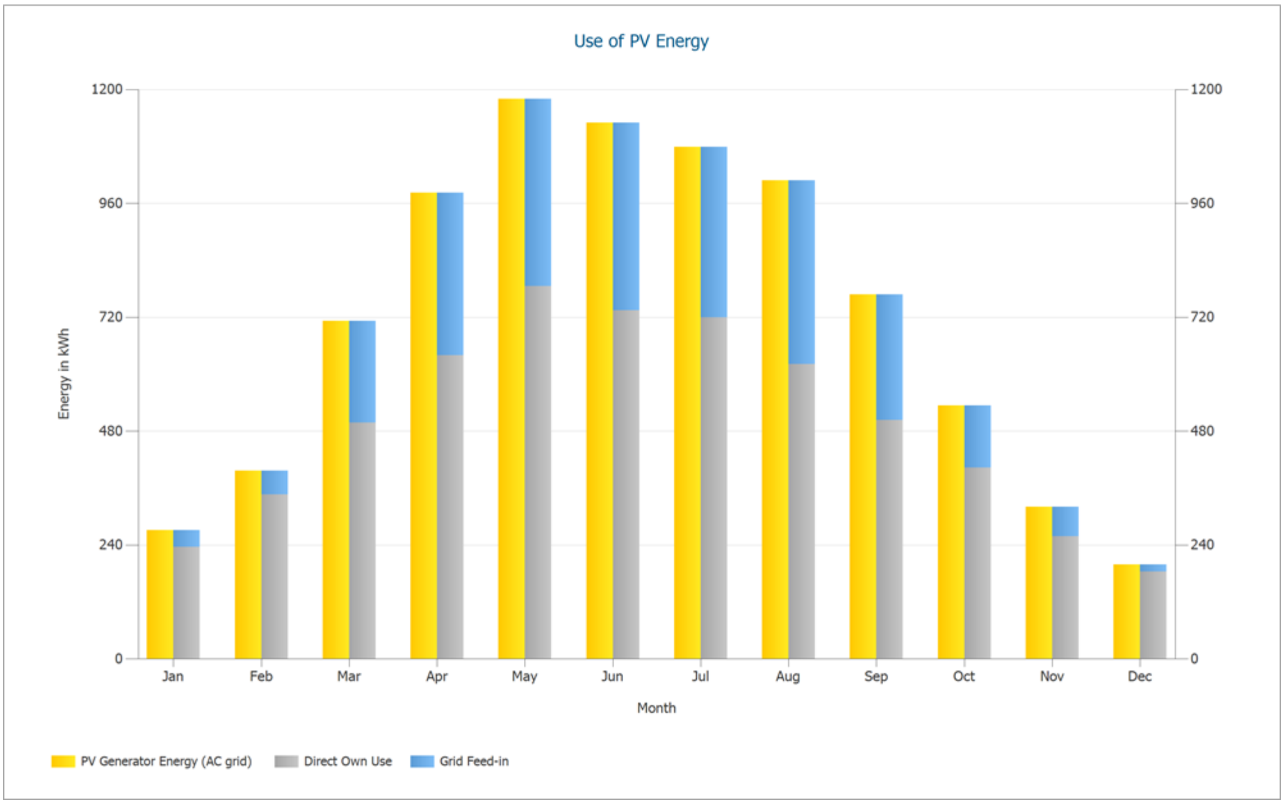
PV System

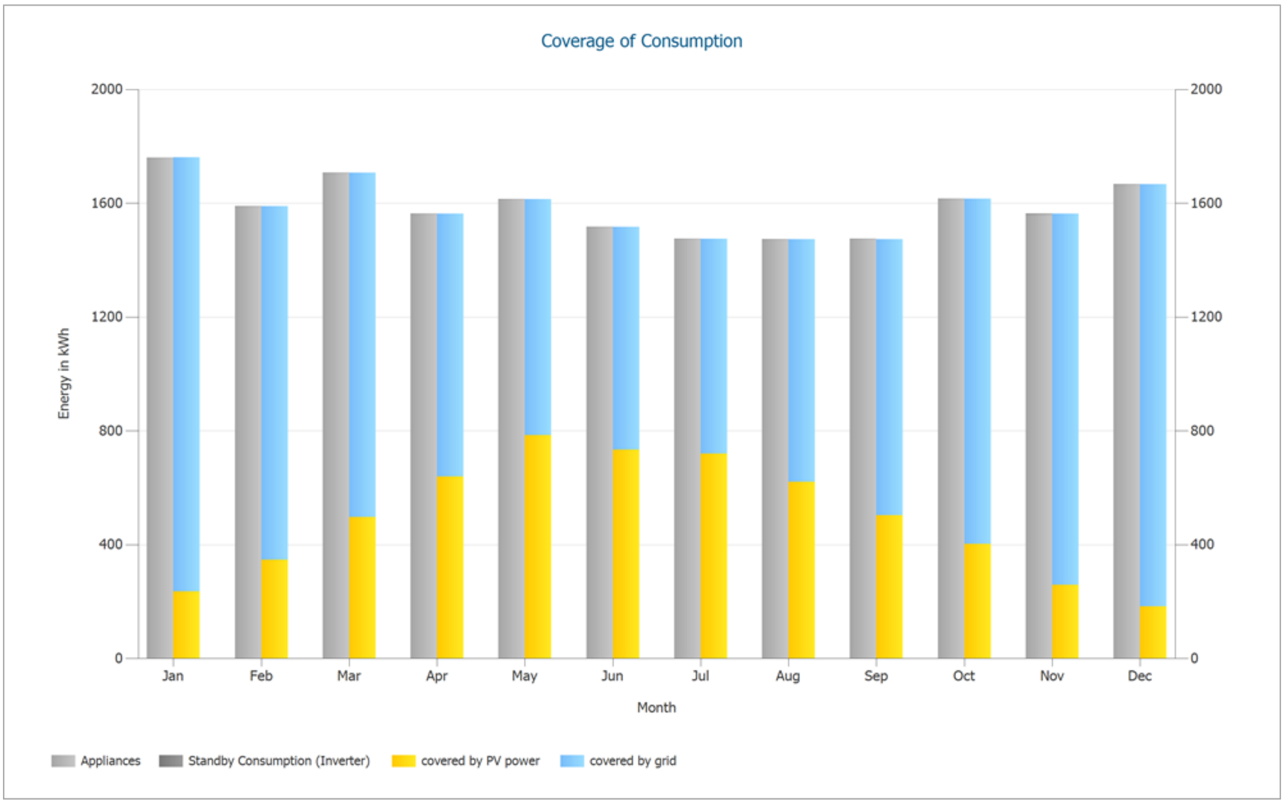
PV Generator Output	9.2 kWp
Spec. Annual Yield	928.66 kWh/kWp
Performance Ratio (PR)	87.4 %
PV Generator Energy (AC grid)	8,581 kWh/Year
Own Consumption	5,929 kWh/Year
Grid Feed-in	2,652 kWh/Year
Down-regulation at Feed-in Point	0 kWh/Year
Own Power Consumption	69.1 %
CO_2 Emissions avoided	3,261 kg / year

Appliances

Appliances	19,000 kWh/Year
Standby Consumption (Inverter)	17 kWh/Year
Total Consumption	19,017 kWh/Year
covered by PV power	5,929 kWh/Year
covered by grid	13,088 kWh/Year
Solar Fraction	31.2 %







A1.3.2.5 Rooftop large agriculture

Climate data

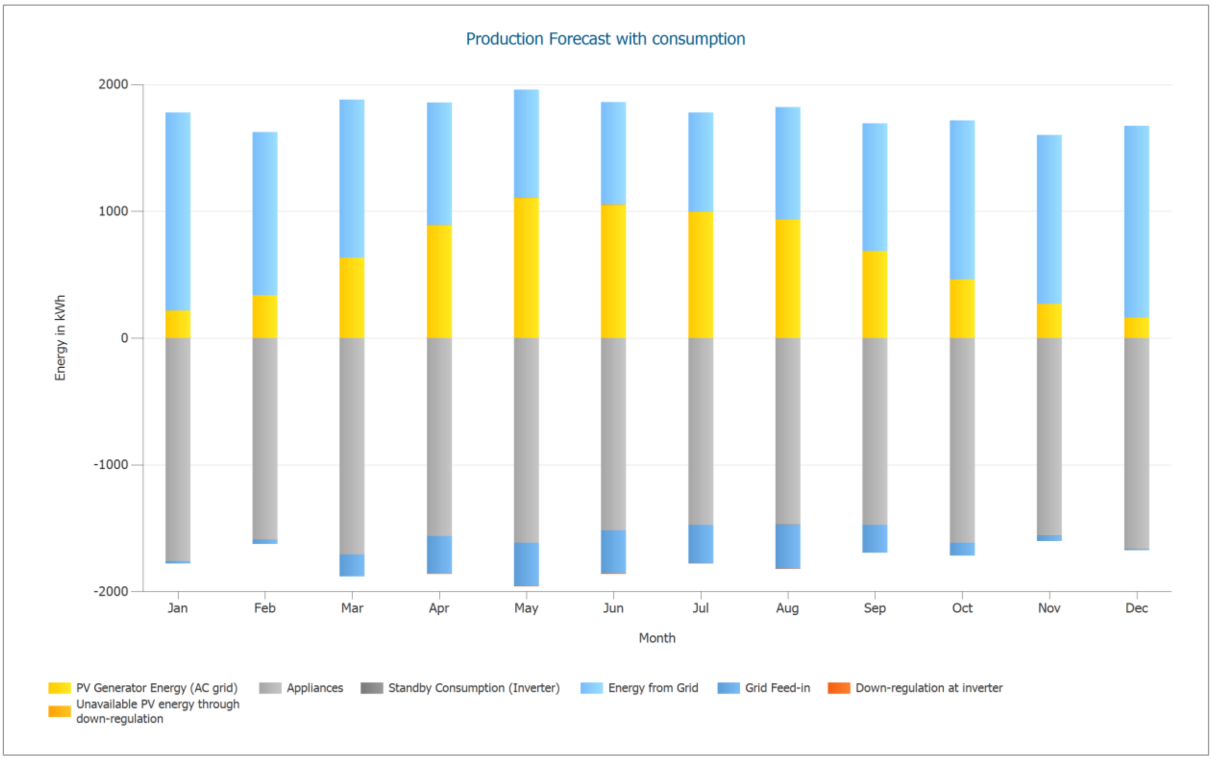
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

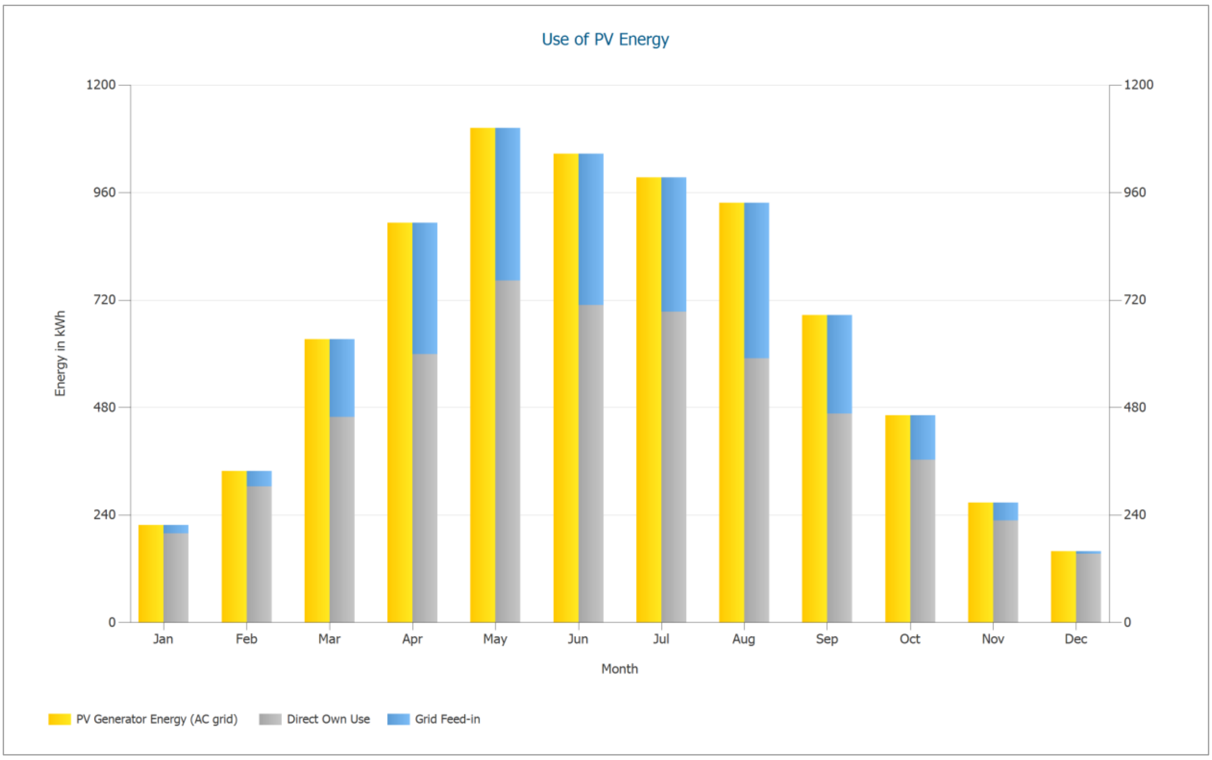
PV System

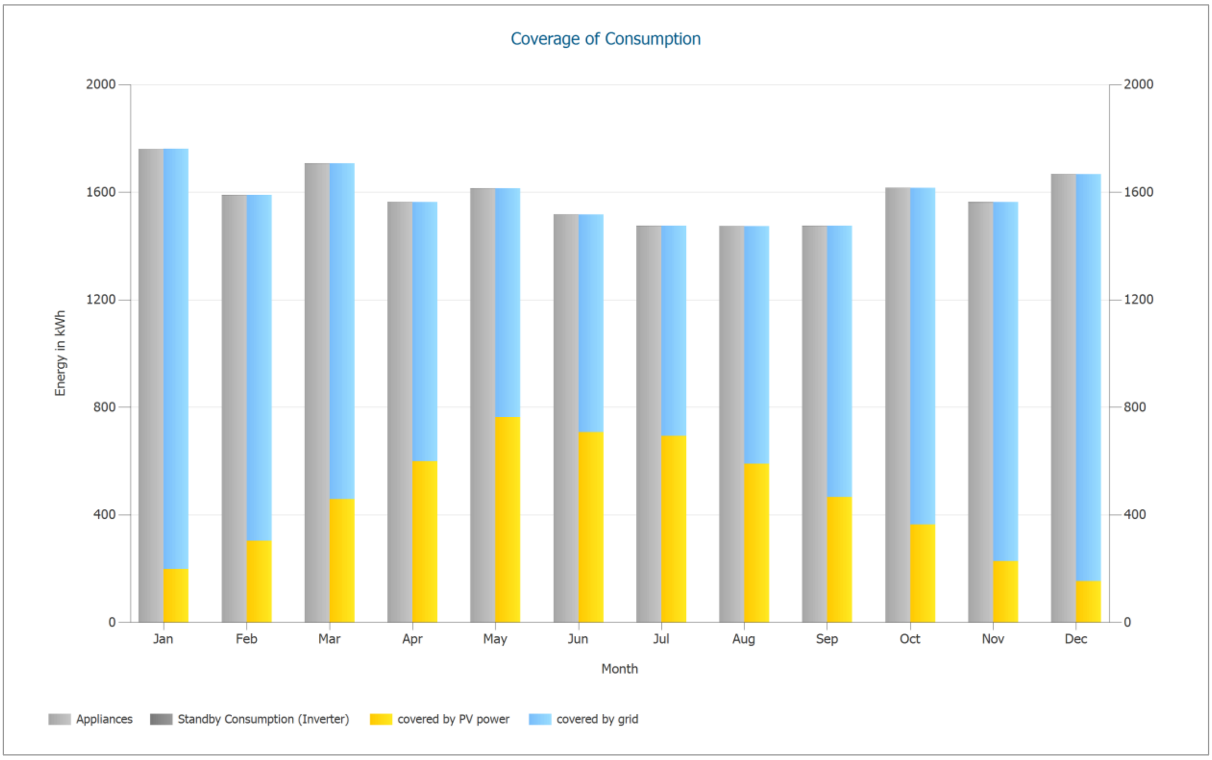
PV Generator Output	9.2 kWp
Spec. Annual Yield	837.30 kWh/kWp
Performance Ratio (PR)	84.3 %
PV Generator Energy (AC grid)	7,737 kWh/Year
Own Consumption	5,525 kWh/Year
Grid Feed-in	2,212 kWh/Year
Down-regulation at Feed-in Point	0 kWh/Year
Own Power Consumption	71.4 %
CO_2 Emissions avoided	2,940 kg / year

Appliances

Appliances	19,000 kWh/Year
Standby Consumption (Inverter)	17 kWh/Year
Total Consumption	19,017 kWh/Year
covered by PV power	5,525 kWh/Year
covered by grid	13,492 kWh/Year
Solar Fraction	29.1 %




Use of PV Energy
Energy in kWh
1200
960
720
480
240
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
PV Generator Energy (AC grid)
Direct Own Use
Grid Feed-in


Coverage of Consumption
Energy in kWh
2000
1600
1200
800
400
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Appliances
Standby Consumption (Inverter)
covered by PV power
covered by grid

