KPMG

A Brighter Future

The Potential Benefits of Solar PV in Ireland

A KPMG report for the Irish Solar Energy Association

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Executive Summary

This report has been written by KPMG LLP, the UK member firm, in collaboration with KPMG Ireland at the request of the Irish Solar Energy Association (ISEA) to assess the potential benefits to the Irish economy from the introduction of a policy support scheme for solar photovoltaic (PV), and to explore the potential policy options. The key messages of the analysis are as follows:

- **Solar PV is rapidly becoming cost competitive, not only against other renewables but also against conventional forms of generation.** The costs of solar fell by 80% from 2008 to 2013, and we estimate that a large scale ground mount project in Ireland would now cost in the region of €150/MWh. The costs of solar PV will continue to fall, with increased volumes worldwide driving cost reductions in module manufacture, and continued technological innovation. It is currently at or very close to 'grid parity' in many markets around the world, and is forecast to become the cheapest electricity generating technology over the coming decades.

- **The deployment of solar technology in Ireland will support economic activity and jobs.** Under a plausible target for deployment, the investment in, and operations of, the solar industry will support around €2 billion of Gross Value Added in Ireland over the period between 2017 and 2030[1]. In addition, this activity will support, up to 7,300 jobs per year over the same period[2]. Many of the jobs generated will benefit the construction sector, which was badly hit during the recent financial crisis. In addition to supporting domestic employment, the development of an Irish solar industry will provide important opportunities for Irish workers to up-skill in a rapidly growing international industry.

- **Solar PV builds on Ireland's economic strengths.** A thriving domestic solar sector, coupled with Ireland's existing strengths in high-tech industries, could make Ireland an attractive location for overseas players in the global solar market looking to establish a manufacturing capability in Europe. It provides a means of diversifying rural income on farms, and offers possibilities for dual land use with agricultural production. In addition, it could provide an effective technology for multinational companies with an Irish presence seeking to source 100% of their electricity from renewable sources as part of initiatives such as Carbon Disclosure Project and The Climate Group's 'RE100' campaign.

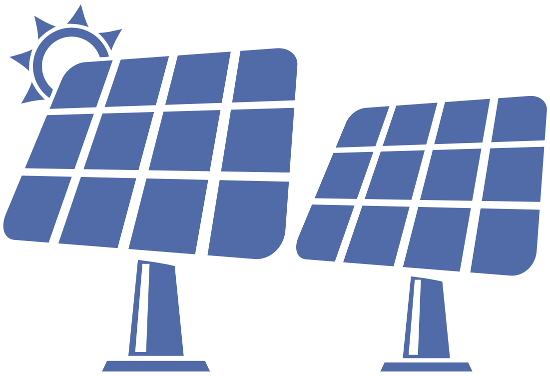
- **Solar PV can increase Ireland's energy security.** It provides a native source of power which will reduce Ireland's current heavy dependence on imported fuels, and could help diversify the energy system risks posed by high levels of wind generation. The areas of Ireland with the most solar resource are along its southern and eastern coasts, close to Ireland's main sources of electricity demand, which will provide for a more efficient use of Ireland's transmission and distribution networks and remove the need for major reinforcements. Rooftop solar is a form of distributed generation, which has the added advantage of being co-located with demand, and so avoids energy losses in the transmission and distribution networks. In addition, solar PV creates exciting possibilities for a more efficient, smarter electricity grid in conjunction with emerging storage technologies.

- **Solar PV can make an important contribution to meeting Ireland's environmental targets.** Ireland's target of sourcing 40% of its electricity from renewables by 2020 is one of the most stretching in the world. On top of this, the United Nations Climate Change Conference (COP 21) to be held in Paris in December 2015 aims to achieve a legally binding global agreement to limit global temperature rises to less than two degrees. Although Ireland is making strong progress towards its 2020 target, a lot of work remains to be done. Ireland's principal renewable technology to date has been onshore wind, but there are signs, as in other European countries, of growing resistance to the technology which could slow the pace of future deployment. Compared to other generation technologies, solar PV can be built and put into operation very quickly, meaning that it could significantly reduce the risk of Ireland missing its 2020 renewables target and incurring large infraction fines, as well as provide a solid foundation to meet future targets.

- **Solar PV can empower Irish citizens and communities to take control of the production and consumption of energy.** It is the most accessible electricity generating technology for households and communities to install, and together with the upcoming roll-out of smart meters, could act as a means of increasing consumers' awareness around energy use. When used in conjunction with energy storage, it could allow consumers to achieve a significant level of 'energy independence'.

- **The Irish solar industry needs a kick-start to be ready for 'grid parity' deployment.** Unlike other countries, very little solar PV has been deployed in Ireland to date, due in part to the absence of direct financial support under the Renewable Energy Feed in Tariff (REFIT) scheme. The introduction of such a support mechanism will allow solar deployment in Ireland to scale up so

Footnotes: 01. In the central scenario. Cumulative 2017-2030, discounted to 2015 at a rate of 5%.
02. This is the peak level of employment supported in the central scenario, other years see lower levels of employment supported.



the benefits from the technology can be enjoyed. In our central scenario, 3.7GW of solar PV is deployed in Ireland out to 2030. While there is great uncertainty around how much solar will be deployed in Ireland, we believe that the deployment scenarios in the report give an indication of the scale of deployment that will be required for Ireland to enjoy the full benefits of solar PV at the lowest possible cost.

- **By supporting solar PV now, Ireland can enjoy the benefits of solar PV while learning from the experience of other countries.** Only a marginal amount of solar PV has been installed in Ireland to date, meaning that the country has a 'late mover advantage'. This should allow it to benefit from the advances made in the technology in recent years, not only in terms of reductions in the costs of modules, but also in terms of planning and installation best practice and the familiarity of financial institutions with the asset class. This should allow for the development of a financially sustainable, responsible sector. We estimate that the total policy support necessary to develop a thriving Irish solar sector will be €670 million over the 2017-2030 period[3], equivalent to a 1% increase in domestic retail electricity prices.

- **Solar PV could be cost competitive in the Irish market by 2030.** We estimate that starting generation tariffs for domestic scale rooftop installations (the most expensive type to install) would need to start at around €13 cents/kWh in 2017 (with additional payments on top of this for electricity exported back to the grid), falling thereafter, with lower levels of support required in the commercial rooftop and large scale ground mount sectors. The falling costs of solar PV, coupled with rising electricity prices, mean that solar PV will be widely deployable in Ireland without policy support by 2030. Ireland will need a solar industry capable of delivering these benefits to consumers.

- **Any support mechanism should ensure value for money for Irish energy consumers and taxpayers.** There are a variety of support mechanisms the Irish Government could use for both rooftop and large scale ground mount deployment, for example:
  - A competitive auction process for contracts for large scale ground mount projects;
  - On smaller rooftop projects, some form of cost control ('degression') mechanism could be designed so as to ensure that support levels continue to reflect technology costs.

We believe that a support structure similar to generation-based Feed in Tariff (FITs) schemes in other countries would be suitable for domestic and commercial rooftop installations, whereby a project receives a tariff for all electricity produced, plus an export payment for power not used on site and exported back to the grid.

For large scale ground mounted projects, we believe that a Contract for Difference (CfD) is the best way of ensuring value for money due to the revenue certainty it offers for investors.

The Government could also explore incentivising solar PV through the tax system (for example through reliefs on property taxes) and through the use of export metering. In addition, higher initial deployment of large-scale ground mount installations can drive the future development of the rooftop sector, by initiating the market and developing the necessary supply chain infrastructure.

Overall, under the scenarios we have modelled, for each €1 of policy support, a solar industry in Ireland will deliver €3 of Gross Value Added[4] to the economy over the 2017-2030 period.

Footnotes: 03. Central scenario. Cumulative 2017-2030, discounted to 2015 at a rate of 5%.
04. Gross GVA.

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Introduction

In recent years, solar PV has come of age as a generation technology. Cost reductions of around 80% between 2008 and 2013[5] have brought solar PV close to cost competitiveness in several countries and market segments. The potential for continued cost reduction raises the prospect of solar PV becoming the cheapest new build renewable electricity generating technology in the not-too-distant future. Furthermore, solar PV developments are extremely flexible in terms of design and scale, and can be deployed very quickly, unlike many other energy technologies.

Ireland does not currently have a policy mechanism to support solar PV akin to a Feed in Tariff or Contract for Difference. The Irish Government is currently consulting on future support schemes for renewable technologies following the closure of the REFIT 2 and REFIT 3 schemes, and has indicated that the review could introduce support for a wider range of technologies, including solar PV.

This report contributes to the review by considering the potential impacts for Ireland of extending policy support to solar PV. It looks at the potential impacts of solar on the Irish energy system and market, in terms of how much might be deployed, what this will cost, what policy support it will require, and how it will interact with other technologies on the system, principally onshore wind. These outputs are then used to assess the wider impacts of solar PV on the Irish economy.

The rest of this report is structured as follows:

- **Section 3** provides background to the analysis, around the costs and characteristics of solar PV and the Irish energy market and the policy environment for renewable energy development.
- **Section 4** sets out potential scenarios for cost reduction and solar PV deployment in Ireland.
- **Section 5** estimates the impacts of solar PV deployment on the Irish energy sector, in terms of its competitiveness with alternative forms of generation, impacts on consumer's bills, contribution to Ireland's environmental targets, and potential security of supply benefits.
- **Section 6** sets out the potential wider economic impacts of solar PV deployment.
- **Section 7** describes potential policy options for supporting solar PV in Ireland, and discusses which might provide the greatest benefits to Ireland.
- The report closes with some key **Conclusions**.

Source: 05. IRENA, 'Rethinking Energy', 2014.

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Background

3.1/ What is solar PV?

Solar Photovoltaics (PV) is a technology for conversion of solar energy to electricity via the use of semiconducting materials. The photovoltaic effect is an electrochemical process that takes place when solar light comes into contact with a semiconductor; this results in atoms being ionised and generating direct current electricity.

PV systems have no moving parts and consist of a panel that is made up of solar cells, a ground or roof-mounting frame and electric cables, and an inverter to convert Direct Current (DC) electricity to Alternating Current (AC) that can be used on-site or exported to the electricity grid. In bigger projects, PV systems can include isolator switches to protect the system and metering equipment.

Solar PV is deployable in a variety of contexts and in a wide range of different sizes. Systems can be deployed either attached to a building ('rooftop installations') or unattached ('ground mount installations'), and range in capacity from a few kW to over 100MW. Compared to other technologies, it can be developed and constructed in a short space of time, with evidence from KPMG's study of the UK market[6] suggesting that developers there are now capable of installing up to 10MW per week.

There are three principal market segments for solar PV:

- **Domestic rooftop:** These are solar PV systems attached to domestic rooftops. Domestic rooftop solar PV is a form of 'decentralised' generation designed primarily to meet the demand of the property it is attached to rather than feeding electricity back into the grid. They are typically less than 10kW in size;
- **Commercial rooftop:** These are systems attached to the rooftops of business properties. As with domestic rooftops, this is a form of 'decentralised' generation. Installations can range greatly in size depending on the size of the property, from small installations not much different to domestic installations to projects of in excess of 1MW capacity installed on the roofs of large factories or warehouses[7]; and
- **Large-scale ground mount:** These are installations unattached to a property which are typically mounted in a field or other agricultural land.