A1.3.2.6 Ground-mount school

Climate Data

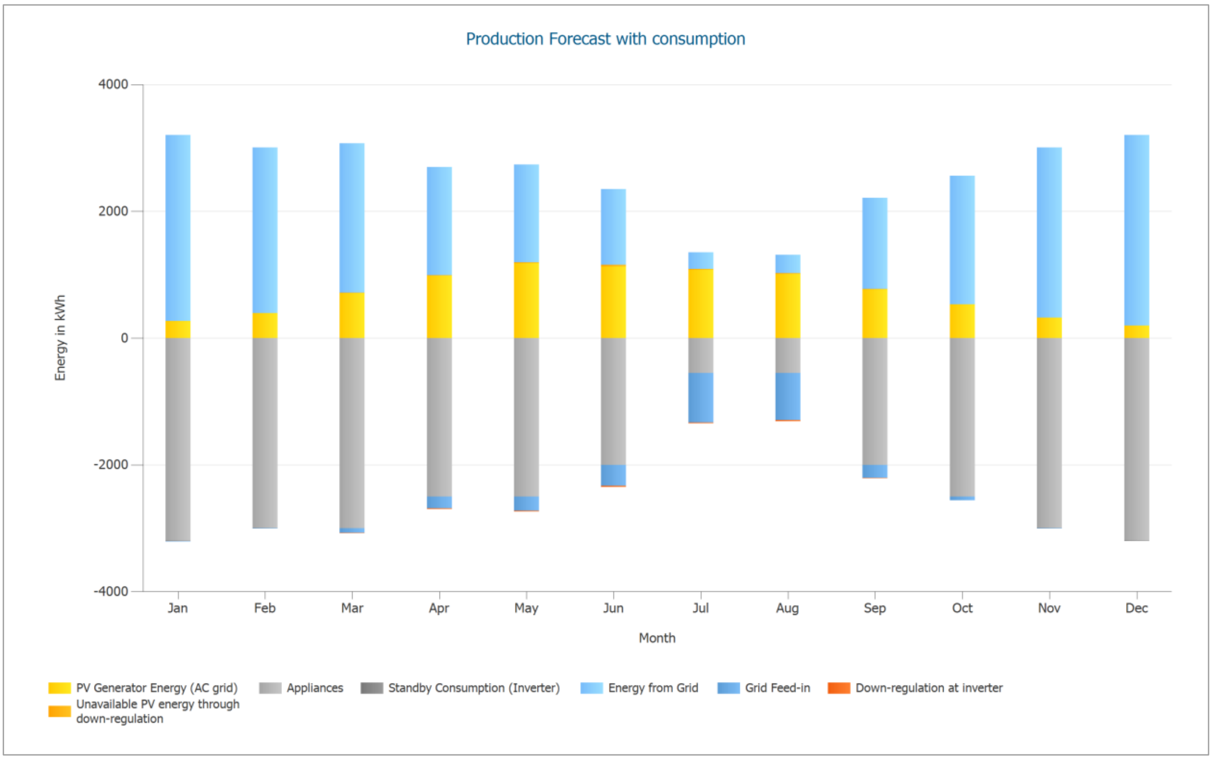
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

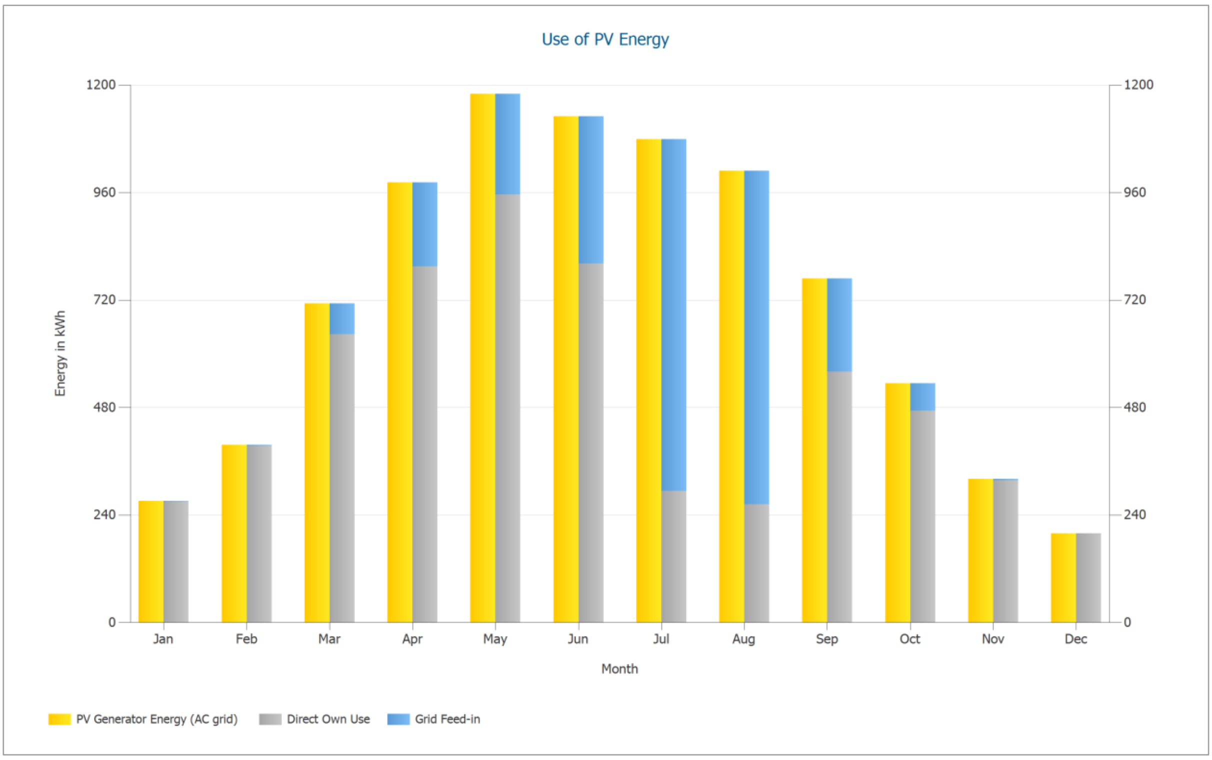
PV System

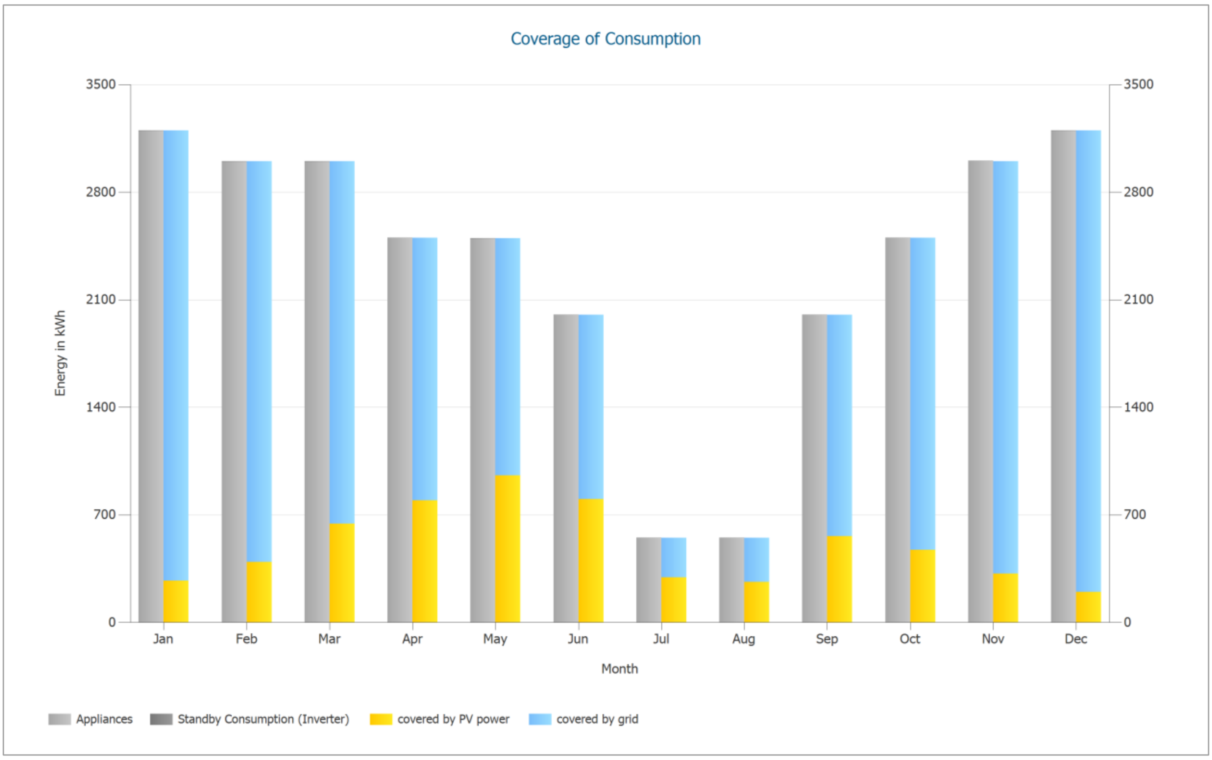
PV Generator Output	9.2 kWp
Spec. Annual Yield	928.66 kWh/kWp
Performance Ratio (PR)	87.4 %
PV Generator Energy (AC grid)	8,581 kWh/Year
Own Consumption	5,968 kWh/Year
Grid Feed-in	2,613 kWh/Year
Down-regulation at Feed-in Point	0 kWh/Year
Own Power Consumption	69.5 %
CO_2 Emissions avoided	3,261 kg / year

Appliances

Appliances	28,000 kWh/Year
Standby Consumption (Inverter)	17 kWh/Year
Total Consumption	28,017 kWh/Year
covered by PV power	5,968 kWh/Year
covered by grid	22,049 kWh/Year
Solar Fraction	21.3 %




Use of PV Energy
Energy in kWh
1200
960
720
480
240
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
PV Generator Energy (AC grid)
Direct Own Use
Grid Feed-in

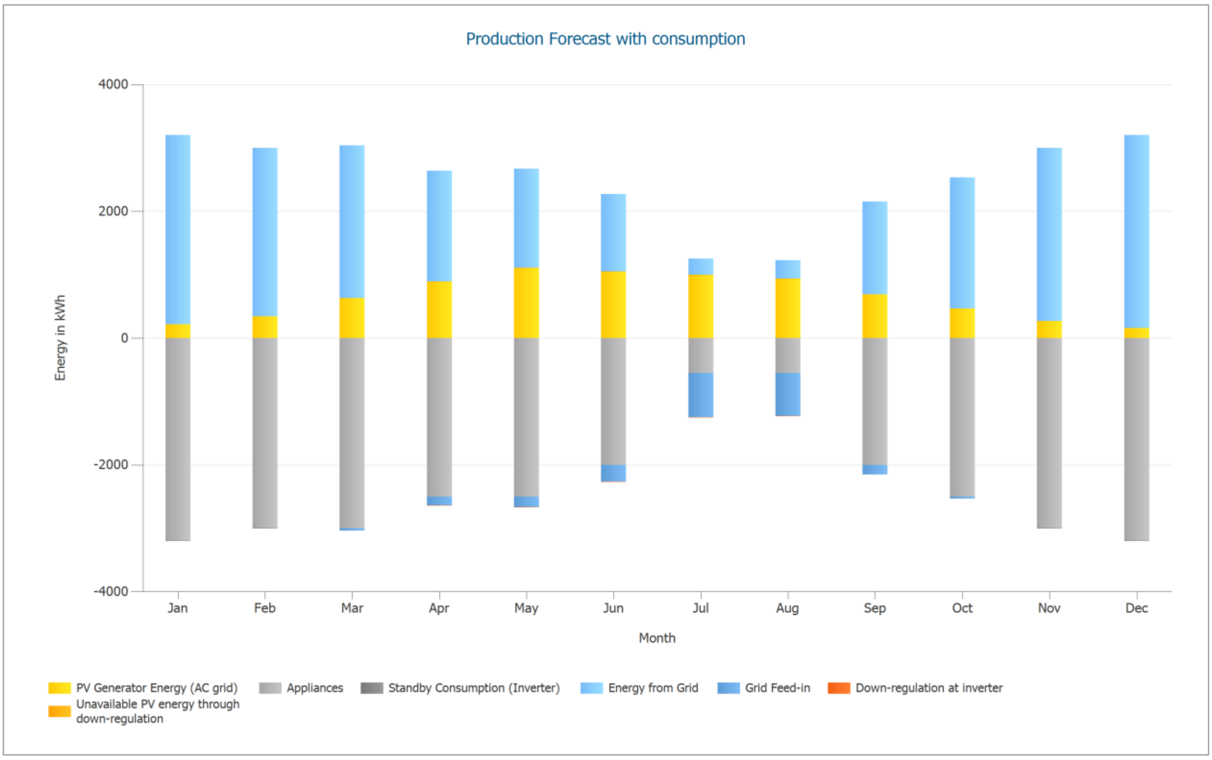

Coverage of Consumption
Energy in kWh
3500
2800
2100
1400
700
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Appliances
Standby Consumption (Inverter)
covered by PV power
covered by grid

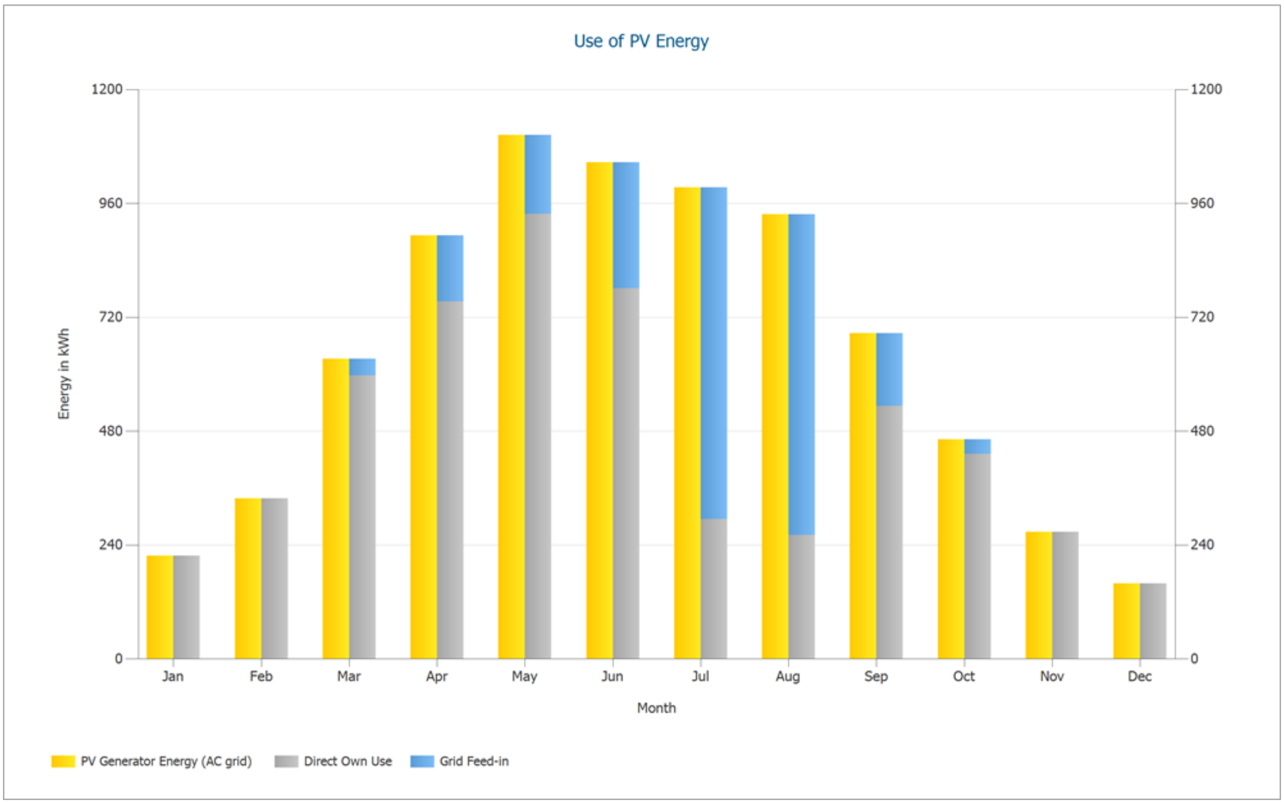
A1.3.2.7 Rooftop school

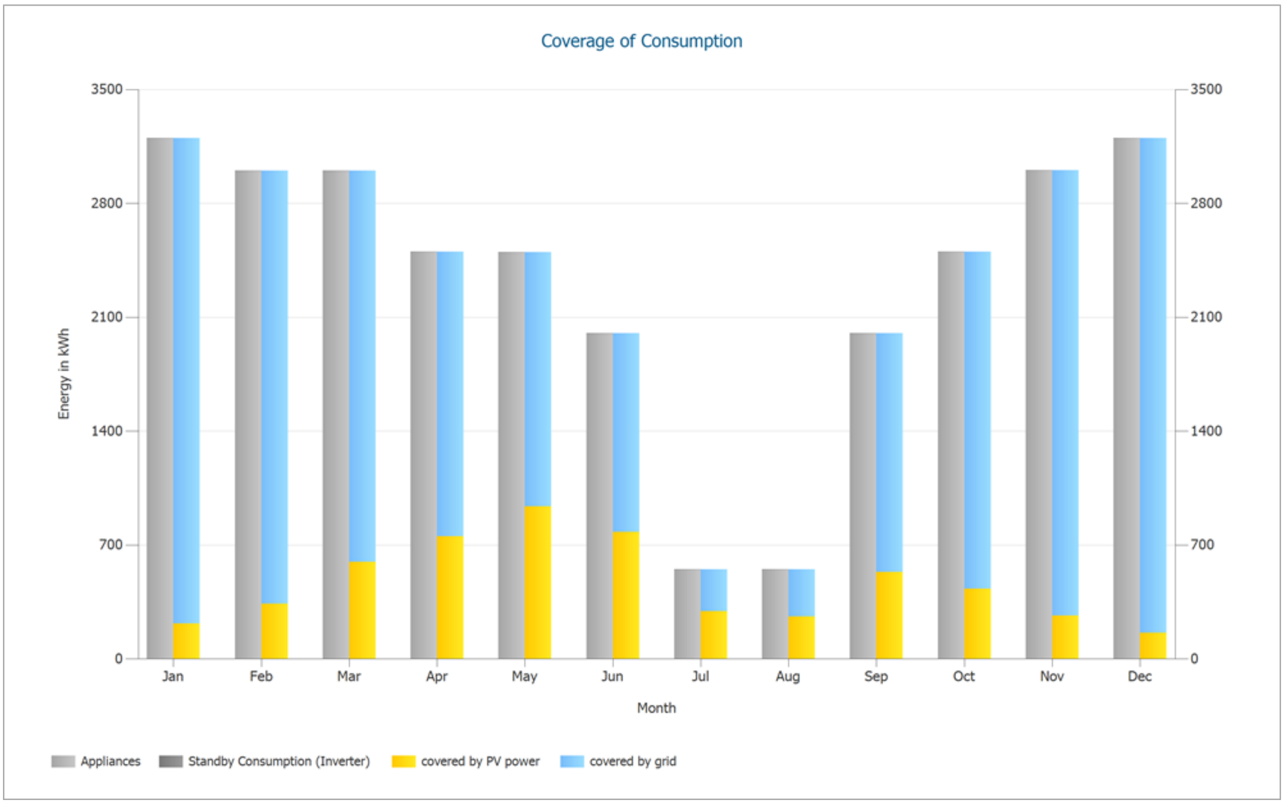
Climate Data	
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

PV System		
PV Generator Output	9.2	kWp
Spec. Annual Yield	837.30	kWh/kWp
Performance Ratio (PR)	84.3	%
PV Generator Energy (AC grid)	7,737	kWh/Year
Own Consumption	5,572	kWh/Year
Grid Feed-in	2,165	kWh/Year
Down-regulation at Feed-in Point	0	kWh/Year
Own Power Consumption	72.0	%
CO_2 Emissions avoided	2,940	kg / year

Appliances		
Appliances	28,000	kWh/Year
Standby Consumption (Inverter)	17	kWh/Year
Total Consumption	28,017	kWh/Year
covered by PV power	5,572	kWh/Year
covered by grid	22,445	kWh/Year
Solar Fraction	19.9	%




Use of PV Energy
Energy in kWh
1200
960
720
480
240
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
PV Generator Energy (AC grid)
Direct Own Use
Grid Feed-in


Coverage of Consumption
Energy in kWh
3500
2800
2100
1400
700
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Appliances
Standby Consumption (Inverter)
covered by PV power
covered by grid

A1.3.2.8 Ground-mount SME commercial/local authority

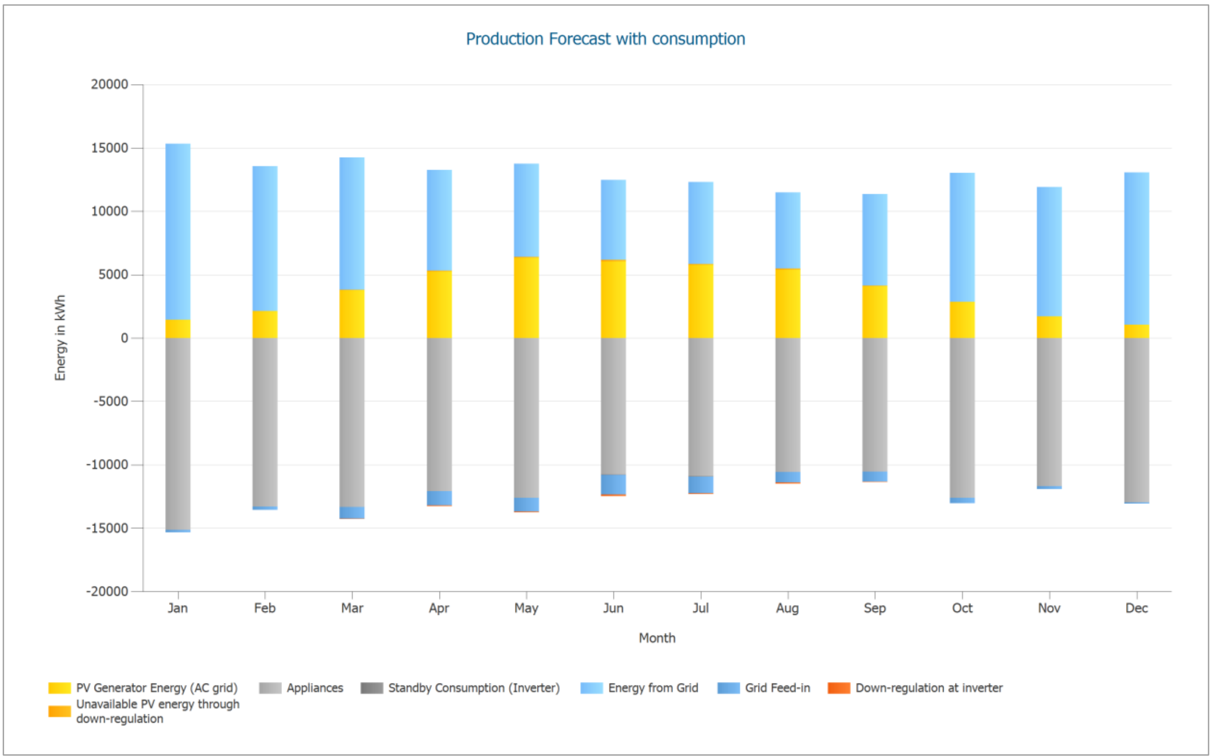
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

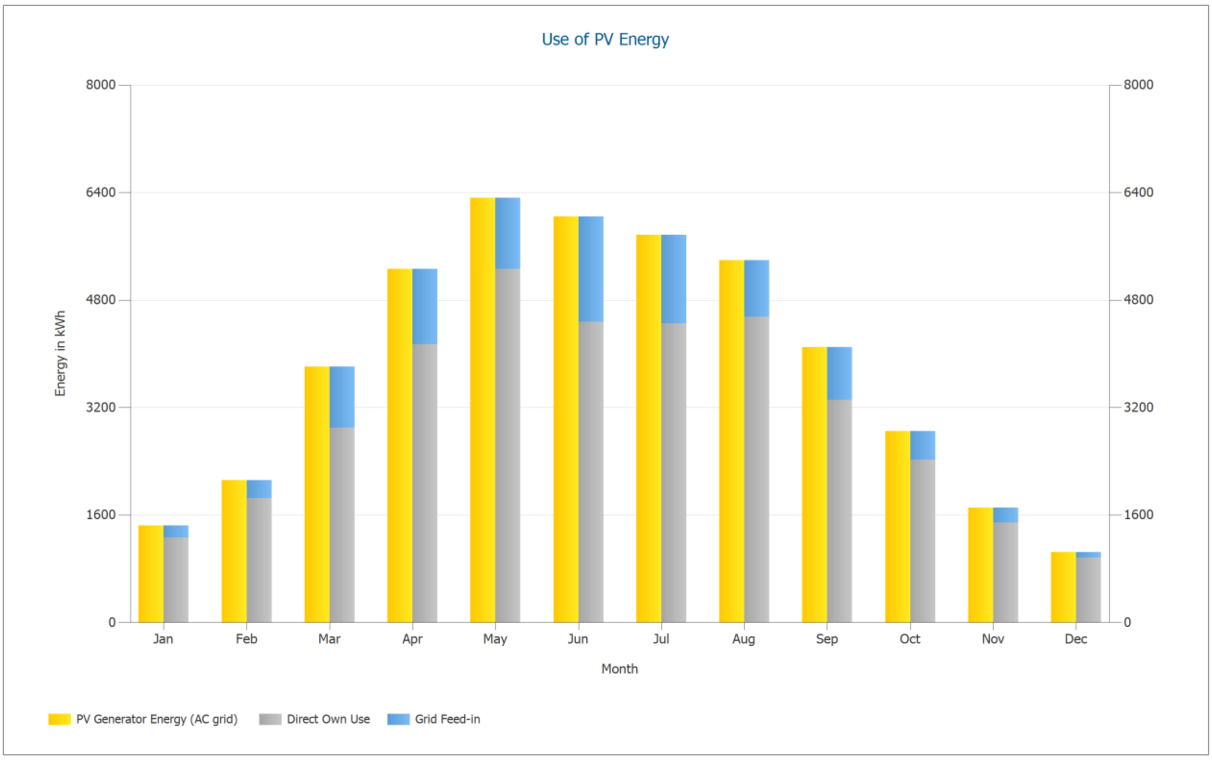
PV System

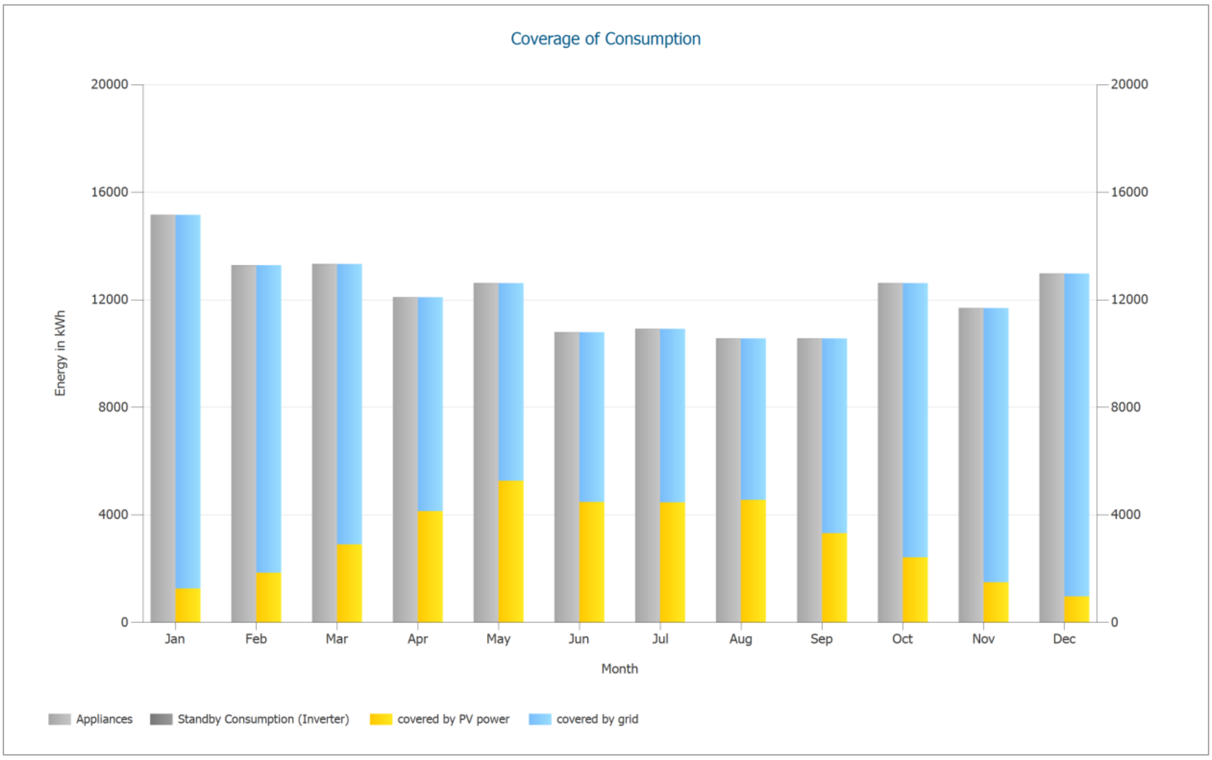
PV Generator Output	49.5	kWp
Spec. Annual Yield	926.47	kWh/kWp
Performance Ratio (PR)	87.2	%
PV Generator Energy (AC grid)	45,860	kWh/Year
Own Consumption	37,080	kWh/Year
Grid Feed-in	8,781	kWh/Year
Down-regulation at Feed-in Point	0	kWh/Year
Own Power Consumption	80.9	%
CO_2 Emissions avoided	17,427	kg / year

Appliances

Appliances	146,500	kWh/Year
Standby Consumption (Inverter)	38	kWh/Year
Total Consumption	146,538	kWh/Year
covered by PV power	37,080	kWh/Year
covered by grid	109,459	kWh/Year
Solar Fraction	25.3	%




Use of PV Energy
Energy in kWh
8000
6400
4800
3200
1600
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
PV Generator Energy (AC grid)
Direct Own Use
Grid Feed-in


Coverage of Consumption
Energy in kWh
20000
16000
12000
8000
4000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Appliances
Standby Consumption (Inverter)
covered by PV power
covered by grid

A1.3.2.9 Rooftop SME commercial/local authority

Climate Data

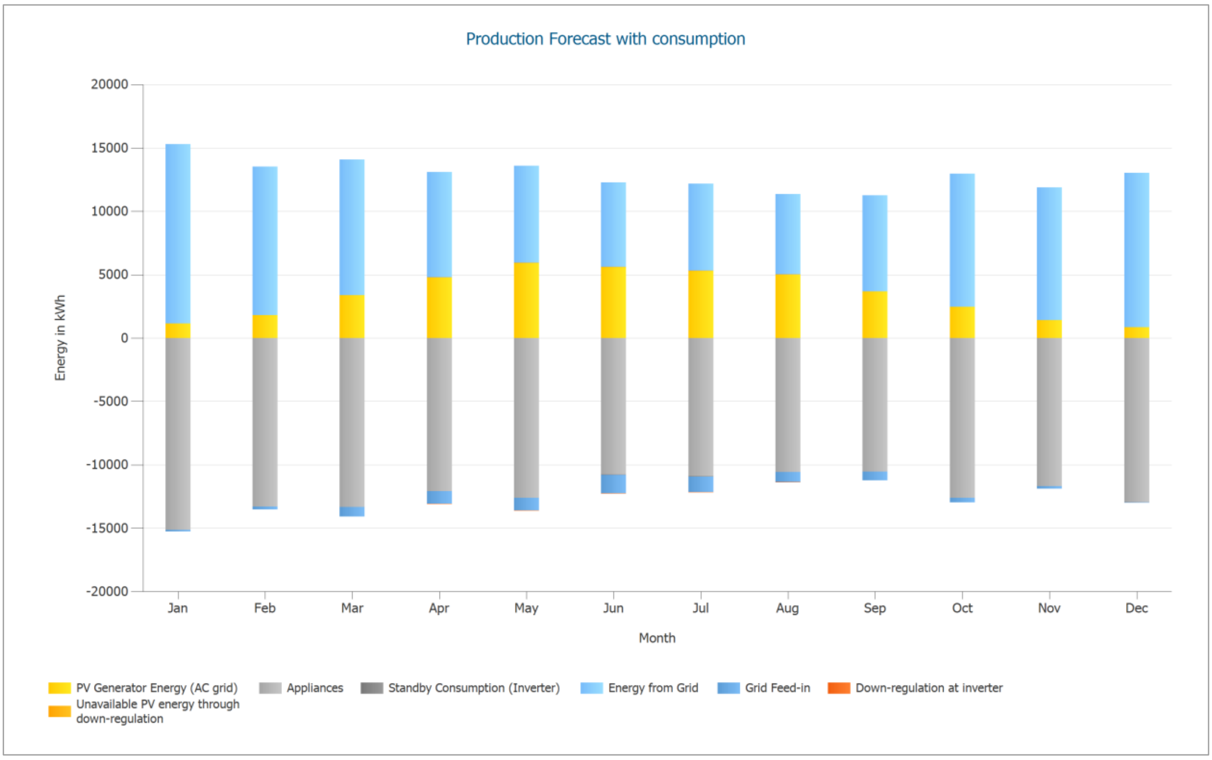
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

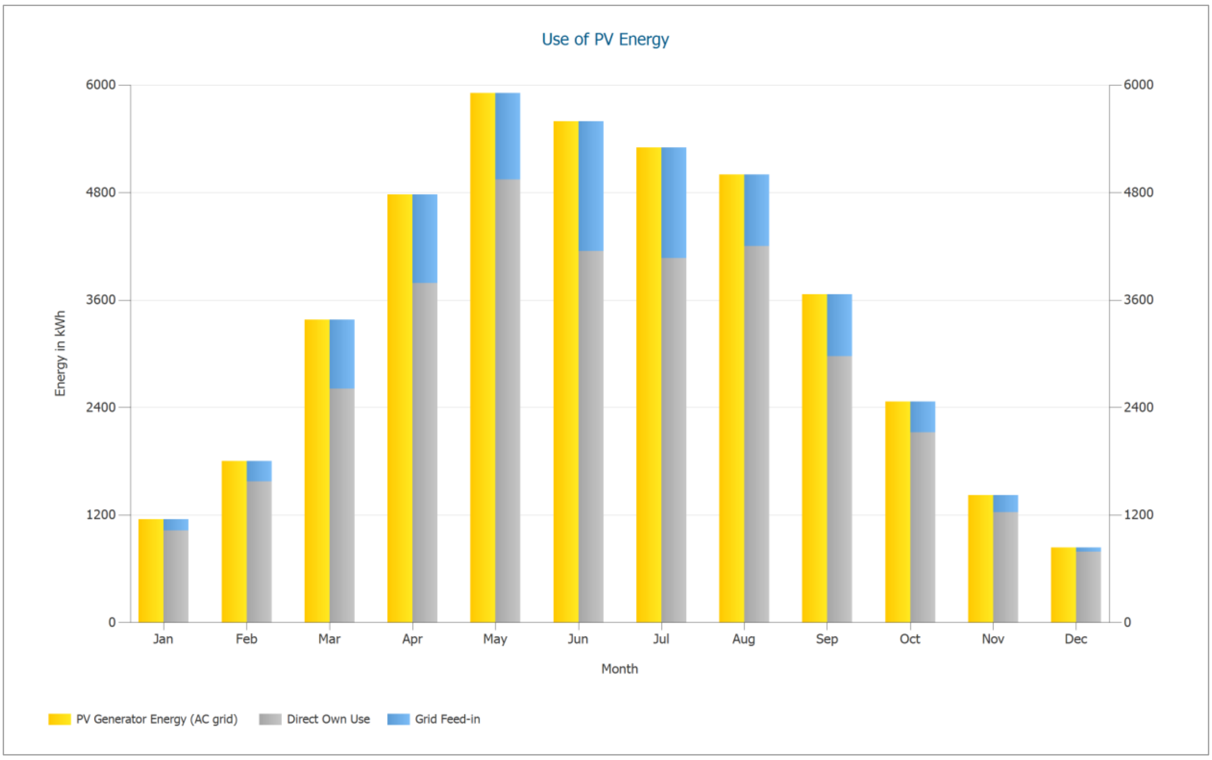
PV System

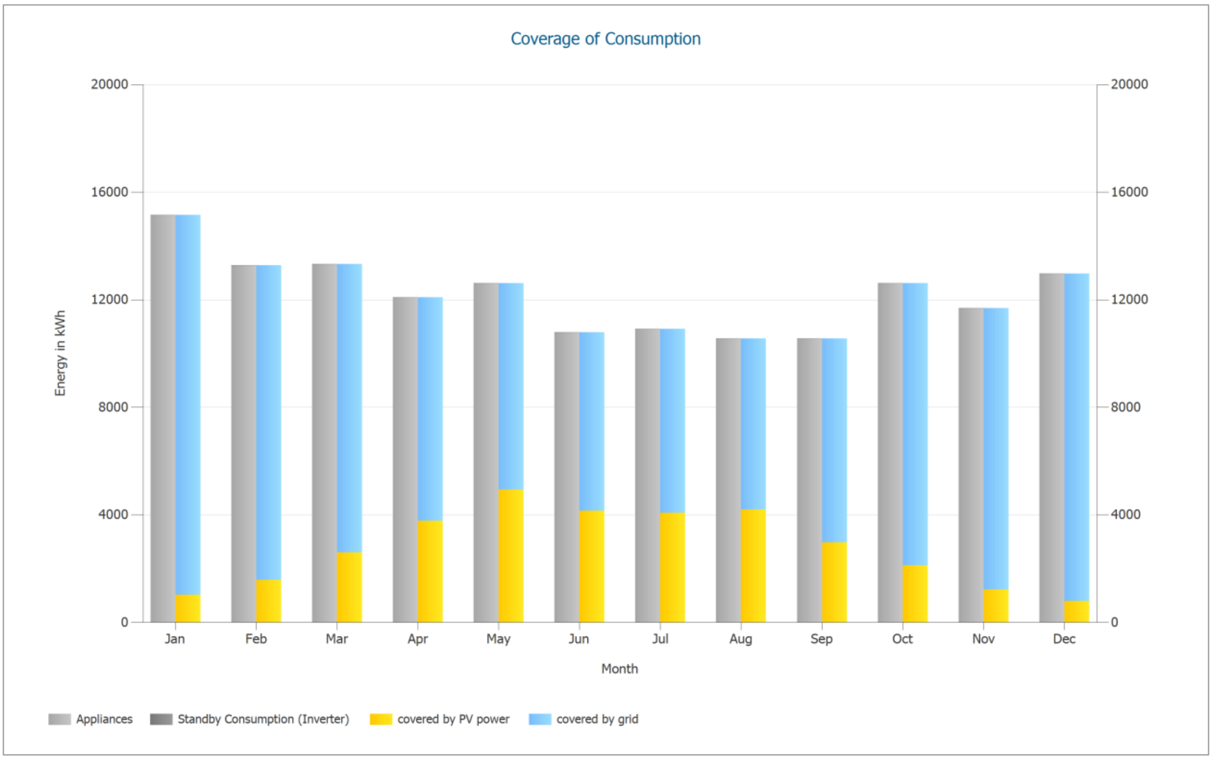
PV Generator Output	49.5	kWp
Spec. Annual Yield	834.48	kWh/kWp
Performance Ratio (PR)	84.1	%
PV Generator Energy (AC grid)	41,307	kWh/Year
Own Consumption	33,473	kWh/Year
Grid Feed-in	7,833	kWh/Year
Down-regulation at Feed-in Point	0	kWh/Year
Own Power Consumption	81.0	%
CO_2 Emissions avoided	15,697	kg / year