These three segments form the basis for the analysis in this report.

3.2/ International deployment and cost reduction

During the past decade, solar PV has been the leading renewable technology across the world in terms of deployment. By the end of 2014, 177GW had been installed worldwide, with nearly 40GW deployed in 2014 alone[8]. Chart 1 shows how the capacity of solar PV deployed worldwide has grown exponentially in recent years.

In Europe, the split between the various market segments varies considerably from country to country. For example, in Spain more than 80% of projects are utility scale ground mount installations, whereas in Denmark and the Netherlands the market is dominated by rooftop installations[9]. In some countries, the relative share of different sectors has changed over time. For example in the UK, early deployment was predominantly rooftop projects, but recently ground mount deployment has accelerated, so that total ground mount development has caught and overtaken rooftop deployment[10].

These levels of PV deployment have been driven by rapid reductions in the cost of the technology. IRENA estimate that the costs of solar PV modules fell by 75% between 2010 and 2014[11]. Indeed, the cost reduction profile

SOLAR PV CAN BE DEPLOYED IN A WIDE RANGE OF ENVIRONMENTS AND AT DIFFERENT SCALES

Footnotes/ Sources:
06. KPMG, UK solar beyond subsidy: the transition', July 2015.
07. For example, Trina Solar has recently installed a project of 40MW on the roof of a logistics centre in Antwerp, Belgium. http://www.trinasolar.com/downloads/us/casestudy_Antwerp_40MW_WW.pdf.
08. IEA PVPS, 'Snapshot of Global PV Markets 2014'.
09. Solar Power Europe, 'Global Market Outlook for Solar Power, 2015-2019'.
10. https://www.gov.uk/government/statistics/solar-photovoltaics-deployment.
11. IRENA, 'Renewable Power Generation Costs in 2014'.

COSTS HAVE FALLEN RAPIDLY IN RECENT YEARS, DRIVING INCREASING LEVELS OF DEPLOYMENT WORLDWIDE

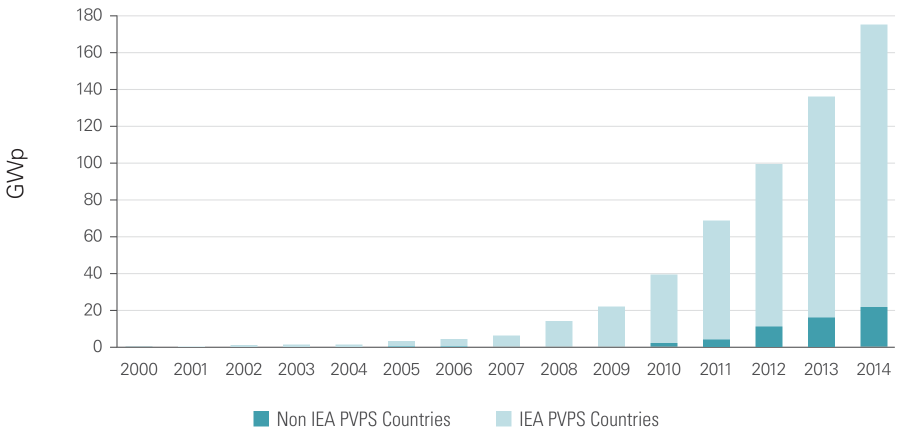
of solar PV has borne a much closer resemblance to those of consumer electronics technologies than to those of other forms of electricity generation, as cost reductions were initially driven by increases in efficiency and then reinforced by strong economies of scale from mass production. Another important factor that has driven cost reduction is the vertical integration of the manufacturing process, from polysilicon feedstock through to module manufacturing.

Most early deployment of solar PV was in Europe, driven by Feed in Tariff schemes in countries such as Germany, Italy and Greece. In these countries, solar now contributes more than 7% of their annual demand[12]. The market for solar PV in Europe has decreased significantly in recent years as support levels have been cut back or removed altogether, coupled with the introduction of Minimum Import Pricing for Chinese solar cells and modules which has kept EU prices significantly above global levels. As a result of these developments, deployment has fallen from 22GW in 2011 to 7GW in 2014[13]. This overall fall masks success stories in some smaller European markets. For example, the Netherlands installed around 400MW in 2014, increasing its overall solar PV capacity by around 80%[14] to top 1GW, with a similar pattern of deployment in Switzerland. As deployment in Europe has fallen, it has increased in other parts of the world, with China, Japan and the USA installing a combined 26GW in 2014.

As the costs of solar PV have fallen, the technology is now competitive with conventional forms of electricity generation as well as the electricity retail price in many parts of the world[15]. As a result of these cost reductions, progressively less subsidies are required to incentivise solar PV deployment. For example, in the UK, the policy support for domestic (less than 4kW) rooftop installations was around 50p/kWh (2015 prices) when the Feed in Tariffs (FITs) scheme started in 2010, whereas tariffs for this category of project currently stand at 12.47p/kWh, or approximately €17 cents/kWh[16].

Chart 1:

Global solar PV deployment 2000-2014



Source: IEA.

Alongside these reductions in the cost of solar PV technology have come advances in how projects are installed to fit with their surroundings and minimise environmental and aesthetic impacts. 'Best practice' guidance from other countries offers a template for the responsible development of a solar sector in Ireland. Some of the guidance produced in other countries is sector-specific, and is relevant for some of the key sectors of Ireland's economy, such as the guidance the National Farmers Union in the UK produced in collaboration with the solar industry[17]. In addition, as more solar PV has developed an operational track record around the world, the financial community has grown increasingly comfortable with the technology as an asset class.

Footnotes/ Sources:
12. IEA PVPS, 'Snapshot of global PV markets 2014'.
13. IEA PVPS, 'Snapshot of global PV markets 2014'.
14. Solar Power Europe, 'Global Market Outlook 2015-2019'.
15. Solar Power Europe, 'Global Market Outlook 2015-2019'.
16. https://www.ofgem.gov.uk/sites/default/files/docs/2015/07/fit_payment_rate_table_for_publication_1_october_2015_pv_tariffs.pdf
17. National Farmers Union, National Solar Centre, Solar Trade Association, 'Agricultural Good Practice Guidance for Solar Farms'

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Background

3.3/ The Irish policy context

As an EU member state, Ireland is bound by the 2009 Renewable Energy Directive, under which it is committed to produce from renewable sources at least 16% of its energy by 2020. This will require 40% of electricity generation to be from renewable sources by 2020[18]. More renewable capacity will be required by 2030 as the EU target for energy sourced from renewables rises to 27% across all member states[19].

Ireland's progress to date towards meeting its targets has principally been through the deployment of onshore wind energy. Onshore wind will continue be the principal means of meeting Ireland's 2020 targets, with a total of 3.2-3.7GW projected to be commissioned by 2020[20]. In 2013, 21% of Ireland's electricity demand was met from renewable sources[21]. Failure to meet EU targets could lead to potentially significant fines for Ireland from 2020 onwards. Although the exact cost of not meeting the 2020 renewables target is not known at this point, initial analysis by DCENR estimates that failing to meet the target by 1-4% could lead to infractions costs of between €140-600 million per year[22].

DEPLOYMENT IN IRELAND TO DATE HAS BEEN LOW, BUT THE COUNTRY HAS SIGNIFICANT SOLAR RESOURCES, AND A STRONG SOLAR PV EXPORT SECTOR

The Irish Government is currently consulting on the successors to the Renewable Energy Feed in Tariff (REFIT) schemes 2 and 3 which are due to close to new entrants of 31 December 2015.

Solar PV is not supported under either of these schemes[23], although there are other policies for incentivising solar PV through tax, buildings and planning policy[24]. The consultation document acknowledges the stretching nature of Ireland's 2020 and 2030 renewables targets, and while wind energy will continue to make an important contribution to the achievement of these targets, the Government recognises that it must be complemented by other technologies if its renewables ambitions are to be met. Solar PV is identified as a technology which 'may play a critical role in diversifying the renewable generation portfolio consistent with a technically feasible, cost effective and fair contribution to overall EU ambitions'[25].

Footnotes/ Sources:

18. Department of Communications, Energy and Natural Resources (DCENR), 'Green Paper on Energy Policy in Ireland', May 2014.
19. See http://ec.europa.eu/energy/en/topics/energy-strategy/2030-energy-strategy.
20. Eirgrid, SONI, 'All-island Generation Capacity Statement 2014-2023'.
21. SEAI, 'Renewable Energy in Ireland-2013 update'.
22. Department of Public Expenditure and Reform, 'Future expenditure risks associated with climate change/climate finance'.
23. The technologies supported under REFIT are as follows: wind, hydro, biomass landfill gas, biomass combustion plant, biomass combined heat and power, anaerobic digestion combined heat and power.
24. SEAI, 'Renewable Energy in Ireland-2013 update'.
25. DCENR, 'Renewable Electricity Support Scheme: Technology review consultation', July 2015.

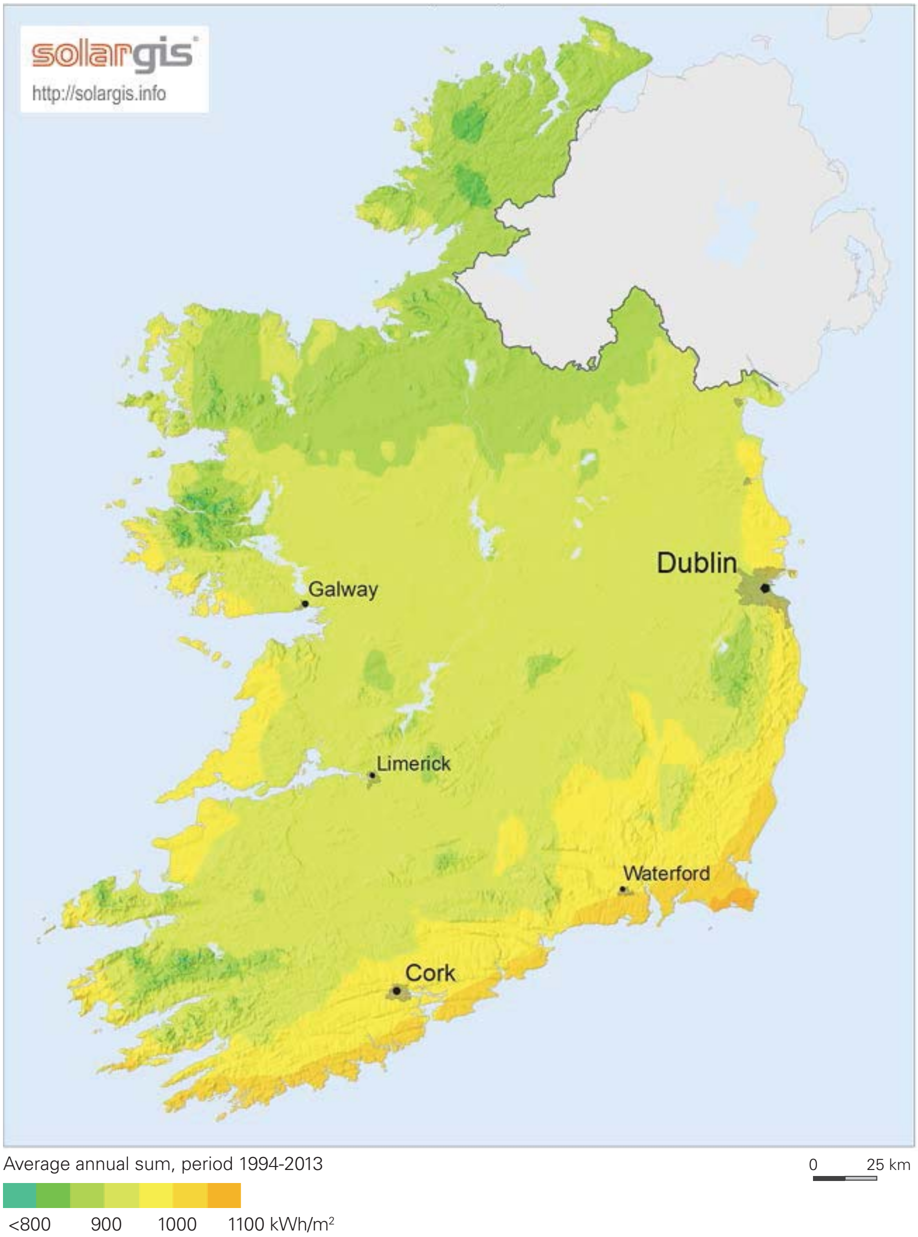
3.4/ The Irish solar PV sector

To date, solar PV deployment in Ireland has been low compared to other European markets such as Germany and the UK. In 2013, solar PV comprised 0.001 % of Ireland's gross electricity consumption[26].