Appliances

Appliances	146,500	kWh/Year
Standby Consumption (Inverter)	38	kWh/Year
Total Consumption	146,538	kWh/Year
covered by PV power	33,473	kWh/Year
covered by grid	113,066	kWh/Year
Solar Fraction	22.8	%




Use of PV Energy
Energy in kWh
6000
4800
3600
2400
1200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
PV Generator Energy (AC grid)
Direct Own Use
Grid Feed-in


Coverage of Consumption
Energy in kWh
20000
16000
12000
8000
4000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Appliances
Standby Consumption (Inverter)
covered by PV power
covered by grid

A1.3.2.10Ground-mount SME industrial

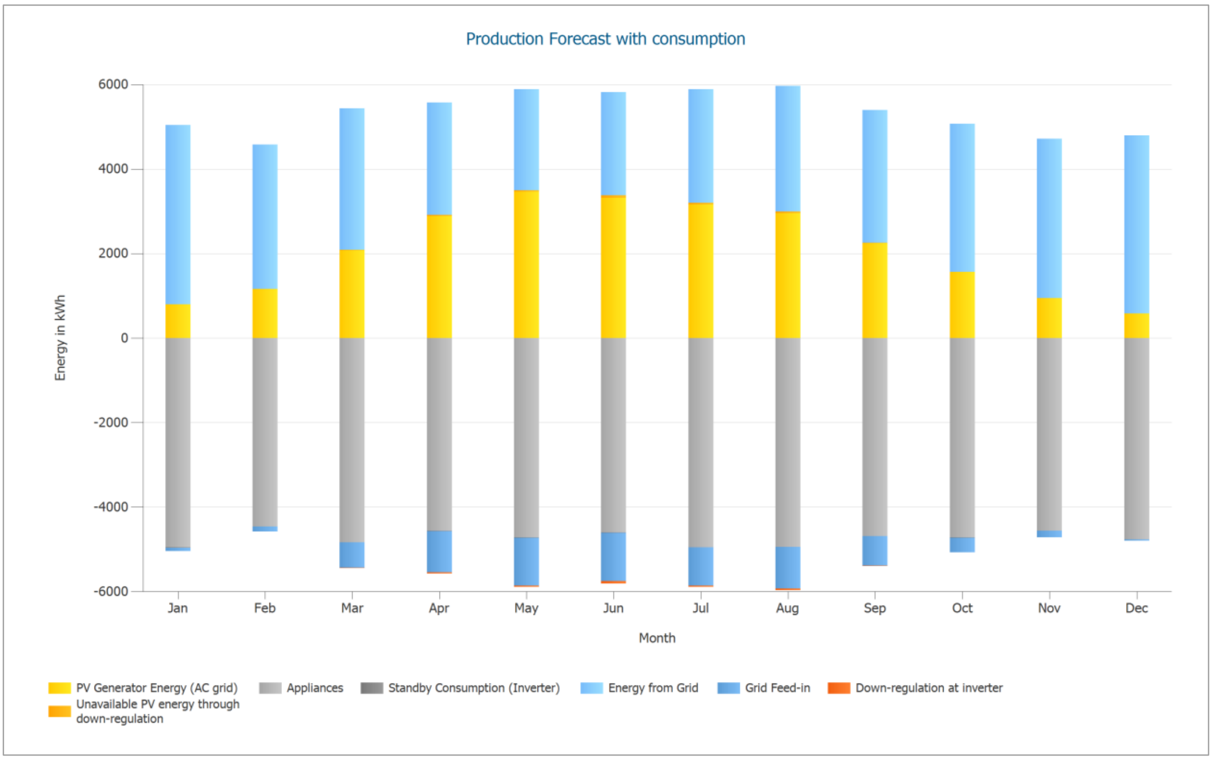
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

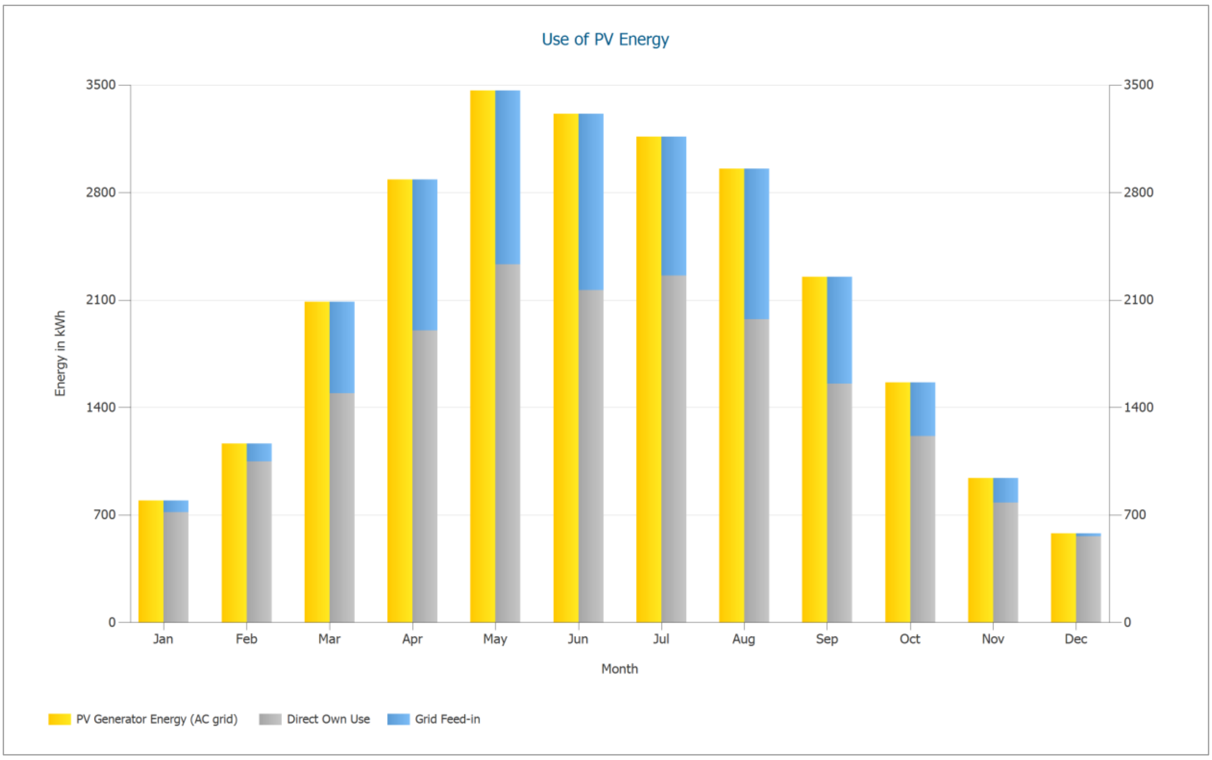
PV System

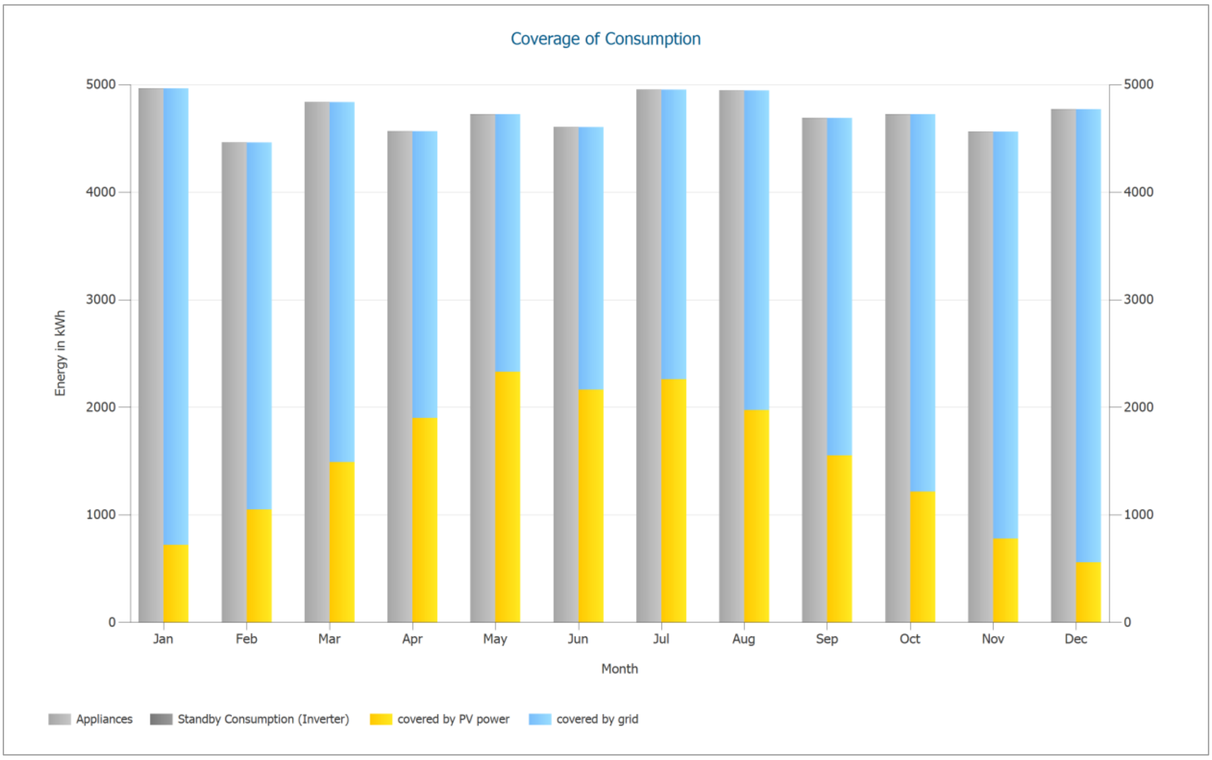
PV Generator Output	27.1	kWp
Spec. Annual Yield	929.96	kWh/kWp
Performance Ratio (PR)	87.5	%
PV Generator Energy (AC grid)	25,165	kWh/Year
Own Consumption	18,000	kWh/Year
Grid Feed-in	7,165	kWh/Year
Down-regulation at Feed-in Point	0	kWh/Year
Own Power Consumption	71.5	%
CO_2 Emissions avoided	9,563	kg / year

Appliances

Appliances	56,750	kWh/Year
Standby Consumption (Inverter)	41	kWh/Year
Total Consumption	56,791	kWh/Year
covered by PV power	18,000	kWh/Year
covered by grid	38,791	kWh/Year
Solar Fraction	31.7	%




Use of PV Energy
Energy in kWh
3500
2800
2100
1400
700
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
PV Generator Energy (AC grid)
Direct Own Use
Grid Feed-in


Coverage of Consumption
Energy in kWh
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Appliances
Standby Consumption (Inverter)
covered by PV power
covered by grid

A1.3.2.11 Rooftop SME industrial

Climate Data

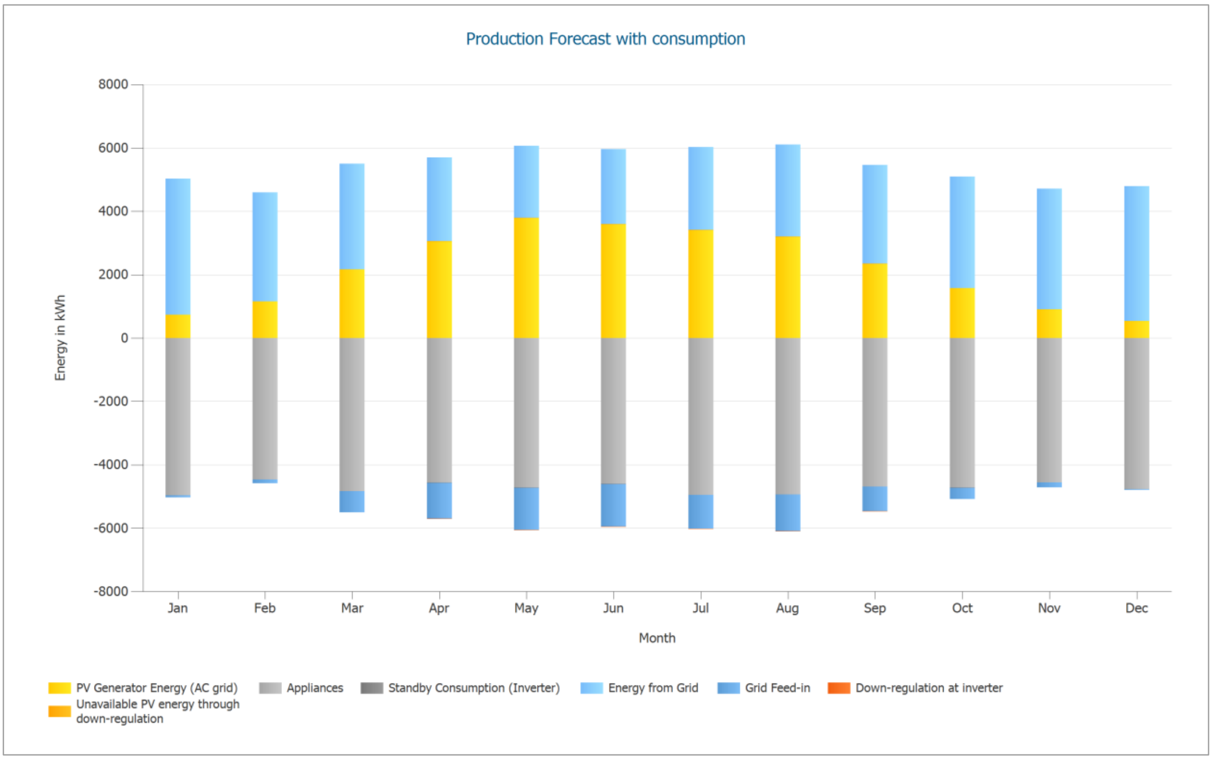
Location	Dublin Airport, IRL (1991 - 2010)
Resolution of the data	1 h
Simulation models used:	
- Diffuse Irradiation onto Horizontal Plane	Hofmann
- Irradiance onto tilted surface	Hay & Davies