Ireland nevertheless has significant unexploited solar resources, especially in the south, as Chart 2 demonstrates. In addition, Ireland already has a significant solar development sector that exports to other markets. This includes market leading firms with a global presence such as Mainstream and BNRG Renewables in the large-scale ground-mount sector who have both developed and constructed many projects in overseas markets and Kingspan, a rooftop developer with significant track record in the UK. In addition, a number of players in the market have recently announced ambitious deployment plans in Ireland. In August this year, Lightsource announced plans to invest €500 million in Ireland by 2020[27], and investment bank Macquarie has signalled that it would invest €180 million in Ireland through the developer Amarenco[28].

Chart 2:

Solar irradiation in Ireland



Source: SolarGIS © 2015 GeoModel Solar

Footnotes/ Sources:
26. SEAI, Renewable Energy in Ireland, 2013 Update.
27. http://www.solarpowerportal.co.uk/guest_blog/lightsource_leading_pv_expansion_in_ireland_3425.
28. https://www.pagerpower.com/news/180-million-euro-investment-scheduled-for-ireland-solar-farms-2015/.

/04

Solar PV cost reduction and deployment scenarios

As a starting point for assessing the economic impacts of solar PV in Ireland, it is necessary to develop potential scenarios around the future cost of solar PV, and what the deployment trajectory might be in Ireland. Even in relatively mature markets, future cost reduction and deployment of solar PV is hard to project accurately. In Ireland, the nascent nature of the solar PV market makes its future development even more uncertain.

4.1/ Potential for future cost reduction

As part of its study of solar PV in the UK[29], KPMG interviewed various market participants to get their views on the likely evolution of solar PV costs in the future. These pointed to several factors in the international solar PV market that were likely to drive future reductions in technology cost, such as:

- Increases in volume driving increases in efficiency for module manufacturers, with the price of polysilicon expected to fall as volume is added in its production;
- Emergence of alternative module types alongside polysilicon, for example thin film CIS (Copper, Indium, Selenium), which may offer advantages in Irish conditions due to factors such as better shade tolerance;
- Trend towards assembling modules in Europe, in line with consumer electronics industries where high value parts are exported from Asia and assembled in local markets: This allows module manufacturers to save on the high transport costs of shipping completed modules from Asia to local markets.

In addition, interviewees pointed to new innovations such as East to West orientation and single axis trackers could allow higher yields in future.

A major obstacle to continued reductions in solar PV prices in Europe is the EU's Minimum Import Price (MIP) restriction and import duties. This sets a minimum price for solar PV modules and cells manufactured in China that are imported into the EU, and was put in place in 2013 to stop below cost dumping by Chinese PV manufacturers and protect European solar manufacturers. The MIP currently stands at 0.56EUR/Watt for solar modules, and 0.28EUR/Watt for solar cells. The MIP stands significantly above the prices Chinese manufacturers would be able to offer in its absence, with the global module price currently standing at around 0.40EUR/Watt, meaning that if the MIP were ended, significant falls in module prices would occur throughout the EU.

Other components of the price of a PV system will be influenced more strongly by the development of the Irish solar PV market and supply chain. As more PV is deployed, the Irish installer base will build up in terms of both volume and skill level. 'Learning by doing' effects will allow Irish developers to find ways of installing projects more efficiently and quickly under Irish conditions. These effects will apply in all parts of the solar supply chain, from developers gaining familiarity with the Irish planning system and reducing the proportion of projects that fail to gain planning permission, through to installers who must learn to work within Ireland's geographic characteristics. These learning effects would appear to be particularly strong in the rooftop segment of the market, where installers must adapt to the particular characteristics of a country's building stock.

The nature of any policy support scheme for solar PV in Ireland will also play a part: for example, contractual flexibility around commissioning dates in contracts would avoid the 'rushes' to install prior to the end of the financial year, and consequent increases in parts and labour costs, that have characterised solar PV deployment under the Renewables Obligation in the UK.

In addition, a clear plan to accommodate solar PV on the distribution grid will ensure that grid connection costs are minimised. Connection costs will be lower where existing grid capacity can be utilised, and where connections are in close proximity to an existing grid connection point.

In summary, the available evidence suggests that solar PV will continue to see reductions in cost worldwide, and that the solar PV sector in Ireland will also be able to benefit from these as deployment ramps up.

Source: 29. KPMG, 'UK Solar beyond subsidy: the transition'.

SIGNIFICANT SOLAR DEPLOYMENT IN THE 2020s WILL HELP IRELAND MEET ITS LONGER TERM RENEWABLES TARGETS

4.1.1/ Cost reduction scenarios

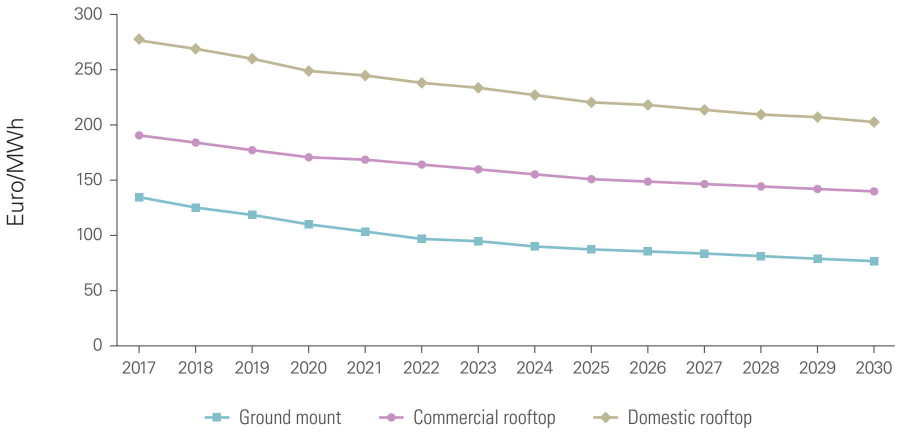
For the analysis in this report, cost reduction scenarios have been developed for the three principal market segments (domestic rooftop, commercial rooftop and large-scale ground mount). These are based on the best available evidence for what the cost and performance characteristics would be for projects built in Ireland today, and the cost reduction profiles developed for KPMG's UK market study.

Within the three market segments, there is considerable scope for variation in costs due to project scale. Rather than to disaggregate each segment into more granular cost bands, cost assumptions have been developed for a 'typical' project in part of the market. More details around these assumptions are set out in Appendix A.

Chart 3 shows projected Irish levelised costs ('LCoE')[30] from 2017 to 2030 across the three market segments.

Chart 3:

Solar PV levelised costs in Ireland, 2017-2030



Source: KPMG.

Footnote: 30. Levelised costs provide a measure of the unit cost of energy production for a project/technology given its risk profile, and is a commonly accepted method for comparing the costs of different generation technologies. The levelised cost calculation divides the discounted sum of costs by the discounted sum of energy production to give a €/MWh figure.

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Solar PV cost reduction and deployment scenarios

4.1.2/ Deployment scenarios

As with cost reduction, the deployment profile for solar PV in Ireland is highly uncertain. Government policy towards solar PV, in terms of the levels of support offered to solar PV and the returns these offer investors, will be a key factor, together with the development of an Irish skills base in solar PV installation that is able to satisfy demand.

Experience from other markets suggests that deployment of solar PV tends to follow an S-shaped curve, with slow initial deployment picking up quickly as markets gain momentum and awareness of the technology spreads. In other countries such as the UK, large amounts of solar have been deployed over very short periods. It is likely that the deployment profile in Ireland will be smoother, due to relatively long timeframes for planning and grid connection. Nevertheless, the development timeframes for solar PV remain shorter than those for other key renewable technologies such as wind.

As well as the shape of the deployment curve, there is also considerable uncertainty around the level of solar PV that will deploy in Ireland. A potential indication of this could lie in the requirements of the 2030 EU energy package. Under this, 27% of all EU energy consumption will have to be sourced from renewables by 2030[31]. Given that to meet its 2020 renewable energy targets Ireland must source 40% of its electricity from renewables, the 2030 requirement could imply that Ireland has to source 45-50% of its energy from renewables.

Irish electricity demand is forecast to reach 29TWh per year by 2020[32]. Ireland's 40% renewable electricity target implies that 11.6TWh of this will come from renewable sources. Based on the growth in electricity demand projected by Eirgrid for the period up to 2023[33], electricity demand could reach around 33TWh by 2030. If Ireland were to set a target of 45% renewable electricity by 2030, this would imply renewable generation of around 14.8TWh. During the late 2020s, Ireland's existing fleet of onshore wind projects will start to be decommissioned. Assuming a 20 year lifetime for onshore wind projects[34], this would mean that the 1.4GW of onshore wind which deployed prior to 2010 (generating a total of 2.8TWh) would retire by 2030. To meet an increased renewables target and help fill the gap left by retiring onshore wind generation, new projects would have to deliver 6TWh of renewable energy by 2030.

It is expected that onshore wind will play a significant part in meeting Ireland's 2030 targets. Indeed, Eirgrid/SONI projections suggest that a further 500MW of onshore wind will be deployed in Ireland between 2020 and 2023[35]. However, the ongoing process to create new planning guidelines for onshore wind in Ireland has created uncertainty in the industry, and may lead to a regime where planning permission is harder to come by. Given this, and expected reductions in cost, solar PV could contribute 50% of the additional Irish electricity generation required from renewable sources in the 2020s. 3TWh of energy generated by solar PV would imply solar deployment by 2030 of approximately 3,500MW. Given an expected start date of 2017 for any policy support mechanism, total solar deployment in Ireland over the 2017-2030 period is projected at approximately 3,700MW in a central scenario.