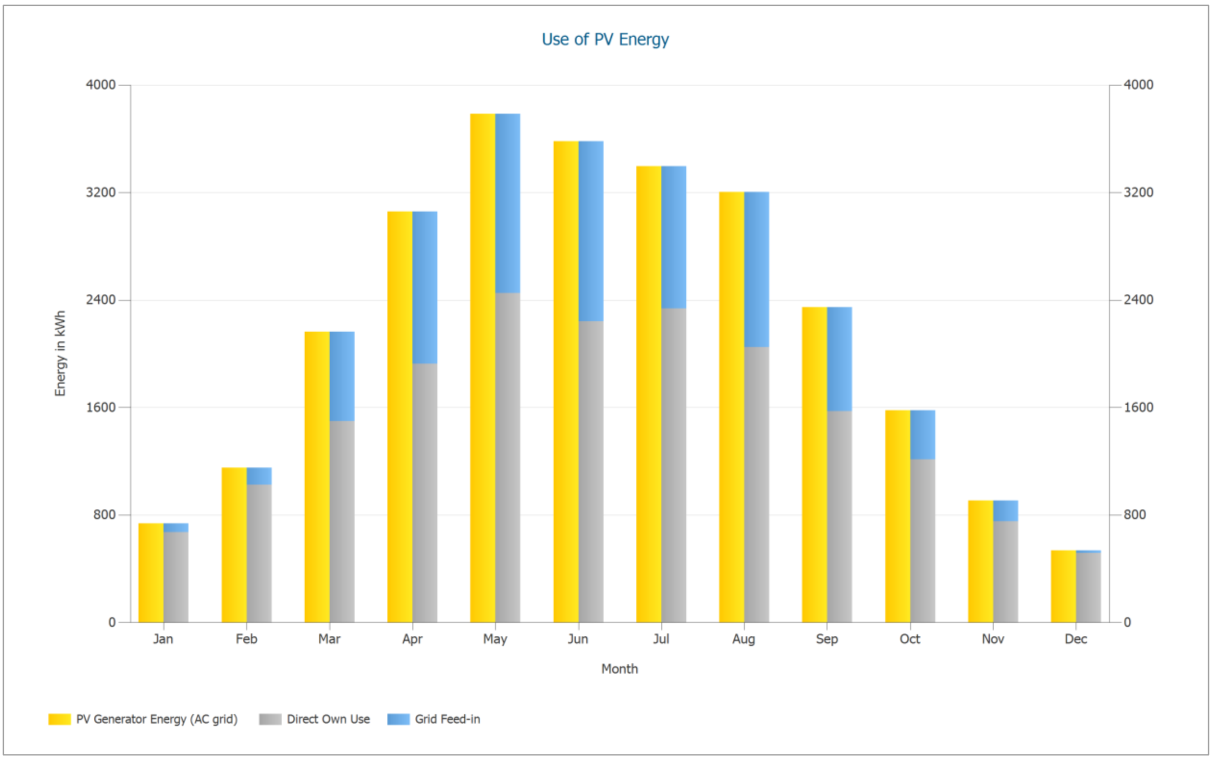
PV System

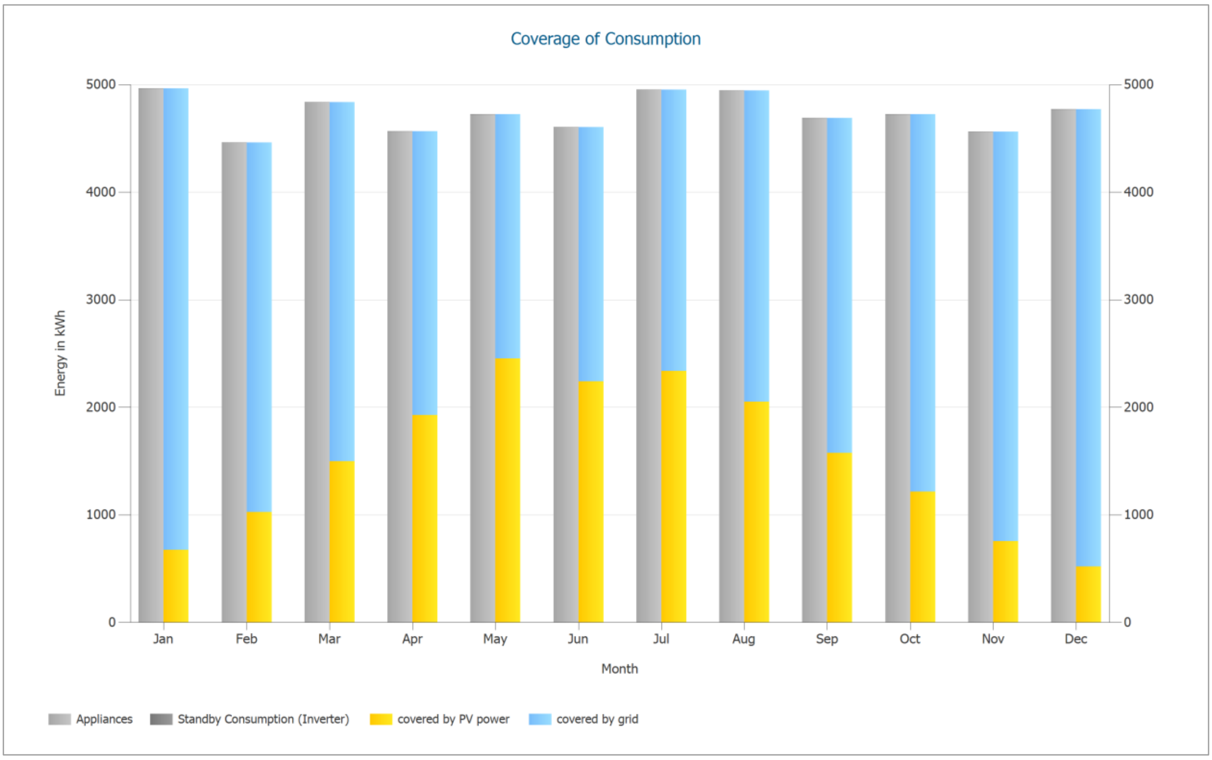
PV Generator Output	31.7 kWp
Spec. Annual Yield	834.69 kWh/kWp
Performance Ratio (PR)	84.1 %
PV Generator Energy (AC grid)	26,443 kWh/Year
Own Consumption	18,265 kWh/Year
Grid Feed-in	8,178 kWh/Year
Down-regulation at Feed-in Point	0 kWh/Year
Own Power Consumption	69.1 %
CO_2 Emissions avoided	10,048 kg / year

Appliances

Appliances	56,750 kWh/Year
Standby Consumption (Inverter)	40 kWh/Year
Total Consumption	56,790 kWh/Year
covered by PV power	18,265 kWh/Year
covered by grid	38,526 kWh/Year
Solar Fraction	32.2 %




Use of PV Energy
Energy in kWh
4000
3200
2400
1600
800
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
PV Generator Energy (AC grid)
Direct Own Use
Grid Feed-in


Coverage of Consumption
Energy in kWh
5000
4000
3000
2000
1000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Appliances
Standby Consumption (Inverter)
covered by PV power
covered by grid

The wind and hydro generation hourly profiles as well as the assumed hourly demand profiles have been determined in sections A1.3.2.1 and A1.3.2.2.

The following example uses hydro for the SME commercial sector to demonstrate the methodology used to determine the capacity for 70% self-consumption.

Figure 7-3 - Hydro SME commercial sizing optimisation

C	E	F	G	H	I	J
146,500.00	83220.00	70.40%	105.64%	29.60%		
SME com demand	Adjusted 1kW generation	Used on site	Imported	Exported/constrained	Hydro performance metric	Value
6.98	7.60	6.98	0.00	0.62	Capacity factor (%)	50%
6.98	7.60	6.98	0.00	0.62	Hours in the year (hours)	8760
6.98	7.60	6.98	0.00	0.62	Capacity (kW)	19
6.98	7.60	6.98	0.00	0.62	Annual generation	83220

Column C is the hourly demand whilst Column E represents the hourly generation. The used-on site figure is calculated that if the generation is bigger than demand, we use the demand, if not we use the generation as 'used on site'. The imported figure is calculated that if the demand – generation is greater than 0, we use demand – generation, if not, use 0. The export is calculated that is generation – demand is greater than 0, we use generation, if not, use 0. The metrics such as capacity factor and capacity are linked to the table so that a manual adjustment to these adjusts the entire generation and therefore the used-on site, imported/exported power figure. The capacities were manually adjusted until a self-consumption of approximately 70% in cell F1 was achieved. Below detail the hydro and wind capacities/assumptions required for around 70% self-consumption.

Figure 7-4 - Wind and hydro self-consumption analysis

Wind generation	Demand	Required capacity for 70% self consumption (kW)	Annual generation of capacity required (kWh)	% of self consumption
Small agriculture	3,000	2.00	3,942	71%
Large agriculture	19,000	8.00	15,768	70%
School	28,000	11.00	21,681	70%
SME-commercial	146,500	38.00	74,898	70%
SME-industrial	56,750	15.00	29,565	69%
Local authority	146,500	38.00	74,898	70%
Hydro	**Demand**	**Required capacity for 70% self consumption (kW)**	**Annual generation of capacity required (kWh)**	**% of self consumption**
Domestic	5,219	1.50	6,570	72%
Small agriculture	3,000	0.90	3,942	70%
Large agriculture	19,000	5.00	21,900	69%
School	28,000	5.50	24,090	71%
SME-commercial	146,500	19.00	83,220	70%
SME-industrial	56,750	7.50	32,850	70%
Local authority	146,500	19.00	83,220	70%

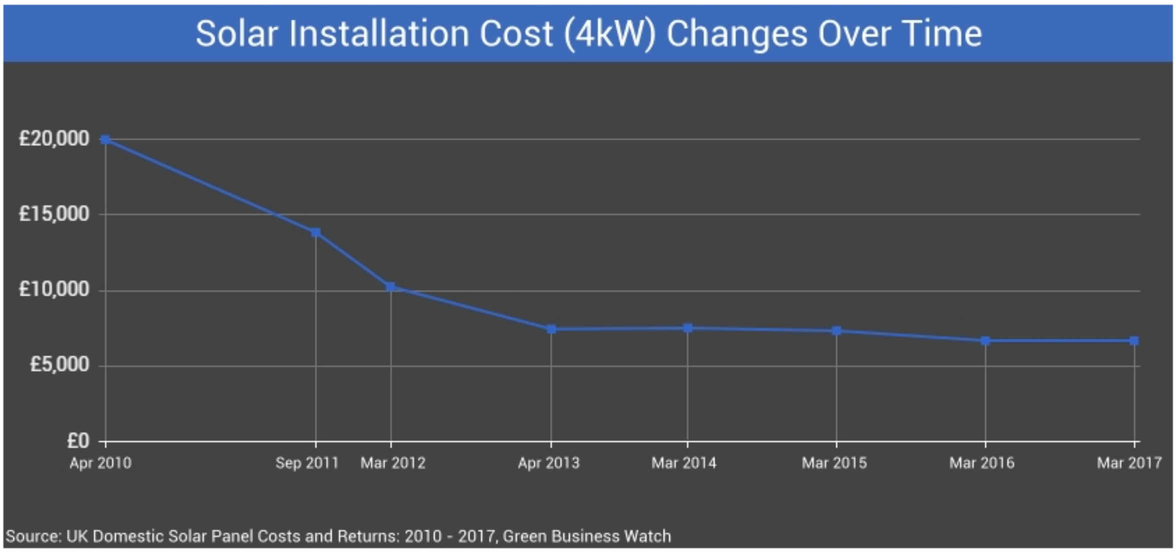
A1.3.3 Cost assessment

To complete the cost assessment a mix of costs from published studies, cost figures provided by SEAI and engagement with the supply chain were used.. The learning rates applied for the period 2020-2030 were also taken from published reports. Where possible, Irish technology cost data is used for greater accuracy. Where Irish costs are not readily available, approximations from UK and European studies were used, with scaling factors applied, as recommended by DECC, to represent forecast costs in Ireland.

CAPEX figures for domestic solar PV vary considerably. This is not surprising given that it is a relatively new market. A range of sources provided show varying 2020 CAPEX costs for domestic PV between €1,800-€2,500/kW[91] [92] [93], with the upper estimate of €2,500/kW provided by SEAI. It is expected by DECC that the 2020 CAPEX is at the lower end of this range at approximately €2,180. DECCThis is especially true considering findings from literature[91] [92] demonstrate the 2016/17 domestic PV CAPEX at approximately €2,100/kW.

It is estimated that the learning rate for domestic schemes will result in costs decreasing by 20% in the period 2020-2030. This is based on learning rates from Irish case studies[91] and UK examples since the introduction of the FiT[94]. It is not expected that there will be a linear reduction in capital costs throughout the period, rather the period 2020-2025 will witness the largest cost decrease as similar to the cost decrease in the UK in the first 3 years of the FiT (image below). As a result, it is modelled that 75% of the 2020-2030 cost decrease will be witnessed up until 2025 even with the scheme starting at the earliest of June 2021.

Figure 7-5 – Cost decrease of 4kW domestic rooftop PV scheme over time[95]



91 SEAI (2017) *Ireland's Solar Value Chain Opportunity*. Available at https://www.seai.ie/publications/Solar-Chain-Opportunity-report.pdf
92 KPMG (2015) *A Brighter Future: Solar PV in Ireland*. Available at https://resources.solarbusinesshub.com/solar-industry-reports/item/a-brighter-future-solar-pv-in-ireland
93 SEAI data provided demonstrating a range of capital costs for both domestic and non-domestic systems using costs from the SEAI solar grant scheme, of an average capital cost of €2,500/kW.
94 Solar PV cost data for range of different years available from UK Government: https://www.gov.uk/government/statistics/solar-pv-cost-data
95 GreenBusinessWatch. 2017. UK Domestic Solar Panel Costs and Returns 2014-2017. Available from: https://greenbusinesswatch.co.uk/uk-domestic-solar-panel-costs-and-returns-2010-2017

The literature review identified that rooftop schemes have marginally higher OPEX compared with ground-mount schemes due to less accessibility (e.g. roof space requiring scaffolding works and extra time for inspection)[96]. Annual OPEX is typically 2.5-3% of the CAPEX cost[41], however the figures were considered too high for smaller schemes. Revised figures were determined in discussion with DECC and are presented in Table 7-27. The OPEX is largely to cover the costs of replacing inverters over the life of the subsidy (one replacement) with a nominal value of €10/kW for all solar archetypes. It is recognised that inverters are likely to be replaced at least once more during the life of the panels.

Table 7-27 – 0-3kW domestic rooftop PV CAPEX and OPEX 2020-2030

Year	0-3kW domestic CAPEX (€/kW)	0-3kW domestic OPEX (€/kW/year)
2020	2,180	10.0
2021	2,115	9.7
2022	2,049	9.4
2023	1,984	9.1
2024	1,918	8.8
2025	1,853	8.7
2026	1,831	8.6
2027	1,809	8.5
2028	1,788	8.4
2029	1,766	8.2
2030	1,744	10.0

The 3-11kW banding for small non-domestic roof solar (medium rooftop solar) assumes a 2020 CAPEX of €1,530/kW. This is based on UK data showing 4-10kW schemes are approximately 20% less on a £/kW basis[94]. Irish data also demonstrates commercial rooftops are around 20% less commercial ground mount of a similar size on a €/kW basis but these are for larger commercial rooftops at around 200kW. Because grid connection is a large fixed cost of Irish schemes, it is assumed the 3-11kW banding is approximately 25% less than the 0-3kW banding on a €/kW basis. After recommendations from DECC it was determined that the3-11kW small rooftop CAPEX figure is €1,530/kW.

As with the domestic scheme, an applied learning rate from 2020-2030 will see costs decrease by 20% on 2020 costs with 75% of the cost reduction witnessed in the period 2020-2025 with the 2020 OPEX at €10/kW.

Table 7-28 - 3-11kW commercial rooftop PV CAPEX and OPEX 2020-2030

Year	3-11kW commercial	3-11kW commercial rooftop

[96] Tsiropoulos I, Tarvydas, D, Zucker, A. (2018). Cost development of low carbon energy technologies - Scenario-based cost trajectories to 2050. 2017 edition. Publications Office of the European Union. Available at https://publications.jrc.ec.europa.eu/repository/bitstream/JRC109894/cost_development_of_low_carbon_energy_technologies_v2.2_final_online.pdf

	rooftop CAPEX (€/kW)	OPEX (€/kW/year)
2020	1,530	10.0
2021	1,484	9.7
2022	1,438	9.4
2023	1,392	9.1
2024	1,346	8.8
2025	1,301	8.7
2026	1,285	8.6
2027	1,270	8.5
2028	1,255	8.4
2029	1,239	8.2
2030	1,224	10.0

The large rooftop (11-50kW) archetype assumes a 2020 CAPEX of €1,300/kW. This is based on the fact that UK shows that 10-50kW schemes are approximately 10-15% less on a €/kW basis than smaller non-domestic schemes. As with the other solar bandings, the study assumes a cost decrease of 20% in the period 2020-2030 with 75% of the cost decrease witnessed up until 2025 with the 2020 OPEX at €10/kW.

Table 7-29 – 11-50kW commercial rooftop PV CAPEX and OPEX 2020-2030

Year	11-50kW commercial rooftop CAPEX (€/kW)	11-50kW commercial rooftop OPEX (€/kW/year)
2020	1,300	10.0
2021	1,261	9.7
2022	1,222	9.4
2023	1,183	9.1
2024	1,144	8.8
2025	1,105	8.7
2026	1,092	8.6
2027	1,079	8.5
2028	1,066	8.4
2029	1,053	8.2
2030	1,040	10.0

A literature review indicated that ground-mounted schemes are generally cheaper on a €/kW basis as they do not require the same degree of installation costs (e.g. from labour and scaffolding) with much easier access and no structural assessments. Data indicates[9192] that equivalent roof mounted schemes are approximately 20% less on a €/kW basis than roof-mounted schemes. However, data provided by SEAI DECC indicated that a small ground-mount scheme costs approximately €300/kW more than a similar size rooftop scheme due to large costs of racking/mounting. This increase in costs was applied in this study.

The literature also suggests a 2020-2030 cost reduction of 20% and assumes that 75% of this cost reduction is witnessed in the period 2020-2025 as in rooftop schemes.

OPEX is typically assumed as an annual cost of 2% of yearly CAPEX as literature suggests slightly lower OPEX cost than rooftop schemes[96]. As discussed with other archetypes however, OPEX is assumed as at a 2020 cost of €10/kW.

Table 7-30 - 0-11kW commercial ground-mount PV CAPEX and OPEX 2020-2030

Year	0-11kW commercial ground-mount CAPEX (€/kW)	0-11kW commercial ground-mount OPEX (€/kW/year)
2020	1,830	10.0
2021	1,775	9.7
2022	1,720	9.4
2023	1,665	9.1
2024	1,610	8.8
2025	1,556	8.7
2026	1,537	8.6
2027	1,519	8.5
2028	1,501	8.4
2029	1,482	8.2
2030	1,464	10.0

It is assumed that the 11-50kW ground-mount systems are €300/kW more than a similar sized rooftop scheme. Therefore the 2020 CAPEX is determined as €1,600/kW. As with the other solar archetypes it is assumed a 20% of cost CAPEX cost reduction in the period 2020-2030 with 75% of this witnessed in the period 2020-2025 whilst the 2020 OPEX is €10/kW.

Table 7-31 – 11-50kW commercial ground-mount PV CAPEX and OPEX 2020-2030

Year	10-50kW commercial rooftop CAPEX (€/kW)	10-50kW commercial rooftop OPEX (€/kW/year)
2020	1,600	10.0
2021	1,552	9.7
2022	1,504	9.4
2023	1,456	9.1

2024	1,408	8.8
2025	1,360	8.7
2026	1,344	8.6
2027	1,328	8.5
2028	1,312	8.4
2029	1,296	8.2
2030	1,280	10.0

A large size range of micro-wind turbines with relevant cost data have been collected and are summarised in the table below.

Table 7-32 – cost data of micro-wind turbines up to 50kW in the UK/Ireland

Turbine capacity (kW)	Cost (£)	CAPEX £/kW
0.5	3,654[97]	7,308
1.5	7,000[97]	4,667
1.8	9,350[97]	5,194
1.9	14,441[97]	7,601
2.4	8,063[97]	3,360
2.5	15,450[97]	6,180
3	12,690[98]	4,230
3	7,440[98]	2,480
5	15,955[98]	3,191
5	25,706[98]	5,141
5	35,000[98]	7,000
5.6	9,414[98]	1,681
7	38,300[98]	5,471
10	45,000[98]	4,500
10	55,250[98]	5,525
15	70,000[98]	4,667
20	63,750[99]	3,188

97 https://www.renewableenergyhub.co.uk/main/wind-turbines/how-much-does-a-wind-turbine-cost/
98 https://www.researchgate.net/publication/320083655_Economic_Analysis_of_Small_Wind_Turbines/figures
99 https://www.researchgate.net/publication/307434882_Small_Wind_Turbines_Specification_Design_and_Economic_Evaluation

25	158,175[100]	6,327
50	277,500[100]	5,550

The capacity banding exercise determines bands of 0-6kW, 6-25kW and 25-50kW. To align with this, the average costs of the 6kW, 25kW and 50kW turbines are determined.