We have assumed that approximately 70% of total deployment out to 2030 will be large-scale ground mount installations, with the remaining 30% on rooftops. This reflects the fact that early deployment of solar PV in Ireland is likely to focus largely on large-scale ground mount installations given plans that have been announced by developers. In addition, if early deployment is led by ground mounted solar, this offers Ireland the opportunity to drive cost reduction in all market segments through the rapid achievement of significant volume: this strategy has been adopted overseas by the Australian Renewable Energy Agency[36].

Given the uncertainty around levels of solar PV deployment, low and high deployment scenarios have also been developed around the central case. In the low scenario, total deployment of solar PV reaches approximately 1,800MW by 2030, while in the high scenario it reaches 5,100MW.

We have also considered the likely deployment that would occur if the Irish Government decided not to introduce a policy support mechanism for solar PV. In the absence of Government support, it is likely that limited deployment would continue to occur in Ireland. This could be driven by:

- 'Green' households and businesses who place a high value on the environmental benefits of solar;
- Households and businesses with high levels of onsite use, who are

Footnotes/ Sources:
31. http://ec.europa.eu/energy/en/topics/energy-strategy/2030-energy-strategy.
32. Eirgrid/SONI, 'All island generation capacity statement, 2014-2023'.
33. Eirgrid/SONI, 'All island generation capacity statement, 2014-2023'.
34. Arvesen and Hertwich, 'Assessing the lifecycle environmental impacts of wind power', 2012.
35. Eirgrid/SONI, 'All island generation capacity statement 2014-2023'.
36. http://www.smh.com.au/business/energy/large-scale-solar-plants-get-350m-push-20150908-gjhg1s.html.

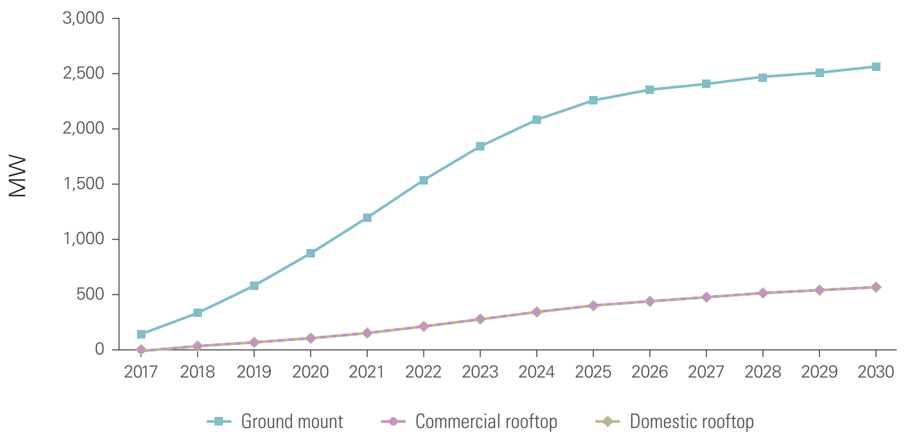
able to offset a greater proportion of their energy costs through solar PV, and thus make significant savings compared to sourcing all their electricity at the retail price. These might be early adopters of energy storage technologies; and

- Businesses looking to enhance their environmental credentials.

We do not believe deployment in the absence of a support mechanism would be significant. The absence of a policy support mechanism would prevent the emergence of a significant ground mount sector in the near to medium term. This would mean that Ireland would be unlikely to see the volume-driven cost reductions that would be required to make solar PV deployable on a large scale without support in the 2020s. While costs remain high, there is likely to be limited deployment by the types of investors listed above, but we do not anticipate that this would exceed 100MW in total by 2030. The benefits of solar deployment in such a scenario, both for the Irish energy system and the economy in general, would be marginal.

Chart 4:

Cumulative Deployment scenarios, by market segment, central scenario 2017-2030



Source: KPMG.

WE PROJECT THAT LEVELISED COSTS FOR GROUND MOUNT COULD REACH AROUND €80/MWH FOR LARGE-SCALE GROUND MOUNT PROJECTS BY 2030

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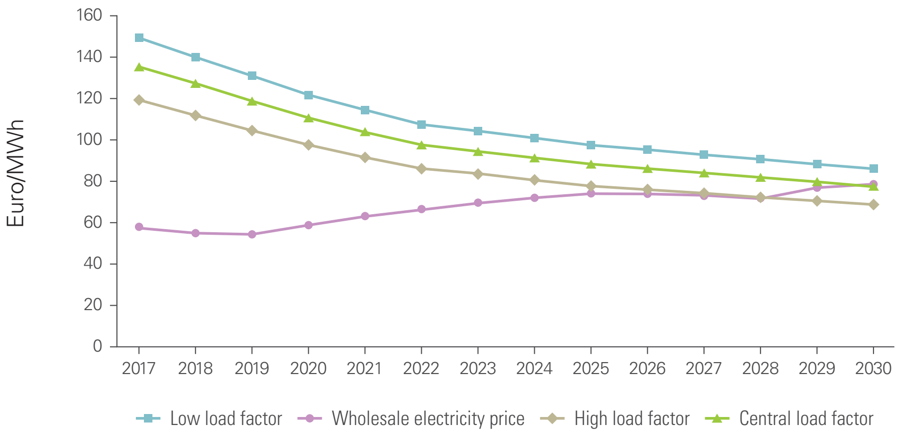
Energy sector impacts in Ireland

In this section, the potential impacts of the solar PV on the Irish energy system are analysed based on the deployment and cost reduction scenarios outlined in Section 4 above in terms of:

- When solar PV might become cost competitive in Ireland;
- What the potential costs of supporting solar PV might be, and the impact on consumer prices;
- Solar PV's contribution to emissions reductions;
- Solar PV's contribution to Ireland's renewable energy targets;
- Solar PV's impact on Ireland's security of supply.

Chart 5:

LCoE of large scale ground mount projects versus comparators



Source: KPMG.
Note: See Appendix A for details of load factor assumptions used.

5.1/ When will solar PV become cost competitive?

A commonly used concept in relation to renewable energy technologies is that of 'grid parity'. Grid parity refers to the point at which a renewable technology is able to produce electricity for the same cost as a conventional substitute. 'Cost' in this context usually refers to a technology's levelised cost[37]. When a technology becomes competitive on price with its substitutes, the implication is that investors would be willing to build projects without policy support.

For solar PV, the appropriate comparator will vary depending on the type of project. For a ground mount, utility scale project exporting electricity back into the grid, a suitable comparator might be some form of the wholesale electricity price. For a rooftop installation, the best comparator would be some combination of the retail price (for that proportion of electricity which is used on site, and which allows the investor to offset electricity purchases) and the price the project is able to achieve for electricity it exports back to the grid. Given that a key comparator here is the retail price, cost competitiveness for rooftop installations is often referred to as 'socket parity'

A technology such as solar PV has a heterogeneous investor population, even within each of the broadly defined market segments of ground mount, commercial rooftop and domestic rooftop. This heterogeneity is particularly marked in the rooftop segments. Firstly, businesses and households will have different incentives for investing in solar PV and hence different expectations of return/payback period. This in effect means that the levelised cost of solar PV will be higher for some businesses and households than others, and that they will require a higher payback to make the investment. Secondly, usage patterns will vary greatly, which will influence the value of the electricity generated by a solar PV installation. For example, the electricity generated by an installation attached to a household whose members are at home for most of the day will be more valuable than if household members were work during daylight hours (and hence forced to export electricity back to the grid).

As a result, different types of investor could adjudge solar PV to have become a worthwhile investment without direct policy support at different points in time. This means that 'grid parity' is reached gradually within a particular market segment rather than overnight.

For large-scale ground mount projects, levelised costs of large scale ground mount projects have been compared to the Irish wholesale price of electricity. LCoE sensitivities around load factor, reflecting varying levels of irradiation across Ireland, are also presented. Chart 5 indicates that large scale ground mount projects will become cost competitive between 2025 and 2030.

Footnote: 37. See footnote 30 for levelised cost definition.

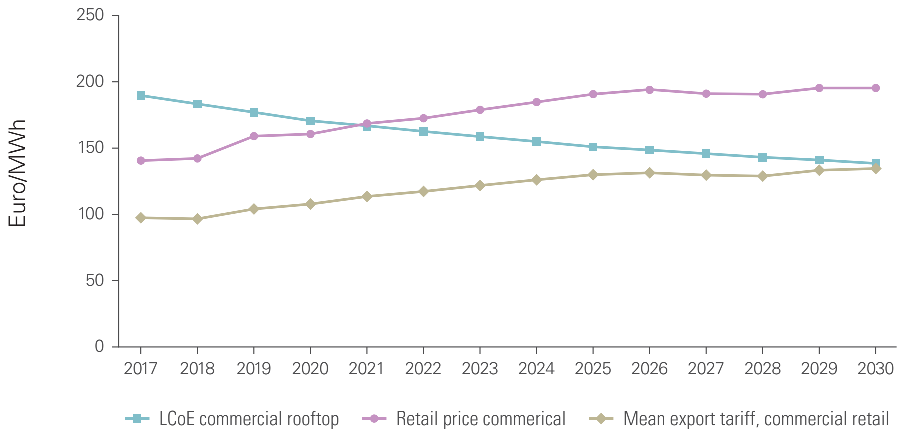
SOLAR PV COULD BECOME COST COMPETITIVE IN THE IRISH MARKET BY 2030

The costs of rooftop projects (commercial and domestic) are compared to the appropriate retail price of electricity[38], i.e. commercial projects are compared to the retail prices faced by businesses while domestic projects are compared to the retail prices faced by households. The comparison between rooftop solar levelised costs and the retail price indicates the date at which solar PV starts to become cost competitive where a high proportion of electricity is used on-site. Rooftop project costs are also compared to a weighted average of the retail price and the price which rooftop installations could expect to receive for the electricity they export back to the grid ('export tariff')[39]. The export value of electricity is assumed to start at €6 Cents/kWh in 2017[40] and changes in line with the wholesale electricity price. This comparison indicates when solar PV becomes cost competitive for installations with typical patterns of on-site use.

Chart 6 indicates that solar PV on commercial properties could become competitive with the retail price in or around 2021, and that it will reach cost parity with the weighted average of retail price and the value of exported electricity by 2030. Chart 7 indicates that solar PV could become competitive with the domestic retail price in Ireland in 2019, and that its cost could be comparable to the weighted average of the export value and the retail price by 2030. The point at which the cost of solar PV meets the weighted average of the retail price and the export value indicates when solar PV would become widely deployable without direct policy support given the typical usage patterns of homes and businesses.

Chart 6:

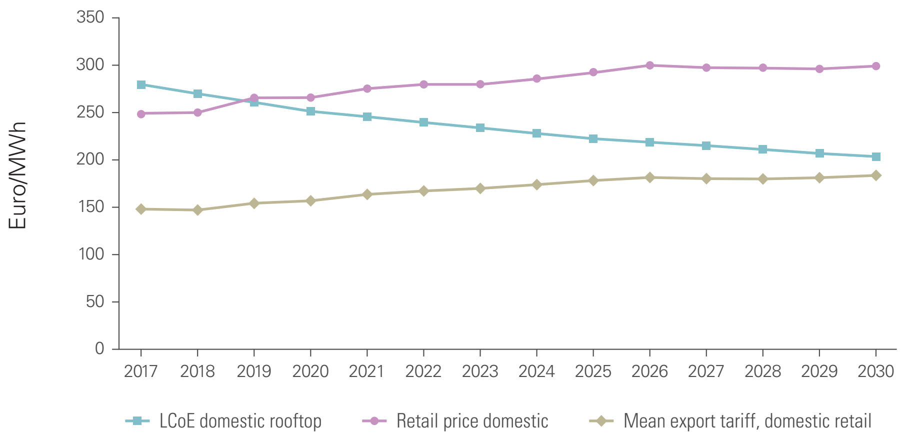
LCoE of commercial rooftop projects versus comparators



Source: KPMG.

Chart 7:

LCoE of domestic rooftop projects versus comparators



Source: KPMG.

Footnotes:
38. There are no publicly available forward looking projections of Irish retail or wholesale electricity prices. In order to construct the series used in the analysis, the latest Irish prices reported by SEAI (see http://www.seai.ie/Publications/Statistics_Publications/Electricity_and_Gas_Prices/Price-Directive-2nd-Semester-2014.pdf) have been used as a starting point, with future changes in price assumed to track those in the UEP projections maintained by the Department of Energy and Climate Change in the UK [update this if any changes made to the way price series are constructed].
39. This weighting is based on the assumed export factor, so with assumed on-site use of 47%, the weighted average price would be 47% * retail price + (1-47%) * export value
40. This is comparable to the export tariff in the UK Feed in Tariff scheme, which currently stands at 4.85p/kWh (2015/16 prices).

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Energy sector impacts in Ireland

5.2/ Required policy support

The analysis in the previous section is used to estimate the level of policy support that will be required to ensure deployment of solar PV prior to the date at which it is cost competitive. The LCoE represents (by implication) the average revenue per unit of electricity a project must receive in order to break even. If revenues fall short of the LCoE, they must be supplemented by policy support if investment is to occur.

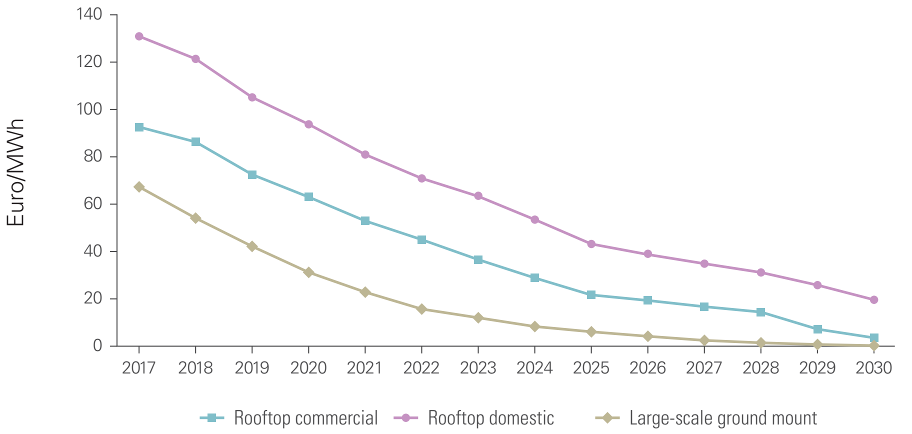
Revenue streams vary according to whether a project is rooftop or ground mounted. A rooftop installation creates income for its owner in two ways. Firstly, it creates bill savings by reducing demand for grid electricity for any electricity used onsite, and secondly it creates income from the sale of any exported electricity back to the grid. The level of support required for rooftop installations will therefore be the difference between the LCoE and the average revenue, i.e. the mean of the retail price and the export value, weighted by the proportion of electricity that is used onsite/exported back to the grid.

For ground mount installations exporting all electricity produced back to the grid, the sole source of revenue will be that from electricity sales. It is assumed that these projects will receive the electricity wholesale price for the electricity produced, such that the level of support required is the difference between the LCoE and the wholesale price[41].

Support for ground mount projects has been estimated based on a mechanism akin to a two-way Contracts for Difference structure such as that introduced in the UK as part of the Electricity Market Reform (EMR) agenda. The required strike price is set equal to the LCoE, and that support payments will make up any difference between the wholesale price and the LCoE. Support payments will vary from year to year, depending on the difference between the LCoE/strike price and the wholesale price, and could become negative if the wholesale price exceeded the LCoE/strike price. Rooftop installations are assumed to receive the same support in p/kWh terms across time, similar to a Feed in Tariff-style scheme.

Chart 8:

Projected support rates (excluding payments for electricity exports) for new rooftop solar PV installations



Source: KPMG.

Table 1:

Projected support rates (excluding payments for electricity exports) for new rooftop solar PV installations

Market segment	2017 €/MWh	2023 €/MWh	2030 €/MWh
Large-scale ground mount	67	12	0
Commercial rooftop	93	37	4
Domestic rooftop	131	64	20

Source: KPMG.

Footnotes: 41. This makes the simplifying assumption that the CfD would last for the lifetime of the plant. In the UK, CfDs are of 15 years duration only, shorter than the expected life of a solar project.
42. Support levels for large-scale ground mount projects are based on the average support paid over the 2017-2030 period. This will vary from year to year due to changes in the electricity price, which will affect the amount of support paid under a CfD mechanism.

SOLAR PV CAN IMPROVE IRELAND'S ENERGY SECURITY

For the purposes of this report, the estimates of required policy support are based on cost, performance and revenue assumptions for a 'typical' installation in each of the main market segments in order to derive a single support profile for each segment. In reality, any policy support mechanism for rooftop installations, is likely to have some kind of banding of support levels to reflect variations in costs and investor types across different scales of installation.

Based on this analysis, indicative support levels for solar PV projects have been derived: these are shown in Chart 8[42].

5.3/ Impact on consumer bills

Required support levels are combined with the deployment scenarios to give a total amount of support payments to solar projects. In the central scenario, total annual support payments peak at around €60 million. Total support payments over the 2017-2030 period are €670 million[43].

It is assumed that these costs will be met through a levy on energy consumers. To calculate the impact on consumer bills, these support costs have been spread across total electricity demand in Ireland to give a €/MWh impact, which is then compared to the Irish retail electricity price to give an estimate of the percentage impact the support payments might have on prices.

These calculations do not account for any behavioural changes that come about as a result of widespread solar PV deployment. By allowing households and communities to generate their own electricity, solar PV can increase awareness of energy use, and stimulate efforts to be more energy efficient. An increased awareness of energy costs could impact on the electricity supply market in terms of higher levels of consumer switching between suppliers.

Table 2:

Bill/price impacts of support payments to Irish solar projects (values discounted to 2015)

		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Low	Total support (€m)	3	10	16	22	26	29	30	31	30	30	29	29	25	23
	Price impact (%)	*0.05%*	*0.16%*	*0.26%*	*0.36%*	*0.43%*	*0.49%*	*0.53%*	*0.55%*	*0.54%*	*0.54%*	*0.56%*	*0.57%*	*0.52%*	*0.49%*
Central	Total support (€m)	6	19	33	43	52	58	61	62	60	60	59	58	51	47
	Price impact (%)	*0.10%*	*0.32%*	*0.52%*	*0.72%*	*0.86%*	*0.98%*	*1.07%*	*1.10%*	*1.08%*	*1.09%*	*1.12%*	*1.15%*	*1.04%*	*0.98%*
High	Total support (€m)	9	29	49	65	78	86	91	92	90	90	88	87	76	70
	Price impact (%)	*0.15%*	*0.48%*	*0.79%*	*1.08%*	*1.29%*	*1.46%*	*1.60%*	*1.65%*	*1.62%*	*1.63%*	*1.69%*	*1.72%*	*1.56%*	*1.47%*

Source: KPMG.

Footnote: 43. Annual support figures are in 2015 prices, discounted.

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Energy sector impacts in Ireland

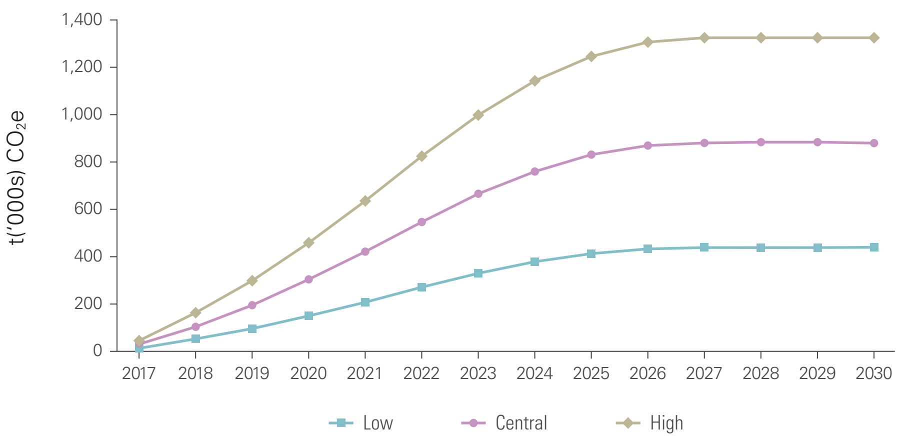
5.4/ Environmental impacts

The Irish electricity generation sector is covered by the EU Emissions Trading Scheme (EU ETS). Under the EU ETS, overall CO_2 emissions are capped, with firms buying and selling emissions permits granting them the right to emit CO_2. Under the EU ETS, a reduction in Irish emissions would not lead to a reduction in global CO_2 emissions, since total EU emissions would be determined by the level of the overall cap. However, the Irish electricity sector would benefit from reduced costs from purchasing EU ETS permits.

It is not certain what form of generation increased amounts of solar PV would replace in the Irish electricity system. To arrive at an estimate of the potential reduction in greenhouse gas emissions (which would benefit the Irish economy in terms of reduced purchases of EU ETS permits), it has been assumed that solar PV would replace generation with the average emissions factor for the Irish system[44]. The benefits to the Irish electricity generation sector from reduced EU ETS permit purchases has been monetised using DECC projections of the future EU ETS price.

Chart 9:

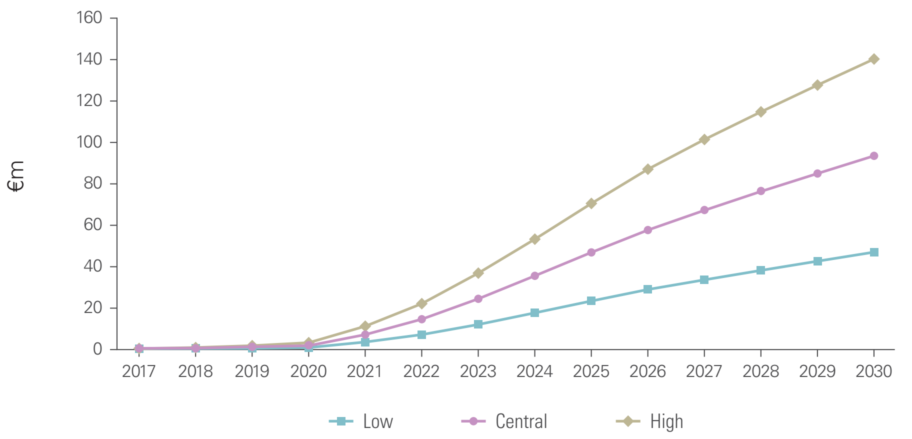
Emissions savings versus Irish electricity production mix counterfactual



Source: KPMG.