The data demonstrates that micro-wind at 6kW is approximately £4,750-£5,250. Using this estimation as a conservative figure, it is estimated that a 6kW wind turbine costs €5,750/kW.

As with all energy generation technologies, there are economies of scale which mean larger capacity generators are less on a €/kW basis. To account for the smaller machines at the lower end of the 6-25kW banding, it is assumed that the 6-25kW banding has a CAPEX of approximately €5,500/kW as fixed civil and grid costs remain a large proportion of the total capex. A 50kW machine was then determined at approximately 20% less than a 6-25kW machine based on the data collected. This gives a 2020 CAPEX of €4,250/kW.

O&M costs for wind are relatively low due to good reliability. A literature review determined[96] that O&M costs are approximately 2.5% of CAPEX on an annualised basis. This includes costs for major refurbishment throughout the life of the turbine. As a result, it is predicted that wind OPEX is 2.5% of CAPEX for every year in the period 2020-2030.

It is likely large-scale wind costs will decrease by approximately 20% in the period 2020-2030 on a €/kW basis[101][102], although micro-wind schemes are much less likely to experience the same reductions. It is therefore assumed that the cost decrease in the period 2020-2030 is 10% on 2020 prices. It is also predicted that 60% of this cost decrease will manifest in the period 2020-2025. Although uptake is likely to be greater at the beginning of the scheme, micro-wind is not as widely utilised as PV due to a greater range of constraints (e.g. planning). As a result, the cost decrease from 2020-2025 is lower than the 75% assumed from solar. The tables below detail the annual CAPEX and OPEX 2020-2030.

Table 7-33 – 0-6kW micro-wind turbine CAPEX and OPEX costs 2020-2030

Year	0-6kW CAPEX (€/kW)	0-6kW OPEX (€/kW/year)
2020	5,750	115.0
2021	5,681	113.6
2022	5,612	112.2
2023	5,543	110.9
2024	5,474	109.5
2025	5,405	108.1
2026	5,359	107.2
2027	5,313	106.3
2028	5,267	105.3
2029	5,221	104.4

100 https://www.mwps.world/market/offered/1kw-150kw/endurance-e3120-wind-turbine/
101 https://www.ewea.org/fileadmin/files/library/publications/reports/EWEA-Wind-energy-scenarios-2030.pdf
102 https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Oct/IRENA_Future_of_wind_2019.pdf

2030	5,175	103.5

Table 7-34 – 6-25kW micro-wind turbine CAPEX and OPEX costs 2020-2030

Year	6-25kW CAPEX (€/kW)	6-25kW OPEX (€/kW/year)
2020	5,500	137.5
2021	5,434	135.9
2022	5,368	134.2
2023	5,302	132.6
2024	5,236	130.9
2025	5,170	129.3
2026	5,126	128.2
2027	5,082	127.1
2028	5,038	126.0
2029	4,994	124.9
2030	4,950	123.8

Table 7-35 – 25-50kW micro-wind turbine CAPEX and OPEX costs 2020-2030

Year	25-50kW CAPEX (€/kW)	25-50kW OPEX (€/kW/year)
2020	4,250	106.3
2021	4,199	105.0
2022	4,148	103.7
2023	4,097	102.4
2024	4,046	101.2
2025	3,995	99.9
2026	3,961	99.0
2027	3,927	98.2
2028	3,893	97.3
2029	3,859	96.5
2030	3,825	95.6

The banding exercise determines two micro-hydro bandings: 0-6kW (pico hydro) and 6-50kW (micro-hydro). Hydro costings vary significantly from site to site as the costs are very site specific, making forecasts of hydro cost very uncertain.

A range of costs were identified from a literature review:

- for schemes under 5kW the British Hydropower Association estimate costs to be £8,000/kW[103], plus approximately £8,000 for fixed costs.
- for larger projects the literature identified costs in excess of €6,000/kW[104].

The British Hydropower data is considered to be the most representative. Utilising the assumed cost formula applied [105], shows the costs for a small scheme (0-15kW) as £8,000/kW variable costs (turbine) + £8,000 fixed cost (civils). Using this assessment for a 5kW scheme this would generate the following CAPEX:

$$(€9,000/kW \times 5kW) + €9,000 = €54,000$$

Therefore, CAPEX is approximately €11,550/kW for 0-6kW schemes.

15-50kW schemes are typically around 20% less than 0-6kW schemes on a €/kW basis, however they incur a higher fixed cost due so results in a cost differential of around 10-15% on a €/kW basis. It is therefore estimated that a 6-50kW scheme is €9,900/kW including fixed development costs. It should be noted however that this is very site specific, with larger projects globally varying between under €1,000/kW and over €6,000/kW[104]

It is assumed that the decrease witnessed 2020-2030 is likely to be negligible. Hydro is a mature technology and is unlikely to witness much in the way of system efficiency improvements. There may be supply chain improvements reducing installation costs, however with a limited resource in Ireland and limited options for high self-consumption, even with the microgeneration support scheme, it is not expected there will be a significant change in the supply chain. Further, cost curves from the literature for hydro indicate indicated very minimal learning, especially when compared with other technologies[106]. As a result, it is assumed that CAPEX will decrease at a linear rate of €1/kW in the period 2020-2030.

This is largely due to the high reliability of hydro systems detailed in the sector analysis, as well as the fact that there is a lack of fuel inputs as in both solar and wind. The literature suggests anywhere from 0.5-1.5% for micro-hydro schemes[96107]. This assessment determines the annual OPEX as 1% of the CAPEX.

Table 7-36 – Pico hydro 0-6kW CAPEX and OPEX 2020-2030

Year	0-6kW CAPEX (€/kW)	0-6kW OPEX (€/kW/year)
2020	11,550	115.5
2021	11,549	115.5
2022	11,548	115.5
2023	11,547	115.5
2024	11,546	115.5

[103] Western Renewable Energy. N. D. Hydro basics – Financial Aspects. Available from: http://www.westernrenew.co.uk/wre/hydro_basics/financial
[104] EU Commission (2019) *Low Carbon Energy Observatory: Hydropower technology development report*. Available at https://publications.jrc.ec.europa.eu/repository/bitstream/JRC118316/jrc118316_1.pdf (acknowledging that 'mini' scale hydro projects (considered under 1MW) exceed this threshold
[105] Costs from British Hydropower Association (BHA) available at Western Renewable Energy - http://www.westernrenew.co.uk/wre/hydro_basics/financial
[106] Rubin (*et al*, 2015) *A review of learning rates for electricity supply technologies*. Energy Policy. Available at https://www.cmu.edu/epp/iecm/rubin/PDF%20files/2015/Rubin_et_al_Areviewoflearningrates_EnergyPolicy2015.pdf
[107] IRENA (2012) RENEWABLE ENERGY TECHNOLOGIES: COST ANALYSIS SERIES – Hydro Power. Available at https://www.irena.org/documentdownloads/publications/re_technologies_cost_analysis-hydropower.pdf

2025	11,545	115.5
2026	11,544	115.4
2027	11,543	115.4
2028	11,542	115.4
2029	11,541	115.4
2030	11,540	115.4

Table 7-37 - Micro-hydro 6-50kW CAPEX and OPEX 2020-2030

Year	6-50kW CAPEX (€/kW)	6-10kW OPEX (€/kW/year)
2020	9,900	99.0
2021	9,899	99.0
2022	9,898	99.0
2023	9,897	99.0
2024	9,896	99.0
2025	9,895	99.0
2026	9,894	98.9
2027	9,893	98.9
2028	9,892	98.9
2029	9,891	98.9
2030	9,890	98.9

CHP costs vary greatly by the size of the system and type of technology. For example, Stirling engines are much more costly on a €/kW basis, hence they are not used in many commercial, large-scale settings.

The 1kW domestic system CAPEX is approximated at €5,700/kW. This is based on a WhisperGen system costing €3,500/kW plus €600 for installation[108]. As a result, the costs of a condensing boiler given in the same source are added:

Stirling engine cost = (€3,500/kW + €600 installation)

Condensing boiler cost = (€1,200/kW + €400 installation)

Total Stirling engine cost = €4,100/kW + €1,600/kW = €5,700/kW.

Using the CHP sizing tool[109], OPEX is estimated at €120/kW for a 1kW system and the assumption is that this cost is fixed over it's lifecycle.

[108] Conroy (*et* al, 2014) Stirling engine economic/energy performance paper - https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1054&context=engschcivart
[109] CHP sizing tool https://chptools.decc.gov.uk/CHPAssessment/(S(mk02b1zdyrbamwpuymgcpxdq))/default.aspx

From the literature review[110] [111] it was identified that in other jurisdictions there has been an approximate CAPEX reduction of 15%, the learning rate, per doubling of CHP installations in that jurisdiction. Based on analysis of the Irish market, it is expected that there is a 13.9% increase in installations per year[108]. Therefore, it is assumed that the CAPEX decrease of systems over the period 2020-2030 is:

$$(15\% \ x \ 13.9\%)/100\%$$

$$= 2.09\% \text{ annual CAPEX decrease}$$

Table 7-38 - Small micro-CHP CAPEX and OPEX 2020-2030

Year	1-1kW CAPEX (€/kW)	1-1kW OPEX (€/kW/year)
2020	5,700	120
2021	5,581	120
2022	5,465	120
2023	5,351	120
2024	5,239	120
2025	5,130	120
2026	5,023	120
2027	4,918	120
2028	4,816	120
2029	4,715	120
2030	4,617	120

Using the same method as in the small banding, the CAPEX cost for the 5.5-30kQ machine is approximately €2,086[112], whilst the 1-5.5kW banding has a 2020 CAPEX of €4,636/kW[113] with an annual decrease of 2.09% in the period 2020-2030.

The medium (1-5.5.kW) banding OPEX is determined as €65/kW, using figures from the UK CHP sizing tool produce by the UK Government and converting to €[109]. This tool was used as there is a lack of data for micro-CHP in the Ireland. This method is used for all other capacities.

Table 7-39 - Medium micro-CHP CAPEX and OPEX 2020-2030

Year	1-5.5kW CAPEX (€/kW)	1-5.5kW OPEX (€/kW/year)
2020	4,636	57.8
2021	4,539	57.8

110 http://www.code2-project.eu/wp-content/uploads/D2.5-2014-12-micro-CHP-potential-analysis_final.pdf
111 https://www.seai.ie/publications/CHP-Update-2018.pdf
112 https://www.chpqa.com/guidance_notes/CHPQA_UNIT_LIST.pdf
113 https://chptools.decc.gov.uk/CHPAssessment/(S(axkmw0j1opehoshzdmpzrj0h))/default.aspx

2022	4,445	57.8
2023	4,352	57.8
2024	4,261	57.8
2025	4,172	57.8
2026	4,085	57.8
2027	4,000	57.8
2028	3,917	57.8
2029	3,835	57.8
2030	3,755	57.8

Table 7-40 - Large micro-CHP CAPEX and OPEX 2020-2030

Year	5.5-30kW CAPEX (€/kW)	5.5-30kW OPEX (€/kW/year)
2020	2,086	63.4
2021	2,042	63.4
2022	1,999	63.4
2023	1,958	63.4
2024	1,917	63.4
2025	1,877	63.4
2026	1,838	63.4
2027	1,800	63.4
2028	1,762	63.4
2029	1,725	63.4
2030	1,689	63.4

A1.3.4 Carbon abatement

Emissions intensities were provided up until 2040. However, some archetypes operational lifecycles extend beyond this period (e.g. solar). Therefore, 2041-2050 grid emissions intensities were estimated. The table below demonstrates the 2040 grid emissions factor at 146.44gCO_2e/kWh. Although there is a stagnation in grid emissions in the period 2030-2040, it is assumed that 2041-2050 will continue to witness a decrease in emissions despite this stagnation and that the 2050 grid intensity is approximately 130gCO_2e/kWh. This is a conservative estimate based on the fluctuations witnessed over the 10 preceding years, particularly given that the 2050 target is an 80% reduction on the baseline to an intensity of 38gCO_2e/kWh[114]

[114] ESB. N.D. Ireland's low carbon future – dimensions of a solution. Page 27 – Available from: https://www.esb.ie/docs/default-source/Publications/dimensions-of-a-solution---full-report-with-contents-links

Table 7-41 – Projected Irish grid emissions factors 2018 - 2050

Year	Grid emissions factor (gCO_2e/kWh)
2018	359.53
2019	363.16
2020	344.17
2021	301.85
2022	264.31
2023	259.03
2024	243.02
2025	197.58
2026	170.43
2027	162.44
2028	154.74
2029	152.28
2030	145.18
2031	145.05
2032	147.24
2033	148.38
2034	149.02
2035	152.39
2036	145.91
2037	146.75
2038	146.44
2039	147.53
2040	146.44
2041	144.79
2042	143.15
2043	141.51
2044	139.86
2045	138.22
2046	136.58
2047	134.93
2048	133.29

2049	131.64
2050	130.00

Using the domestic solar archetype as an example, the calculation table used below demonstrates the layout for the range of annual emissions offset for the upper and lower capacities in each archetype. Emissions offsets are calculated for each year of the technology operational lifecycle and then totalled for a lifecycle offset of emissions.

Technology option	Metric	2020
Rooftop_domestic_solar	Grid emissions factor (gCO2e/kWh)	344.17
	Assumed lifecycle of technology (years)	30
	Lower threshold capacity (kW)	1
	Lower capacity band threshold annual generation of option (kWh)	799
	Lower threshold annual offset of emissions (tCO2e)	0.27
	Lower threshold lifecycle offset of emissions (tCO2e)	3.73
	Upper threshold capacity (kW)	3
	Upper capacity band threshold annual generation of option (kWh)	2397
	Upper threshold annual offset of emissions (tCO2e)	0.82
	Upper threshold lifecycle offset of emissions (tCO2e)	11.19

Below demonstrates the carbon abatement for the domestic CHP (lower 1kW band in the small micro-CHP archetype). This is different calculation than the other technologies as it incorporates the emissions from fuel combustion. Note that the Gross Caloric Value (GCV) for natural gas is obtained from the BEIS 2020 emissions factors[115]. The offset of emissions for CHP is calculated as:

(Grid emissions factor *x* annual electricity generation + heat generation/0.81 *x* natural gas GCV – fuel input *x* heat generation)/1,000,000

Using the figures, this is represented as:

(344.17 *x* 1,395 + 13,500/0.81 *x* 184-17,647 *x* 184)/1,000,000

= 0.2996tCO_2e

115 BEIS 2020 emissions factors - https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020

Technology option	Metric	2020
CHP Domestic	Grid emissions factor (gCO2e/kWh)	344.17
	Emissions factor for natural gas g/kWh (GCV)	184
	Assumed lifecycle of technology (years)	15
	Lower threshold electrical capacity (kW)	1.00
	Lower capacity band threshold annual electricity generation of option (kWh)	1,395
	Lower capacity band threshold annual heat generation of option (kWh)	13,500
	Lower capacity band threshold annual fuel input of option (kWh)	17,647
	Lower threshold annual offset of emissions (tCO2e)	0.2996
	Lower threshold lifecycle offset of emissions (tCO2e)	1.46
	Upper threshold electrical capacity (kW)	1
	Upper capacity band threshold annual electricity generation of option (kWh)	1,395
	Upper capacity band threshold annual heat generation of option (kWh)	13,500
	Upper capacity band threshold annual fuel input of option (kWh)	17,647
	Upper threshold annual offset of emissions (tCO2e)	0.30
	Upper threshold lifecycle offset of emissions (tCO2e)	1.46

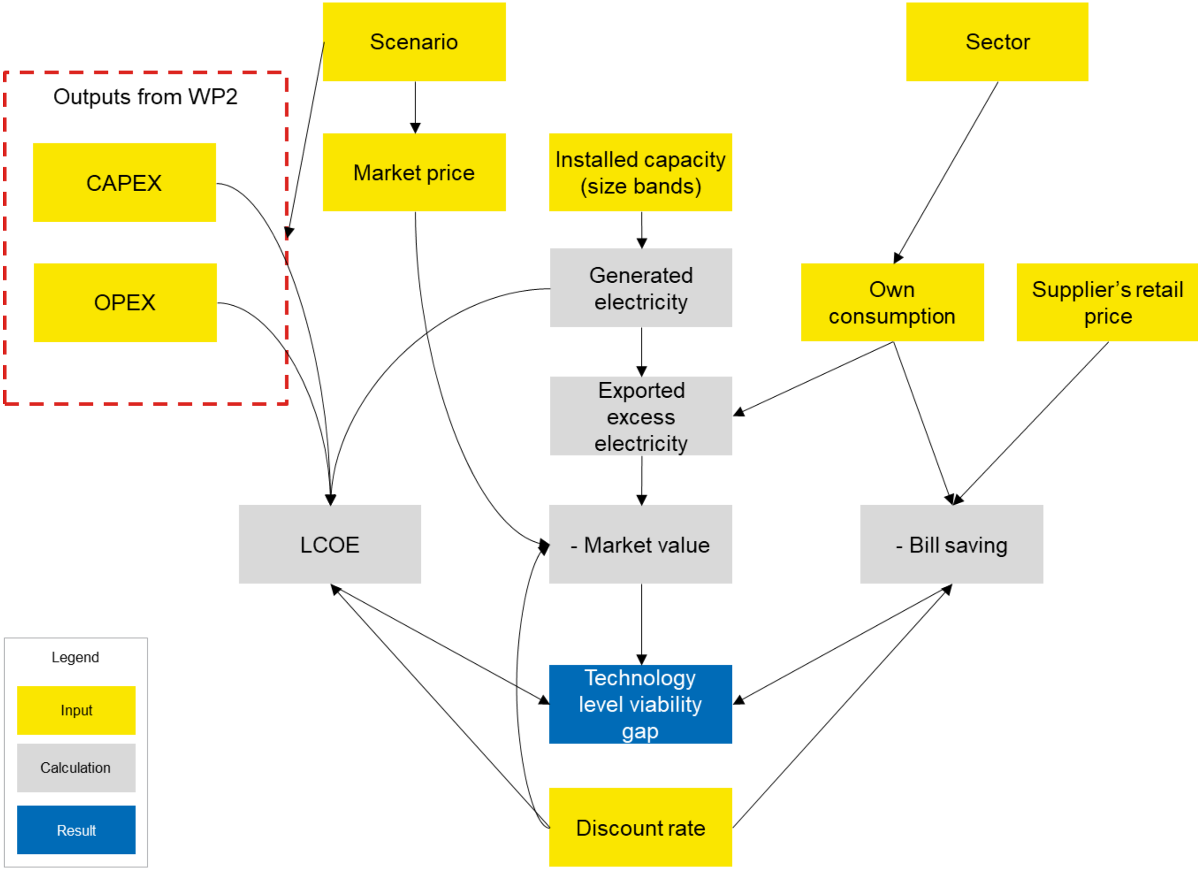
A1.4 Viability gap assessment and cost of policy options

A1.4.1 Methodology

To forecast key elements of the viability gap assessment, such as the levelized cost of electricity (LCOE) and bill saving, a flexible MS-Excel based financial model (the Model) was developed. To calculate the levelized parameters of the viability gap, the Discounted Cash Flow (DCF) method has been applied. All costs and revenues were expressed in real terms (i.e. in 2020 euros).

The structure of the Model is presented on the figure below.

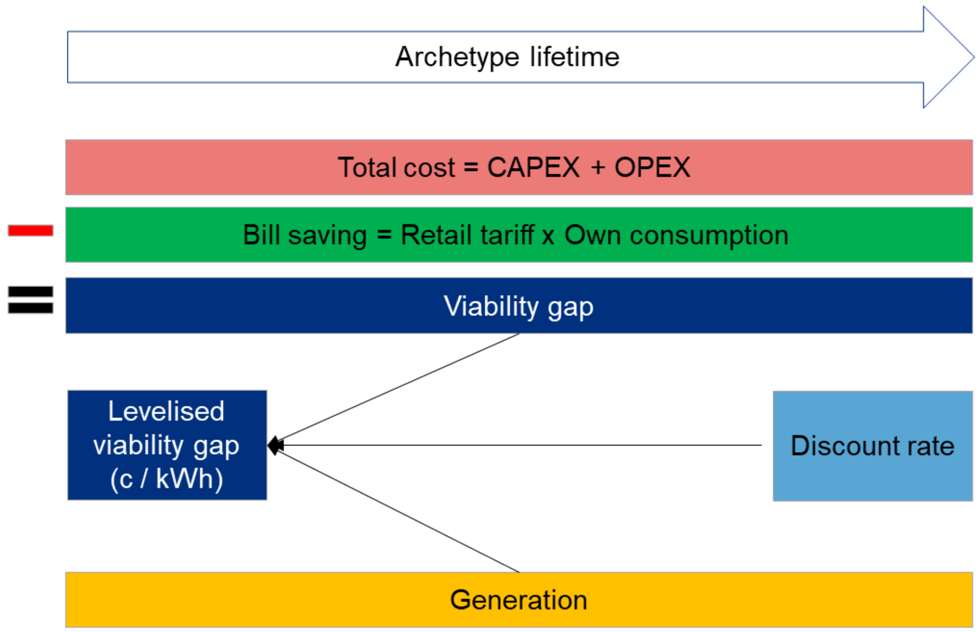
Figure 7-6 - Modules of the financial model



As a first step, the main assumptions have been set and the outputs have been modelled for the 'Base case' scenario. The main results of the Model were calculated with a cash flow analysis for the duration of the lifetime of the archetype. The analytical framework in this assessment consisted of two core components: the total costs over the lifetime and the value of self-consumption (i.e. the savings to the prosumer from not having to buy the electricity from a supplier).

The annual viability gaps and generation of the archetype were discounted to present value at each year of the analysis (2021-2030) assuming the given year as the installation date for the technology. It was assumed that all installations in a particular year started to generate from the next year. The unit viability gap (i.e. 2020 EUR/kWh) was calculated as a ratio of total discounted viability gap and the total discounted generation. To show the full cost, it was assumed that the costs for domestic archetypes include VAT. The framework is shown on the following chart.

Figure 7-7 - Analytical framework for the assessment of viability gaps



The next step was undertaking a sensitivity analysis which is a powerful tool to assess the impact of possible future events (e.g. change in the key assumptions) on the viability gap as they do not try to show one exact picture of the future, but rather a range of outcomes.

To calculate the self-consumption savings on purchased electricity, ‘High price’ and ‘Low price’ trajectories were provided by the Sustainable Energy Authority of Ireland (SEAI). The trajectories were sourced from SEAI’s National Energy modelling Framework (NEMF) projections. This is a collaborative annual project involving the Economic % Social Research Institute’s (ESRI) Ireland Environment, Energy and Economy (I3E) macro-economic model, SEAI’s energy models and the Environmental Protection Agency’s (EPA) emissions inventory models. The modelling is undertaken in close collaboration and for direct output for DECC. The outputs for input to this report, wholesale price projections and retail price projection, are a cumulation of modelling in SEAI’s NEMF, made up of efficiency, heat, transport and electricity models. The projections used in this instance are submitted as part of Ireland’s Final National Energy and Climate Plan (NECP), on the back of the Government’s Climate Action Plan 2019. The two prices trajectories serve the purpose to provide insights on a range of potential future outcomes between a low price scenario (BEIS low 2019) or a high price scenario (EU Ref 2016). The fuel price is a key macro driver driving demand projection from ESRI’s I3E model for input into SEAI’s energy models i.e. a low fuel price trajectory will forecast a higher demand than a high fuel trajectory, which in turn drives more effort needed to decarbonise for a fixed % RES target. Also, the financial incentive to switch in a low price fuel trajectory is less than in a high price one.

The opportunity cost of investing in a comparable investment is captured in the discount rates. To set a level playing field, DECC requested to use the same discount rate for all archetype. As a result of the research and optimisation process DECC suggested a 3.75% discount rate in the Base case.

After the viability gaps have been modelled, we used the aggregated viability gaps as a proxy for the cost of the policy options. As a first step, we set up the revenue inputs in the model to reflect the design of the revenue streams by policy options set out in 5.1. We then used the uptake scenarios (the installed capacities per archetype) and the cost and performance inputs to model the total generation, the total costs and the total value of the bill saving per archetype and per installation year. Considering the value of the potential payments over the exported electricity (market value), we calculated the required subsidy levels (target subsidies) for each policy option to bridge the viability gap. To model a technology neutral scheme, a uniform target subsidy level was set building on the viability gap assessment.

With the target subsidies we then calculated the aggregated subsidy payments which were considered as a proxy for estimating the cost of the policy options. The cost of the policy options was calculated per installation year (from 2021 to 2030) as a discounted value of all subsidy payments under a certain policy option over the whole subsidy life for all archetypes installed in that year. As the cost of the policy options was modelled from the public perspective, we found it appropriate using the social discount rate (4% real under the Public Spending Code).

A1.4.2 Assumptions

During the preparation of the Model, a number of assumptions have been made for the viability gap assessment and for the policy cost estimates. Some of them are related to the timeline:

Table 7-42 - Timeline assumptions

Section	Timeline
Model start date	1 January 2021
Phase 1 of new policy scheme	1 July 2021 – 31 December 2025
Phase 2 of new policy scheme	1 January 2026 – 31 December 2030
Forecast period (to match the maximum archetype lifetime)	1 January 2031 – 31 December 2060 (30 years)

Other main assumptions are set out in the following table. The detailed cost and performance data were taken from A1.3.

Table 7-43 - Main assumptions

Description	Assumption	Source	Further details
Long-term inflation	1.6%	ECB[116] (accessed on 5 Aug 2020)	Year on year percentage change in the euro area all items Harmonised Index of Consumer Prices (HICP)
Discount rate – real, pre-tax	3.75%	DECC	Used to calculate the viability gaps for all archetypes
Social discount rate - real	4%	Department of Public Expenditure and Reform, Government of Ireland[117]	Social discount rate which is recommended to be used in cost-benefit and cost-effectiveness analyses of public sector projects. Used to discount the required subsidy payments to the year of installation.
Retail electricity prices - residential	See separate trajectory	SEAI	As last data provided for 2045, this data was

[116] European Central Bank. 2020. HICP Inflation forecasts. Available from: https://www.ecb.europa.eu/stats/ecb_surveys/survey_of_professional_forecasters/html/table_hist_hicp.en.html
[117] Ireland Government. 2019. Project Evaluation/Appraisal: Applicable rates. Department of Public Expenditure and Reform. Available from: https://www.gov.ie/en/policy-information/1a0dcb-project-discount-inflation-rates/?referrer=http://www.per.gov.ie/en/project-discount-inflation-rates/

Description	Assumption	Source	Further details
			used for the remaining years of the projection. Prices were adjusted to €2020 price levels
Retail electricity prices – business (ex VAT)	See separate trajectory	SEAI	As last data provided for 2045, this data was used for the remaining years of the projection. Prices were adjusted to €2020 price levels
Retail natural gas prices - residential	See separate trajectory	SEAI	As last data provided for 2045, this data was used for the remaining years of the projection. Prices were adjusted to €2020 price levels
Retail natural gas prices - business	See separate trajectory	SEAI	As last data provided for 2045, this data was used for the remaining years of the projection. Prices were adjusted to €2020 price levels
Wholesale electricity prices	See separate trajectory	SEAI	As last data provided for 2045, this data was used for the remaining years of the projection. Prices were adjusted to €2020 price levels

Figure 7-8 - Electricity retail price scenarios

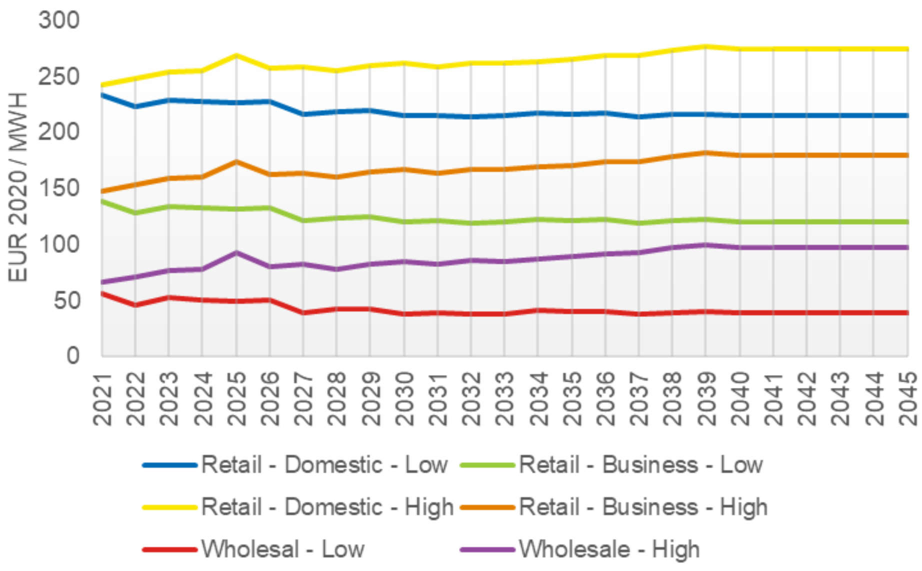


Figure 7-9 - Natural gas retail price scenarios

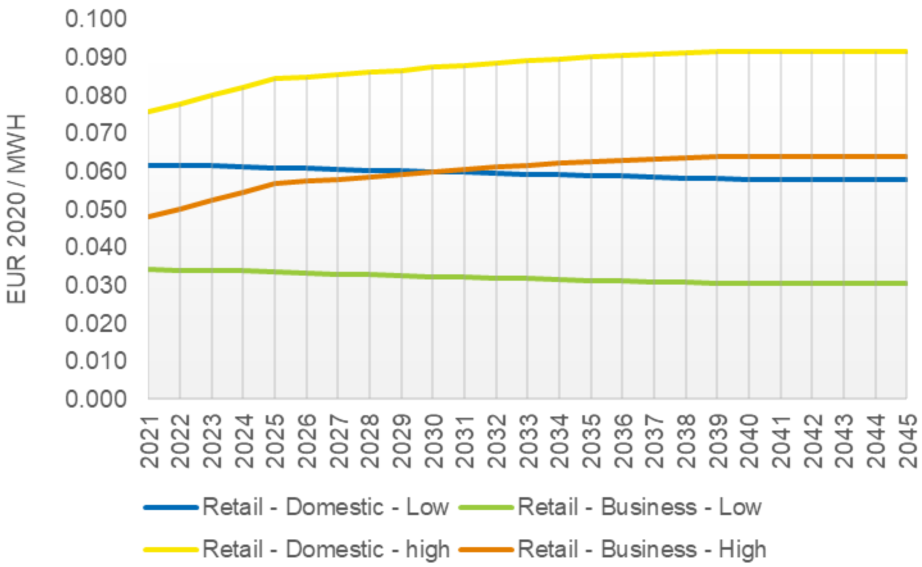


Table 7-44 - Base case levelized cost of electricity

Archetype technology	Sector	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Dom_Small_rooftop_solar	Domestic	c/kWh	17.46	16.92	16.38	15.84	15.30	15.12	14.94	14.76	14.58	14.40
Small_rooftop_solar	Small agriculture	c/kWh	17.46	16.92	16.38	15.84	15.30	15.12	14.94	14.76	14.58	14.40
Medium_rooftop_solar	Large agriculture	c/kWh	12.08	11.70	11.33	10.96	10.58	10.46	10.33	10.21	10.08	9.96
Medium_rooftop_solar	School	c/kWh	12.08	11.70	11.33	10.96	10.58	10.46	10.33	10.21	10.08	9.96
Large_rooftop_solar	SME-commercial	c/kWh	10.49	10.17	9.84	9.52	9.19	9.09	8.98	8.87	8.76	8.65
Large_rooftop_solar	SME-industrial	c/kWh	10.49	10.16	9.84	9.52	9.19	9.08	8.98	8.87	8.76	8.65
Large_rooftop_solar	Local authority	c/kWh	10.49	10.17	9.84	9.52	9.19	9.09	8.98	8.87	8.76	8.65
Small_ground_solar	Small agriculture	c/kWh	12.64	12.25	11.86	11.47	11.08	10.95	10.82	10.69	10.56	10.43
Small_ground_solar	Large agriculture	c/kWh	12.79	12.40	12.00	11.61	11.21	11.08	10.95	10.82	10.68	10.55
Small_ground_solar	School	c/kWh	12.79	12.40	12.00	11.61	11.21	11.08	10.95	10.82	10.68	10.55
Large_ground_solar	SME-commercial	c/kWh	11.36	11.01	10.66	10.31	9.95	9.84	9.72	9.60	9.49	9.37
Large_ground_solar	SME-industrial	c/kWh	11.32	10.97	10.62	10.27	9.92	9.80	9.68	9.57	9.45	9.33
Large_ground_solar	Local authority	c/kWh	11.36	11.01	10.66	10.31	9.95	9.84	9.72	9.60	9.49	9.37
Small_micro_wind	Large agriculture	c/kWh	26.51	26.18	25.86	25.54	25.22	25.00	24.79	24.57	24.36	24.15
Medium_micro_wind	Small agriculture	c/kWh	26.73	26.41	26.08	25.76	25.43	25.22	25.00	24.78	24.57	24.35
Medium_micro_wind	School	c/kWh	26.73	26.41	26.08	25.76	25.43	25.22	25.00	24.78	24.57	24.35
Large_micro_wind	SME-industrial	c/kWh	20.66	20.41	20.15	19.90	19.65	19.49	19.32	19.15	18.98	18.82
Large_micro_wind	SME-commercial	c/kWh	20.66	20.41	20.15	19.90	19.65	19.49	19.32	19.15	18.98	18.82
Large_micro_wind	Local authority	c/kWh	20.66	20.41	20.15	19.90	19.65	19.49	19.32	19.15	18.98	18.82
Small_micro_hydro	Domestic	c/kWh	17.43	17.42	17.42	17.42	17.42	17.42	17.42	17.41	17.41	17.41
Small_micro_hydro	Small agriculture	c/kWh	17.43	17.42	17.42	17.42	17.42	17.42	17.42	17.41	17.41	17.41
Small_micro_hydro	Large agriculture	c/kWh	17.43	17.42	17.42	17.42	17.42	17.42	17.42	17.41	17.41	17.41
Large_Micro_hydro	School	c/kWh	14.94	14.93	14.93	14.93	14.93	14.93	14.93	14.92	14.92	14.92
Large_Micro_hydro	SME-industrial	c/kWh	14.94	14.93	14.93	14.93	14.93	14.93	14.93	14.92	14.92	14.92
Large_Micro_hydro	SME-commercial	c/kWh	14.94	14.93	14.93	14.93	14.93	14.93	14.93	14.92	14.92	14.92
Large_Micro_hydro	Local authority	c/kWh	14.94	14.93	14.93	14.93	14.93	14.93	14.93	14.92	14.92	14.92
Small_micro_CHP	Domestic	c/kWh	120.12	119.15	118.15	117.18	116.23	115.30	114.41	113.55	112.72	111.92
Small_micro_CHP	Small agriculture	c/kWh	56.06	55.57	55.06	54.55	54.06	53.59	53.14	52.71	52.30	51.91
Medium_micro_CHP	Large agriculture	c/kWh	25.52	25.23	24.94	24.65	24.38	24.11	23.84	23.59	23.35	23.12
Medium_micro_CHP	School	c/kWh	25.52	25.23	24.94	24.65	24.38	24.11	23.84	23.59	23.35	23.12
Large_micro_CHP	SME-commercial	c/kWh	19.14	18.94	18.74	18.54	18.34	18.15	17.97	17.79	17.62	17.46
Large_micro_CHP	SME industrial	c/kWh	18.41	18.24	18.06	17.89	17.72	17.55	17.40	17.25	17.10	16.97
Large_micro_CHP	Local authority	c/kWh	19.14	18.94	18.74	18.54	18.34	18.15	17.97	17.79	17.62	17.46