Chart 10:

Monetised carbon savings versus Irish electricity production mix counterfactual



Source: KPMG.

Footnote: 44. This was 469gCO_2/kWh in 2013, and is assumed to decrease by 2.8% per year in future, in line with observed reductions between 1990 and 2013 (Source, SEA).

5.5/ Contribution to Irish environmental targets

Ireland has a legally binding target to source 16% of its energy from renewable sources by 2020. It is also bound by the 2030 target to source 27% of EU energy from renewable sources. In order to meet its 2020 obligations, Ireland has a target of sourcing 40% of its electricity demand from renewable sources by 2020. While Ireland is more than halfway towards this target, with 21% of electricity coming from renewable sources in 2013, considerable effort is still required to avoid potentially large infraction penalties from 2021 onwards. While onshore wind has driven Ireland's progress towards its renewables targets to date, it cannot be relied upon to ensure compliance. Ireland is currently developing a new set of planning guidelines for onshore wind, which may make it harder for projects to achieve planning permission. Solar does not face some of the planning issues faced by wind around visual amenity and turbine noise.

A key characteristic of solar PV is that it can be built very quickly, with very large ground mount projects in other countries being installed in a matter of months[45]. If it became apparent that other technologies were deploying slower than expected, solar PV could be deployed very quickly to prevent any shortfall against Ireland's 2020 targets.

Ireland is also likely to face stretching 2030 renewable electricity targets for 2030 due to the EU directive. These will be made even more challenging by increases in Irish electricity demand, and the retirement of some of Ireland's existing wind capacity as it reaches the end of its life in the 2020s. As the costs of solar PV become competitive with those of wind, it is likely that a mix of solar PV and wind will be deployed in the 2020s to meet Ireland's 2030 targets.

This report does not attempt to quantify the benefits solar PV might bring in terms of reducing the possibility of meeting its 2020 targets and avoiding fines, due to the uncertainties surrounding how such fines will be calculated, and to what extent Ireland may fall short of meeting its targets. Nevertheless, it is reasonable to assume that with a policy support mechanism to incentivise deployment, solar PV could contribute towards Ireland meeting its targets if required.

3.7GW OF SOLAR COULD BE DEPLOYED BY 2030 WITH AN ANNUAL SUPPORT EQUIVALENT TO A 1% INCREASE IN DOMESTIC ELECTRICITY PRICES

Footnote: 45. See for example http://www.jpcs.co.uk/about-us/case-studies/case-study-5mwp-ground-mounted-solar-pv-farm-at-cadland-estate-the-biggest-solar-farm-in-the-uk/

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Energy sector impacts in Ireland

5.6/ Security of supply impacts

Ireland is heavily import-dependent in energy, currently importing 89% of its total energy fuel needs. In addition, its renewable energy portfolio is dominated by onshore wind. As the capacity of onshore wind in Ireland has increased, so have times when wind energy has to be 'turned off' (in other words, wasted) to ensure overall system security. In 2013, Eirgrid estimated that the 'dispatch-down' from wind generation was 171GWh, equivalent to around 3.5% of available wind energy[46]. In addition, Ireland's wind potential is largely located in the west of the country, away from the centres of population (and energy demand) in the east.

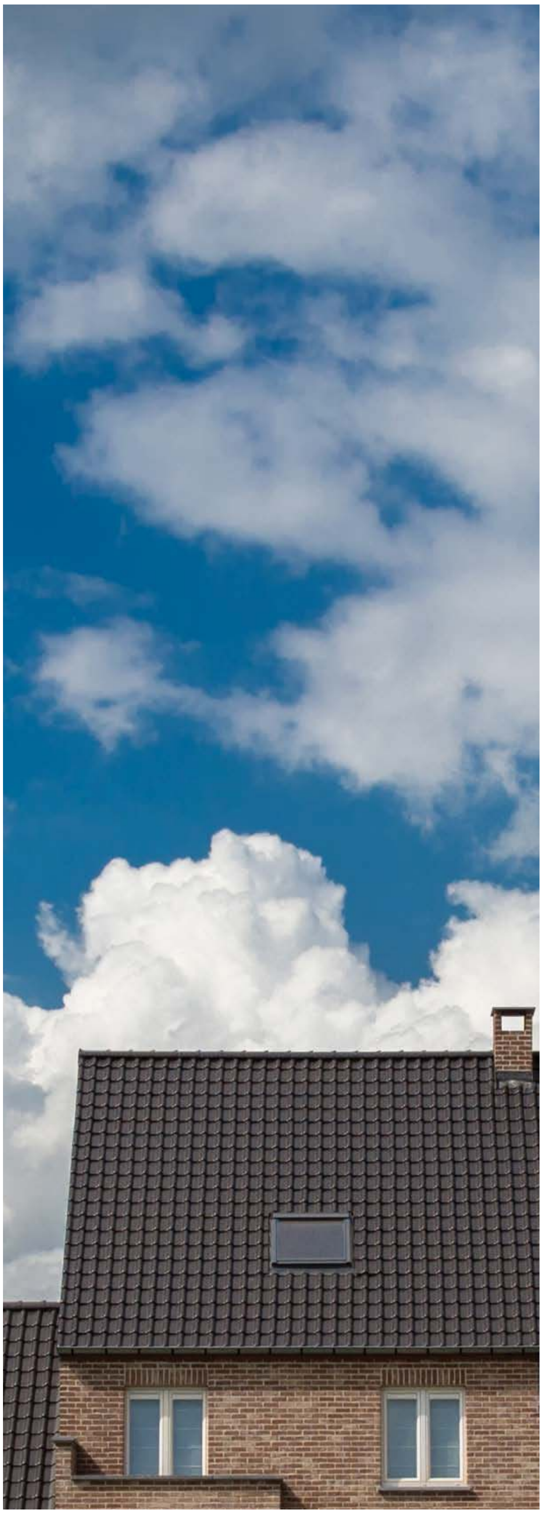
Solar PV has the opportunity to address some of these issues. Firstly, it provides an indigenous source of electricity production which, were it to replace any of Ireland's existing fossil fuel generating capacity, would reduce Ireland's dependence on fuel imports.

Secondly, solar PV would diversify Ireland's renewable energy generation portfolio. This could provide system benefits by reducing wind curtailment, since its output is unlikely to be correlated with that of wind. To ensure system stability, the Irish electricity system has a limit on the amount of non-synchronous generation such as wind and solar (the System Non-Synchronous Penetration limit) which is currently set at 50% of total generation. This limit leads to wind curtailment when demand is low and wind output is high, for example on a windy night. Significant solar PV deployment could limit wind curtailment in situations such as these, since solar PV's output at night is zero.

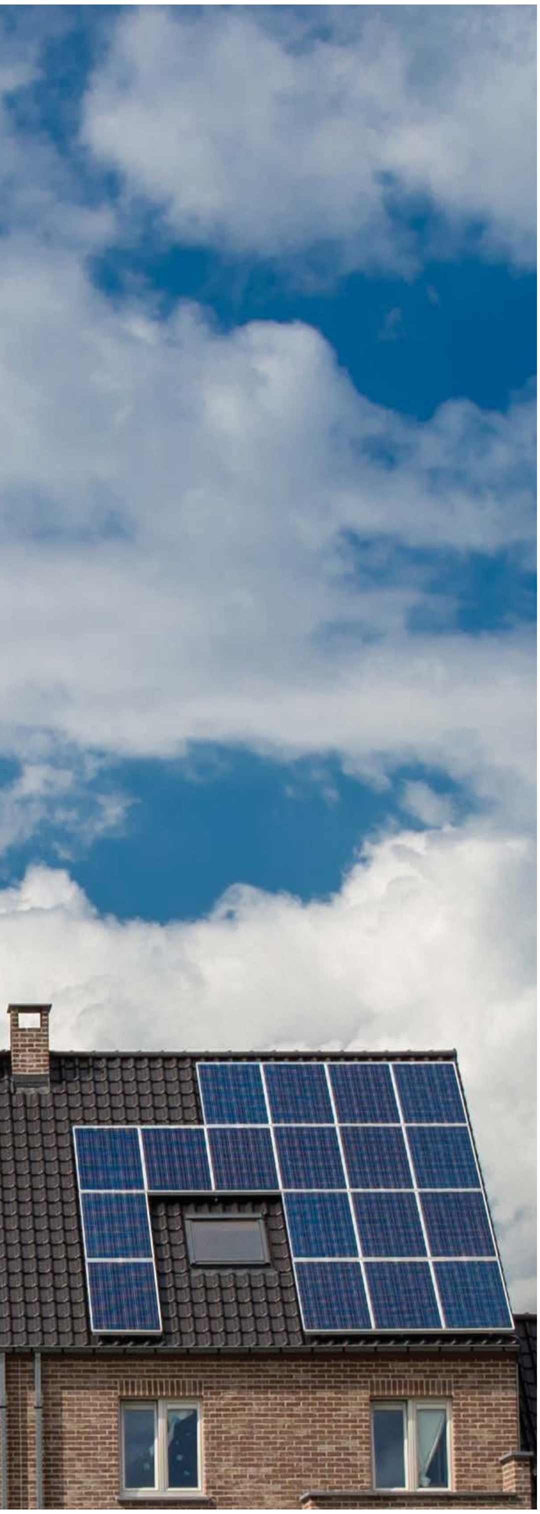
Thirdly, Ireland's solar PV resource is located along its southern and eastern coasts, close to its centres of population. It therefore avoids the need for expensive reinforcement of the Irish grid to enable the transportation of electricity over long distances, and allows for more efficient use of the existing infrastructure. These benefits are particularly pronounced with rooftop PV, which as a form of distributed generation helps reduce the cost, complexity and interdependencies associated with high and low voltage transport/distribution. Decentralised generation can enhance the resilience of the system, if properly managed, along with other low carbon technologies. Although solar PV will not contribute towards winter peak demand (normally 5pm to 7pm) as it will not be generating at this time, it will still contribute to winter day time demand albeit at slightly lower levels than at other times of the year.

Solar PV could also have a significant impact on the generation mix in Ireland. PV generally generates when electricity is needed (during the day), and may replace the output of the most expensive inflexible baseload capacity (for example older, less efficient gas units), that might not be economic to run their power plant in daily cycles (i.e. shut down in the day and run at night). This means that even though solar PV may make up only a small proportion of overall generation, it can still have a significant impact on the generation mix.

Another important consideration is that PV 'embedded' in distribution networks is 'invisible' to the System Operator, Eirgrid. Nearly all distributed PV electricity production will effectively reduce demand at distribution network supply points and be seen by the System Operator as 'less demand' on the national transmission network, so that every GWh generated by PV is displacing an equivalent amount of electricity generated and transmitted through the High Voltage (HV) grid. This fact can present Eirgrid with a number of technical challenges in terms of system balancing and provision of reserve, as forecasted demand on the HV grid can be more difficult to estimate and eventually will become more volatile.



Footnote: 46. Eirgrid/SEMO/SONI, 'Annual Wind Constraint and Curtailment Report 2013'



Although weather forecasting has improved significantly over the past few decades the predictability of cloud coverage in the near term remains low. Electricity generation from PV still remains an 'intermittent' source, as cloud coverage and solar irradiance can vary significantly, from day-to-day and across the seasons. As electricity generation from PV follows solar irradiance, the profile of production from PV in Ireland will not match the demand profile that normally peaks in early evening. Therefore PV has been traditionally considered as 'non-firm' capacity that normally would require back-up from conventional technologies (like gas).

However, the availability of PV electricity is likely to change with the advent of energy storage. Energy storage, in its various forms (from utility scale to domestic) has the potential to capture and 'store' excess electricity production from PV and other renewable technologies such as wind, and make that electricity available at times when the sun is not shining. Energy storage for use in electricity systems has had limited applications so far worldwide, as costs remain high and the industry remains immature. But battery storage technologies, such as Lithium-ion, have seen significant cost reductions in recent years, partly as a direct outcome of their increasing use in personal electronics and electric vehicles. Ireland is leading the way in developing commercial storage solutions, with a flywheel storage project with a capacity of 20MW already in testing, and due to come fully online in 2017.

As the cost of storage falls, it seems that its commercial viability is not far off even for domestic applications. The combination of a domestic PV system with storage (and possibly an electric vehicle) could truly revolutionise the way that households consume electricity, as they will be able not only to store excess PV production and use it in evenings, but also take advantage of the price differentials in grid electricity costs between day and night to lower their bills.

'Distributed' PV (as represented by the commercial and domestic rooftop sectors) represents a particular type of variable (or intermittent) energy resource, with three characteristics that set PV generators apart from conventional generators. Firstly, distributed PV generators, by their very nature, provide installed capacity that is spread over numerous devices scattered across a large geographic area; secondly, their power output is variable because of the solar cycle and clouds. Thirdly, their power output is uncertain because, although the amount of sunlight reaching the PV array follows a regular pattern on average, chaotic atmospheric changes account for large deviations that are difficult to predict precisely.

Previous experience in countries that have witnessed large scale deployment of PV, like Germany or Italy, has shown that there are ways to manage large load variations during the day by using traditional means (scheduled dispatchable generation, various system balancing ancillary services, curtailment) even without the need for massive storage infrastructure.

Also, as more modern distribution grid technology is deployed and potentially stored, this would increase the capability of the distribution system to manage loads and variability, and sometimes even 'offer' system ancillary services (like power quality, voltage control and fault management).

/06

Economic benefits to Ireland

6.1/ Summary of key findings

Ireland has recently emerged from one of the deepest economic crises in its history. The latest consensus forecasts suggest the economy will grow by more than 4%[47] in 2015. However, there is still some way to go to secure a stable and prosperous future[48] for Ireland.

At the centre of its Medium Term Economic Strategy 2014-2020, the Government placed an objective of generating jobs. That objective, further articulated in the Action Plan for Jobs, includes a commitment to generate employment in the locally traded sectors[49] and to nurture internationally competitive export oriented industries.

In addition to helping Ireland fulfil its renewable energy ambitions, the solar industry has the potential to make an important contribution to Ireland's growth agenda. The accelerated deployment of solar PV will generate jobs, particularly in the construction and installation sectors. A larger domestic market will enhance Ireland's offering as a location for firms in the solar PV supply chain, which could bring further jobs and investment in high-tech, exporting industries.

The deployment of solar PV will create €2 billion in gross value added to the economy and sustain 7,300 jobs annually.

With spare capacity in the economy and exceptionally low interest rates for borrowers, there is an opportunity for galvanizing investment in the solar industry in Ireland.

The economic activity supported by investment in the solar PV sector will also support tax revenues and a reduction in benefit dependency.

THE DEPLOYMENT OF SOLAR PV WILL CREATE €2 BILLION IN GROSS VALUE ADDED TO THE ECONOMY AND SUSTAIN 7,300 JOBS ANNUALLY

Footnote: 47. Consensus forecasts, September 2015.
48. Medium Term Economic Strategy 2014-2020.
49. Action Plan for Jobs Strategic Ambition 3.

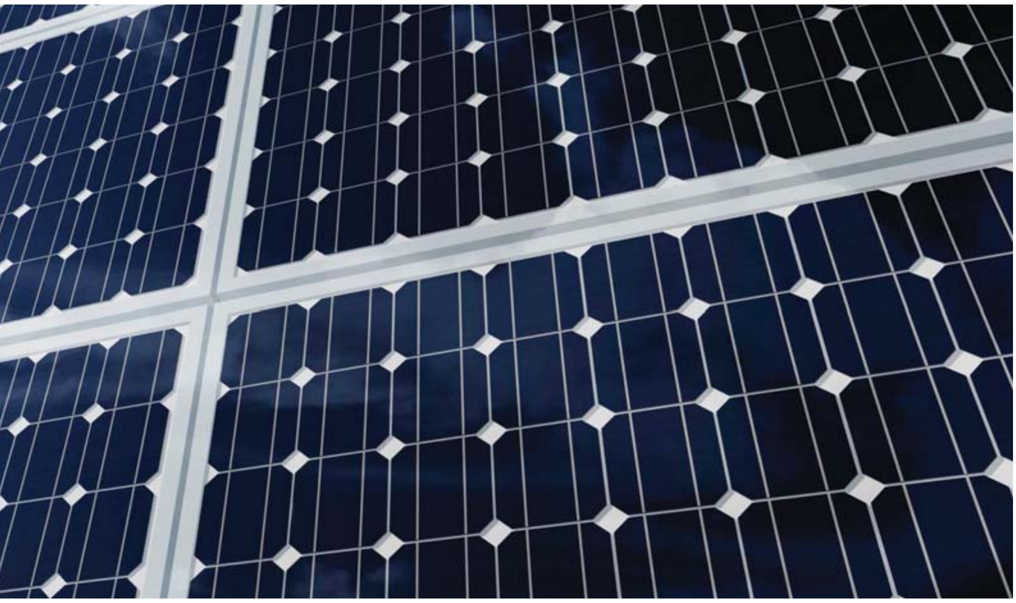
6.2/ Our approach to estimating economic impacts

Our calculations of economic impacts consider the activity generated directly through construction and operation of solar PV capacity, in line with the three scenarios outlined in the section above. We also estimate the indirect effects generated in the solar PV supply chain and the induced effects arising from the spending of those employed by the solar PV industry and its supply chain. Impacts are calculated in terms of GVA, employment and tax revenues.

We do not factor in any employment generated by firms in the supply chain for the module parts. Whilst it is likely that some parts of the supply chain would develop in Ireland if there was a more vibrant domestic product market, our analysis make conservative assumptions that the status quo, of no significant domestic production, is maintained.

The numbers we present are gross impacts, they do not factor in any displaced activity in production of fossil fuels or behavioural responses caused by price differences resulting from any policy support received by the industry. However, we discuss the likely net impacts of solar PV deployment at the end of this section.

Underlying our calculations is an Input-Output model, which allows us to examine the flows of goods and services between individual sectors of Ireland's economy. It also enables us to capture the economic activity generated by employees of the solar industry and its supply chain, spending their money. The analysis utilises a series of multipliers that are applied to the direct output and employment of the Solar Industry. The model uses multipliers published by the Central Statistics Office where available. Where these were not available we calculated the relevant multipliers using raw Input-Output data from Eurostat. Further detail on Input-Output analysis can be found in the appendix to this report.



Input-Output analysis is a widely used and transparent tool for assessing economic impact. However it has some limitations, which should be born in mind in interpreting our results. Notably:

- The model uses a snapshot of the structure of the Irish economy in 2010. Large interventions or improvements in technology over time may lead to changes in the mix of inputs used by each sector and the extent to which the supply chain is on- or off-shored. These effects are not accounted for in the model and may result in the realised size of impacts differing from modelled impacts. The model also does not include dynamic feedbacks as a result of changes in prices.
- The model only allows a certain level of granularity in the analysis: there is, for example, no separate treatment of solar construction, but only a generic construction sector.
- The model does not capture many of the welfare benefits that would be experienced by those who install solar PV modules. For example, the installation of solar PV may allow a farmer to diversify their income, mitigating income risk. This is an economic benefit will not be captured in the Input-Output analysis.

Whilst many studies use Input-Output analysis, care should be taken in comparing results. There are a series of decisions taken by the modeller about what types of impacts are included in the course of an analysis that may lead to differences in results, despite the use of a similar framework.

The Input-Output analysis provides a basis for our estimates of Gross Value Added, employment and tax revenues supported by an Irish solar PV industry as detailed in the three deployment scenarios. Details of key assumptions can be found in the Appendix to this report.

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Economic benefits to Ireland

6.3/ €2 billion Gross Value Added (GVA)

Gross Value Added measures the difference between the total output or revenue[50] of an industry and what it spends on intermediate inputs. Intermediate inputs are the goods and services used up in production[51]. GVA is the industry level equivalent of Gross Domestic Product (GDP), the measure used to assess the size of an economy.

The solar industry will generate GVA directly through its operations, indirectly through the production of the goods and services used to create solar energy and through the capital spending required to deploy the technology. The spending of employees will also generate further induced GVA impacts.

To arrive at our estimates of GVA we passed the assumptions on Capex, Opex, electricity prices and output for the three scenarios (discussed in earlier sections) through our Input-Output model.

The results of our analysis are shown in Table 3. The total GVA (cumulative 2017-2030) comes to €2.0 billion in our central scenario[52], with €1.2 billion in GVA generated directly added to €0.8 billion in indirect and induced effects.

The impacts will not be felt uniformly across the sectors of Ireland's economy. Sectors which experience the biggest impact outside of the energy sector are those that produce the intermediate inputs and capital goods (and services)[53]. Given that we do not factor in any of the manufacturing supply chain moving to Ireland, the sectors that benefit the most are the solar industry itself and the construction, installation and professional services associated with developing and installing the solar capacity.

Table 3:

The results of our analysis

Cumulative € billion 2017-2030	Low	Central	High
Revenue	0.7	1.3	2.1
Capital Spend	1.4	2.8	4.2
Total GVA	**1.0**	**2.0**	**3.0**
Direct GVA	0.6	1.2	1.7
Indirect GVA (from capital and operational spend)	0.3	0.5	0.8
Induced GVA	**0.1**	**0.3**	**0.4**

Source: KPMG.
Note: All figures are cumulative 2017-2030 and discounted at a rate of 5% to 2015.

Table 4 shows a breakdown of the GVA impacts, across broad sectors. As noted above, the solar industry and households or businesses with rooftop installations capture much of the GVA through its direct operations, although the installation and construction sectors capture 14% of the total GVA or around €250m over the period between 2017 and 2030.

Table 4:

GVA supported by the solar industry is shared between the sectors of Ireland's economy

Sector	GVA (Central Scenario)
Solar energy producers, business and households with rooftop installations	€1.2bn
Installation and construction	€0.2bn
Project development and professional services	€0.2bn
Other	€0.4bn

Source: KPMG.
Notes: 1. All figures are cumulative 2017-2030 and discounted at a rate of 5% to 2015.
2. Installation and construction sectors include Nace rev 2. Sectors 33, 41-43; Professional services include sectors 64-66 and 69-75.