Table 7-45 - Base case viability gaps over generation over lifetime

Archetype technology	Sector	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Dom_Small_rooftop_solar	Domestic	c/kWh	2.56	2.04	1.55	1.05	0.55	0.42	0.24	0.07	(0.10)	(0.28)
Small_rooftop_solar	Small agriculture	c/kWh	2.42	1.90	1.41	0.91	0.41	0.28	0.10	(0.07)	(0.23)	(0.42)
Medium_rooftop_solar	Large agriculture	c/kWh	3.25	2.90	2.58	2.25	1.92	1.84	1.72	1.61	1.50	1.37
Medium_rooftop_solar	School	c/kWh	3.18	2.83	2.50	2.17	1.84	1.77	1.65	1.53	1.43	1.30
Large_rooftop_solar	SME-commercial	c/kWh	0.48	0.18	(0.09)	(0.36)	(0.64)	(0.69)	(0.80)	(0.89)	(0.98)	(1.09)
Large_rooftop_solar	SME-industrial	c/kWh	1.95	1.65	1.37	1.09	0.80	0.74	0.64	0.54	0.45	0.34
Large_rooftop_solar	Local authority	c/kWh	0.48	0.18	(0.09)	(0.36)	(0.64)	(0.69)	(0.80)	(0.89)	(0.98)	(1.09)
Small_ground_solar	Small agriculture	c/kWh	3.85	3.48	3.14	2.79	2.45	2.36	2.23	2.12	2.00	1.87
Small_ground_solar	Large agriculture	c/kWh	4.26	3.88	3.53	3.18	2.83	2.74	2.61	2.49	2.37	2.24
Small_ground_solar	School	c/kWh	4.21	3.83	3.48	3.13	2.78	2.69	2.56	2.44	2.33	2.19
Large_ground_solar	SME-commercial	c/kWh	1.36	1.04	0.74	0.44	0.14	0.07	(0.04)	(0.15)	(0.24)	(0.36)
Large_ground_solar	SME-industrial	c/kWh	2.48	2.15	1.85	1.55	1.24	1.17	1.06	0.95	0.85	0.73
Large_ground_solar	Local authority	c/kWh	1.36	1.04	0.74	0.44	0.14	0.07	(0.04)	(0.15)	(0.24)	(0.36)
Small_micro_wind	Large agriculture	c/kWh	17.65	17.35	17.09	16.82	16.55	16.39	16.18	15.98	15.79	15.57
Medium_micro_wind	Small agriculture	c/kWh	18.06	17.77	17.50	17.23	16.95	16.79	16.58	16.38	16.18	15.96
Medium_micro_wind	School	c/kWh	18.08	17.78	17.51	17.24	16.97	16.81	16.59	16.39	16.19	15.97
Large_micro_wind	SME-industrial	c/kWh	12.07	11.84	11.65	11.45	11.25	11.14	10.97	10.82	10.67	10.50
Large_micro_wind	SME-commercial	c/kWh	11.95	11.73	11.54	11.34	11.14	11.03	10.86	10.71	10.56	10.39
Large_micro_wind	Local authority	c/kWh	11.95	11.73	11.54	11.34	11.14	11.03	10.86	10.71	10.56	10.39
Small_micro_hydro	Domestic	c/kWh	1.75	1.77	1.82	1.86	1.89	1.94	1.94	1.95	1.96	1.96
Small_micro_hydro	Small agriculture	c/kWh	8.81	8.83	8.87	8.91	8.95	8.99	8.99	9.00	9.01	9.01
Small_micro_hydro	Large agriculture	c/kWh	8.93	8.95	8.99	9.03	9.06	9.11	9.11	9.12	9.13	9.12
Large_Micro_hydro	School	c/kWh	6.20	6.22	6.26	6.30	6.34	6.38	6.38	6.39	6.40	6.40
Large_Micro_hydro	SME-industrial	c/kWh	6.35	6.37	6.41	6.45	6.49	6.53	6.53	6.54	6.55	6.55
Large_Micro_hydro	SME-commercial	c/kWh	6.25	6.27	6.31	6.35	6.39	6.43	6.43	6.44	6.46	6.45
Large_Micro_hydro	Local authority	c/kWh	6.25	6.27	6.31	6.35	6.39	6.43	6.43	6.44	6.46	6.45
Small_micro_CHP	Domestic	c/kWh	98.13	97.21	96.32	95.43	94.56	93.74	92.85	92.01	91.21	90.41
Small_micro_CHP	Small agriculture	c/kWh	47.01	46.56	46.12	45.68	45.25	44.85	44.40	43.99	43.60	43.21
Medium_micro_CHP	Large agriculture	c/kWh	15.10	14.86	14.65	14.44	14.23	14.04	13.78	13.55	13.34	13.10
Medium_micro_CHP	School	c/kWh	12.99	12.76	12.57	12.37	12.18	12.01	11.75	11.52	11.32	11.08
Large_micro_CHP	SME-commercial	c/kWh	6.62	6.47	6.37	6.25	6.15	6.06	5.88	5.72	5.59	5.42
Large_micro_CHP	SME industrial	c/kWh	12.15	12.01	11.88	11.75	11.62	11.51	11.35	11.22	11.09	10.95
Large_micro_CHP	Local authority	c/kWh	6.62	6.47	6.37	6.25	6.15	6.06	5.88	5.72	5.59	5.42

Table 7-46 - Base case viability gaps over export over 15-year subsidy life

Archetype technology	Sector	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Dom_Small_rooftop_solar	Domestic	c/kWh	12.23	9.74	7.39	5.01	2.62	1.99	1.13	0.32	(0.46)	(1.33)
Small_rooftop_solar	Small agriculture	c/kWh	11.80	9.26	6.86	4.44	2.00	1.36	0.48	(0.34)	(1.14)	(2.03)
Medium_rooftop_solar	Large agriculture	c/kWh	17.27	15.40	13.68	11.93	10.17	9.78	9.12	8.52	7.95	7.28
Medium_rooftop_solar	School	c/kWh	17.24	15.33	13.58	11.79	10.00	9.59	8.92	8.31	7.73	7.04
Large_rooftop_solar	SME-commercial	c/kWh	3.84	1.45	(0.69)	(2.89)	(5.10)	(5.51)	(6.37)	(7.12)	(7.84)	(8.72)
Large_rooftop_solar	SME-industrial	c/kWh	9.58	8.08	6.73	5.34	3.95	3.65	3.13	2.65	2.20	1.66
Large_rooftop_solar	Local authority	c/kWh	3.84	1.45	(0.69)	(2.89)	(5.10)	(5.51)	(6.37)	(7.12)	(7.84)	(8.72)
Small_ground_solar	Small agriculture	c/kWh	20.24	18.30	16.51	14.69	12.85	12.43	11.74	11.12	10.52	9.83
Small_ground_solar	Large agriculture	c/kWh	20.91	19.06	17.36	15.62	13.88	13.47	12.82	12.23	11.66	11.00
Small_ground_solar	School	c/kWh	20.93	19.07	17.34	15.58	13.82	13.40	12.75	12.15	11.57	10.91
Large_ground_solar	SME-commercial	c/kWh	10.83	8.23	5.89	3.49	1.08	0.59	(0.33)	(1.15)	(1.94)	(2.89)
Large_ground_solar	SME-industrial	c/kWh	13.22	11.47	9.87	8.24	6.60	6.24	5.62	5.07	4.54	3.90
Large_ground_solar	Local authority	c/kWh	10.83	8.23	5.89	3.49	1.08	0.59	(0.33)	(1.15)	(1.94)	(2.89)
Small_micro_wind	Large agriculture	c/kWh	75.43	74.17	73.05	71.90	70.74	70.07	69.16	68.31	67.47	66.55
Medium_micro_wind	Small agriculture	c/kWh	73.28	72.07	71.00	69.89	68.77	68.13	67.25	66.43	65.63	64.75
Medium_micro_wind	School	c/kWh	73.09	71.89	70.81	69.71	68.59	67.95	67.08	66.26	65.46	64.58
Large_micro_wind	SME-industrial	c/kWh	47.97	47.08	46.32	45.52	44.72	44.28	43.62	43.01	42.42	41.75
Large_micro_wind	SME-commercial	c/kWh	48.95	48.03	47.25	46.43	45.61	45.16	44.48	43.85	43.25	42.55
Large_micro_wind	Local authority	c/kWh	48.95	48.03	47.25	46.43	45.61	45.16	44.48	43.85	43.25	42.55
Small_micro_hydro	Domestic	c/kWh	9.81	9.92	10.17	10.40	10.61	10.86	10.85	10.91	10.99	10.97
Small_micro_hydro	Small agriculture	c/kWh	46.02	46.12	46.36	46.56	46.75	46.98	46.97	47.02	47.09	47.07
Small_micro_hydro	Large agriculture	c/kWh	45.20	45.30	45.52	45.71	45.90	46.11	46.11	46.15	46.22	46.20
Large_Micro_hydro	School	c/kWh	33.47	33.58	33.82	34.03	34.24	34.47	34.47	34.52	34.59	34.57
Large_Micro_hydro	SME-industrial	c/kWh	32.90	33.00	33.23	33.43	33.62	33.84	33.84	33.89	33.96	33.94
Large_Micro_hydro	SME-commercial	c/kWh	33.27	33.37	33.61	33.82	34.02	34.25	34.24	34.30	34.37	34.35
Large_Micro_hydro	Local authority	c/kWh	33.27	33.37	33.61	33.82	34.02	34.25	34.24	34.30	34.37	34.35
Small_micro_CHP	Domestic	c/kWh	-	-	-	-	-	-	-	-	-	-
Small_micro_CHP	Small agriculture	c/kWh	169.43	167.82	166.23	164.64	163.08	161.64	160.02	158.53	157.15	155.74
Medium_micro_CHP	Large agriculture	c/kWh	89.85	88.42	87.20	85.91	84.68	83.57	82.03	80.66	79.39	77.98
Medium_micro_CHP	School	c/kWh	-	-	-	-	-	-	-	-	-	-
Large_micro_CHP	SME-commercial	c/kWh	-	-	-	-	-	-	-	-	-	-
Large_micro_CHP	SME industrial	c/kWh	24.28	23.99	23.74	23.48	23.23	23.00	22.69	22.42	22.16	21.89
Large_micro_CHP	Local authority	c/kWh	-	-	-	-	-	-	-	-	-	-

Table 7-47 - Base case viability gaps over generation over 15-year subsidy life

Archetype technology	Sector	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Dom_Small_rooftop_solar	Domestic	c/kWh	3.88	3.09	2.35	1.59	0.83	0.63	0.36	0.10	(0.15)	(0.42)
Small_rooftop_solar	Small agriculture	c/kWh	3.67	2.88	2.14	1.38	0.62	0.42	0.15	(0.11)	(0.36)	(0.63)
Medium_rooftop_solar	Large agriculture	c/kWh	4.94	4.40	3.91	3.41	2.91	2.80	2.61	2.44	2.27	2.08
Medium_rooftop_solar	School	c/kWh	4.83	4.29	3.80	3.30	2.80	2.69	2.50	2.33	2.16	1.97
Large_rooftop_solar	SME-commercial	c/kWh	0.73	0.27	(0.13)	(0.55)	(0.97)	(1.05)	(1.21)	(1.35)	(1.49)	(1.66)
Large_rooftop_solar	SME-industrial	c/kWh	2.96	2.50	2.08	1.65	1.22	1.13	0.97	0.82	0.68	0.51
Large_rooftop_solar	Local authority	c/kWh	0.73	0.27	(0.13)	(0.55)	(0.97)	(1.05)	(1.21)	(1.35)	(1.49)	(1.66)
Small_ground_solar	Small agriculture	c/kWh	5.85	5.29	4.77	4.24	3.71	3.59	3.39	3.21	3.04	2.84
Small_ground_solar	Large agriculture	c/kWh	6.46	5.89	5.36	4.83	4.29	4.16	3.96	3.78	3.60	3.40
Small_ground_solar	School	c/kWh	6.38	5.82	5.29	4.75	4.21	4.09	3.89	3.71	3.53	3.33
Large_ground_solar	SME-commercial	c/kWh	2.07	1.57	1.12	0.67	0.21	0.11	(0.06)	(0.22)	(0.37)	(0.55)
Large_ground_solar	SME-industrial	c/kWh	3.77	3.27	2.81	2.35	1.88	1.78	1.60	1.44	1.29	1.11
Large_ground_solar	Local authority	c/kWh	2.07	1.57	1.12	0.67	0.21	0.11	(0.06)	(0.22)	(0.37)	(0.55)
Small_micro_wind	Large agriculture	c/kWh	21.67	21.31	20.99	20.66	20.33	20.13	19.87	19.63	19.39	19.12
Medium_micro_wind	Small agriculture	c/kWh	22.19	21.82	21.49	21.16	20.82	20.62	20.36	20.11	19.87	19.60
Medium_micro_wind	School	c/kWh	22.20	21.83	21.51	21.17	20.83	20.64	20.37	20.13	19.88	19.62
Large_micro_wind	SME-industrial	c/kWh	14.82	14.54	14.31	14.06	13.81	13.68	13.47	13.28	13.10	12.89
Large_micro_wind	SME-commercial	c/kWh	14.68	14.41	14.17	13.93	13.68	13.54	13.34	13.15	12.97	12.76
Large_micro_wind	Local authority	c/kWh	14.68	14.41	14.17	13.93	13.68	13.54	13.34	13.15	12.97	12.76
Small_micro_hydro	Domestic	c/kWh	2.76	2.79	2.86	2.92	2.98	3.05	3.05	3.07	3.09	3.08
Small_micro_hydro	Small agriculture	c/kWh	13.88	13.91	13.98	14.04	14.10	14.17	14.16	14.18	14.20	14.20
Small_micro_hydro	Large agriculture	c/kWh	14.07	14.10	14.16	14.22	14.28	14.35	14.35	14.36	14.38	14.38
Large_Micro_hydro	School	c/kWh	9.76	9.79	9.87	9.93	9.99	10.06	10.05	10.07	10.09	10.09
Large_Micro_hydro	SME-industrial	c/kWh	10.00	10.03	10.10	10.17	10.22	10.29	10.29	10.30	10.33	10.32
Large_Micro_hydro	SME-commercial	c/kWh	9.85	9.88	9.95	10.01	10.07	10.14	10.14	10.15	10.17	10.17
Large_Micro_hydro	Local authority	c/kWh	9.85	9.88	9.95	10.01	10.07	10.14	10.14	10.15	10.17	10.17
Small_micro_CHP	Domestic	c/kWh	98.13	97.21	96.32	95.43	94.56	93.74	92.85	92.01	91.21	90.41
Small_micro_CHP	Small agriculture	c/kWh	47.01	46.56	46.12	45.68	45.25	44.85	44.40	43.99	43.60	43.21
Medium_micro_CHP	Large agriculture	c/kWh	15.10	14.86	14.65	14.44	14.23	14.04	13.78	13.55	13.34	13.10
Medium_micro_CHP	School	c/kWh	12.99	12.76	12.57	12.37	12.18	12.01	11.75	11.52	11.32	11.08
Large_micro_CHP	SME-commercial	c/kWh	6.62	6.47	6.37	6.25	6.15	6.06	5.88	5.72	5.59	5.42
Large_micro_CHP	SME industrial	c/kWh	12.15	12.01	11.88	11.75	11.62	11.51	11.35	11.22	11.09	10.95
Large_micro_CHP	Local authority	c/kWh	6.62	6.47	6.37	6.25	6.15	6.06	5.88	5.72	5.59	5.42

A1.5 Scaling microgeneration uptake

Table 7-48 - Low scenario - Installed capacity, generation and export

Archetype	Archetype technology	Sector	Installed capacity (MW)	Annual generation (GWh)	Annual export (GWh)
Archetype 1	Micro_solar	Domestic Pre 2021	46.13	34.79	1.29
Archetype 1	Micro_solar	Domestic new build	44.50	32.97	1.23
Archetype 1	Micro_solar	Domestic retrofit	69.23	47.44	17.26
Archetype 2	Small_rooftop_solar	Small agriculture	1.81	1.30	0.40
Archetype 3	Small_rooftop_solar	Large agriculture	2.03	1.53	0.44
Archetype 4	Small_rooftop_solar	School	0.10	0.01	0.02
Archetype 5	Large_rooftop_solar	SME-commercial	46.96	35.14	6.68
Archetype 6	Large_rooftop_solar	SME-industrial	7.68	8.98	1.78
Archetype 7	Large_rooftop_solar	Local authority	1.68	1.26	0.24
Archetype 9	Medium_ground_solar	Large agriculture	0.23	0.19	0.06
Archetype 14	Micro_wind	Large agriculture	0.09	0.16	0.05
Archetype 18	Large_ wind	SME-commercial	1.59	2.89	0.87
Archetype 22	Micro_hydro	Large agriculture	0.26	1.06	0.33
Total			222.30	167.73	30.63

Table 7-49 - Medium scenario - Installed capacity, generation and export

Archetype	Archetype technology	Sector	Installed capacity (MW)	Annual generation (GWh)	Annual export (GWh)
Archetype 1	Micro_solar	Domestic Pre 2021	46.13	34.79	1.29
Archetype 1	Micro_solar	Domestic new build	210.94	156.27	5.81
Archetype 1	Micro_solar	Domestic retrofit	328.13	224.86	81.79
Archetype 2	Small_rooftop_solar	Small agriculture	10.86	7.78	2.42
Archetype 3	Small_rooftop_solar	Large agriculture	12.20	9.16	2.62
Archetype 4	Small_rooftop_solar	School	0.34	0.05	0.07
Archetype 5	Large_rooftop_solar	SME-commercial	281.77	210.86	40.06
Archetype 6	Large_rooftop_solar	SME-industrial	46.08	53.89	10.66
Archetype 7	Large_rooftop_solar	Local authority	8.42	6.30	1.20
Archetype 9	Medium_ground_solar	Large agriculture	1.36	1.13	0.35
Archetype 14	Micro_wind	Large agriculture	3.28	5.95	1.80
Archetype 18	Large_ wind	SME-commercial	60.42	109.57	32.86
Archetype 22	Micro_hydro	Large agriculture	1.88	7.56	2.35
Total			1,011.79	828.16	183.28

Table 7-50 - High scenario - Installed capacity, generation and export

Archetype	Archetype technology	Sector	Installed capacity (MW)	Annual generation (GWh)	Annual export (GWh)
Archetype 1	Micro_solar	Domestic Pre 2021	46.13	34.79	1.29
Archetype 1	Micro_solar	Domestic new build	590.63	437.56	16.26
Archetype 1	Micro_solar	Domestic retrofit	918.75	629.62	328.34
Archetype 2	Small_rooftop_solar	Small agriculture	39.80	28.52	8.87
Archetype 3	Small_rooftop_solar	Large agriculture	44.75	33.60	9.61
Archetype 4	Small_rooftop_solar	School	0.68	0.09	0.14
Archetype 5	Large_rooftop_solar	SME-commercial	1,033.14	773.16	146.90
Archetype 6	Large_rooftop_solar	SME-industrial	168.98	197.59	39.08
Archetype 7	Large_rooftop_solar	Local authority	16.83	12.59	2.39
Archetype 9	Medium_ground_solar	Large agriculture	4.97	4.14	1.28
Archetype 14	Micro_wind	Large agriculture	17.22	31.22	9.45
Archetype 18	Large_ wind	SME-commercial	317.22	575.22	172.52
Archetype 22	Micro_hydro	Large agriculture	7.00	28.21	8.78
Total			3,206.1	2,786	744.92

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