Footnote: 50. This includes electricity purchases avoided.
51. Employee wages or dividends paid to shareholders are not intermediate inputs, but are included in GVA.
52. Cumulative over the period 2017-2030 and discounted to 2015.
53. In the appendix we detail the breakdown of OPEX and CAPEX by sector.

6.4/ Up to 7,300 jobs supported

The solar industry will require workers in construction of solar plants, the manufacture of parts and in operations and maintenance. With, at present, little of the solar PV supply chain in Ireland most of those jobs will be in construction and installation of solar PV capacity, with some additional jobs in operating and maintaining the plants.

However, estimates of the number of jobs required to install and maintain solar PV capacity vary widely. This is the result of differences in capability across countries, across individual projects and the tendency towards rapid gains in the efficiency of installation once the solar PV market starts maturing within a country.

Table 5 summarises the results of a number of studies which have assessed the labour requirement for solar PV in terms of jobs or job years per MW. Whilst the number of jobs in operations is relatively consistent (and fairly low) the number of job years in construction, installation and manufacturing ranges from 17 to 69 job years per MW across the studies we reviewed.

The 2013 study[54] undertaken by the UK's Department for Business, Innovation and Skills into the low-carbon economy estimated that there were 20,300 direct jobs in the solar PV industry in 2013 in the UK. Given the scale or installations that year and existing solar PV capacity, our calculations[55] suggest that equates to around 18 direct jobs per MW associated with the development, construction, installation and manufacturing of solar PV modules.

Whilst 18 jobs per MW may appear to be a reasonable assumption to apply to the construction and installation of solar PV capacity in Ireland, a figure this high would not be consistent with the amount of GVA generated nor the capital expenditure required to deploy solar PV. The 18 jobs figure captures some, limited, manufacturing and research activities that we have explicitly excluded from analysis of the impact on Ireland and appears to capture some of the activities that we count further down the supply chain[56].

We use a figure of 13 jobs per MW for rooftop installation and 4.5 jobs per MW for ground mount installations in 2017.

We assume that figure falls over time as increases in efficiency are realised, at a rate of 4% per year. This reflects a faster than historic average productivity growth[57] for Ireland, and reflects the expectation that the significant improvements in the cost efficiency of solar PV will continue. Given the mix of ground mount and rooftop installations, the average jobs per MW for construction and installation never falls below 6.2.

We assume the operations of solar PV capacity requires 0.3 jobs per MW and that falls in line with efficiencies realised in OPEX spend.

Footnote/ Sources:
54. BIS (2015). The size and performance of the UK low carbon economy.
55. Data on installations is taken from https://www.gov.uk/government/statistics/solar-photovoltaics-deployment. We assume 0.3 jobs per MW in operations and maintenance.
56. There are likely to be other reasons that the methodology used in the BIS study leads to inconsistencies when applied in the context of the modelling we are doing; this is an area for further investigation.
57. Our calculations on OECD data for GDP per hour worked, suggest real productivity growth averaged 3% p.a. over the 25 years to 2014.

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Economic benefits to Ireland

6.4/ Up to 7,300 jobs supported *continued*

Table 5:

Employment in the solar PV industry

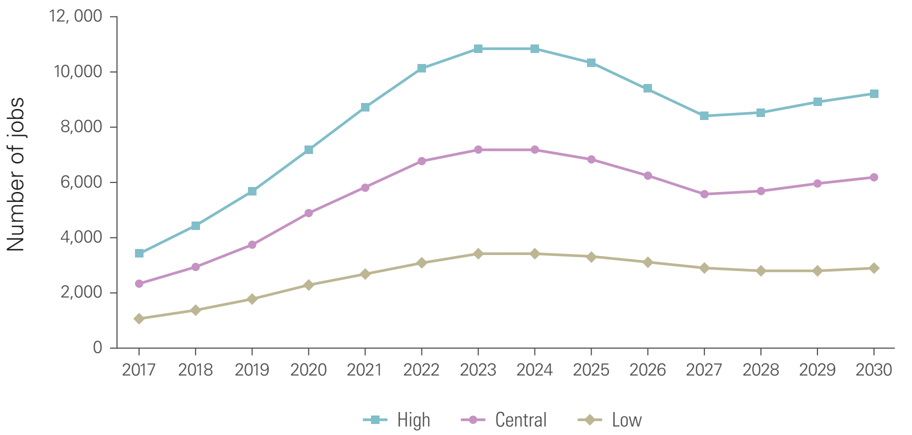
Region/country	Year	Construction Job Years/MW	Manufacturing Job Years/MW	O&M Jobs/MW	*Notes and data source*
Cross-country	2012	11	6.9	0.3	Rutovitz and Harris (2012). Institute for Sustainable Futures. Figures are an average of other studies.
Cross-country	2014	13.2	16.8	0.3	UKERC (2014) median figures from meta-analysis of other studies.
Cross-country	2010	29.0	9.3	0.4	Rutovitz (2010).
Global	2011	23.0	7.0		Global average of 30 jobs for construction, manufacturing and installation from European Photovoltaic Industry Association and Greenpeace (2011). Split between Construction and Manufacturing from calculations by Rutovitz and Harris (2012).
South Africa	2008	52.3	16.8	0.7	Based on European Photovoltaic Industry Association (EPIA 2008A), and O&M factors are from Germany industry data (BMU 2008a). Factors are multiplied by 2.15 to reflect differences in wage intensity.
Japan			7.6		Derived from Yamamoto and Ikki (2010).
US	2008			0.5	Local direct employment estimated to be generated by a 75MW solar PV project in Kittitas County in the United States (World Bank, 2011, page 29).
Germany	2009			0.2	Derived from Mulenhoff (2010).
Germany	2009	12.6			Based on country total annual increase of 2,000 MW and Kunz (2010).
US	2009	11.3			National Commission on Energy Policy, 2009. Appendix A (Bechtel report).
South Korea	2010		3.1		Employment figures for total country manufacturing (Korea Energy management corporation (KEMCO) and New and Renewable Energy Center (NREC), 2012).
Greece	2011	11.2	6.0		From Tourkolias and Mirasgedis, (2011) table 3 and table 8.
US	2011	9.0	11.0	0.2	JEDI model (National Renewable Energy Laboratory, 2010a).
Germany	2007/08	10.7	6.0		One company, total installation 3.09MW Reisinger Sonnenstrom.

The resulting number of jobs supported in each of the scenarios are shown in Chart 11. As construction of solar capacity is completed employment falls and is partially replaced by employment in operations and maintenance; although given the much higher job intensity of installation the jobs are not fully replaced in the period to 2030.

In addition to the direct effect, there are indirect and induced effects on employment. Using the Input-Output model we arrive at an overall employment impact of up to 7,300 jobs per year supported in between 2017 and 2030 in our central scenario, reaching 10,900 in the high deployment scenario.

Chart 11:

Employment in all three scenarios



Source: KPMG.

Table 6:

Jobs supported in the central scenario by sector in year of peak employment

Average jobs supported	Total Employment (Central Scenario)
Electricity and gas supply	850
Installation and construction	2,740
Project development and professional services	540
Other	3,170

Source: KPMG.

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Economic benefits to Ireland

6.5/ €0.8 billion in tax revenues

The activity of the solar industry and its supply chain will lead to the generation of tax revenues. As part of the macroeconomic analysis we were asked to assess the likely impact on tax revenues.

The Input-Output modelling does not allow for a detailed, line-by-line analysis of each element of the Irish tax code. Instead, with the aid of the Input-Output modelling, we made a series of assumptions to arrive at estimates of the key taxable financial streams and the associated effective tax rates. As such, these estimates should be treated as broad estimates which serve to illustrate the potential size of the tax revenue. Our overall estimate of tax revenues generated is made up of the following elements:

Labour taxes, including income tax, Universal Social Charge (USC) and Pay Related Social Insurance (PRSI). This is calculated by applying the average labour tax paid – 20.4% income tax plus USC and 9.1% PRSI – as a percentage of employee compensation (wages and employer contributions) in Ireland to the total employee compensation generated in each scenario.

Product taxes including VAT and other taxes and duties levied on individual products or services. A key source of product tax revenues from the solar PV industry will be the tax paid on the electricity it generates. We calculated tax paid on electricity by applying the average tax paid in Ireland (10.1%) to total revenue generated by the solar PV industry (we assume all VAT paid by businesses is recoverable). The Input-Output modelling gives us the (net) product taxes in the supply chain.

Taxes on production. These are taxes such as business rates which tax elements of the process of production rather than final products. The key source of production taxes in the solar PV industry will be the business rates paid by solar plants. We apply a basic assumption of €7,000[58] per MW to calculate business rates paid. The Input-Output modelling gives us the (net) production taxes in the supply chain.

Taxes on profits. Given the difficulty of identifying taxable profit without a full and detailed consideration of the financing models used by solar PV operators and in identifying taxable profit in the supply chain, we adopted an indirect approach to estimating the total corporation tax impact. We applied an uplift to the other taxes calculated, based on the share of corporation tax in total tax revenues in 2014 (8.4%).

All estimates are for the Republic of Ireland only. More detail on our assumptions and calculations can be found in the appendix to this report.

Our estimates of total tax generated are shown in Table 7. In the central scenario we see revenues of around €0.8bn generated.

Table 7:

Tax revenues

Type of tax (€ million)	Central Scenario
Labour taxes	400
Product taxes	150
Of which tax on electricity	*140*
Production taxes	140
Profit taxes	70
Total	**800**

Source: KPMG.

These calculations give broad estimates, although they are likely to be an underestimate of gross tax revenue generated by the solar PV industry under our deployment scenarios. This is because (i) we have not considered any import duties paid on the goods imported directly as part of the initial capital spend, and (ii) the calculations of production and product taxes in the supply chain subtract some subsidies offered and do not include any induced effects.

Jobs supported by the industry will also lead to reductions in benefit payments, where workers would otherwise be unemployed; which will also add to the exchequer, although these benefits aren't counted here.

Moreover, the rates of tax paid are kept constant over time. Whilst in some cases this may mean we overestimate revenues, as, for example USC is due to fall. In other cases taxes in future years may go up.

Footnote/ 58. Assumption provided by ISEA.

6.6/ Development of the supply chain

As the solar industry in Ireland develops, there will be a larger product market for potential suppliers. We have not counted the potential for supply chain development in our analysis, but it remains a further potential source of economic impact.

The prospect of being closer to that market may attract downstream elements of the solar supply chain and, potentially, research and development activity. Ireland is one of the most competitive economies in Europe and so would be well placed to compete within Europe for elements of the solar industry once its domestic industry has reached a critical size. However, there may be a limited window for attracting such activity. Once established in another country in Europe it will be more difficult to attract it to Ireland.

6.7/ Summary of impacts

Based on the three scenarios described in Section 3, accelerated development of the solar industry would support jobs, value added and tax revenues. We estimate that with the appropriate incentives, over the period from 2017-2030, the solar industry in Ireland has the potential to provide support for:

- ***€2 BILLION IN GVA***[59]***,***
  EQUIVALENT TO €3 FOR EVERY €1 OF SUPPORT
- *UP TO* ***7,300 JOBS*** *PER YEAR*[60]
- ***€0.8 BILLION IN TAX REVENUES***[61]

Footnote/ Sources:
59. Cumulative 2017-2030, discounted at 5% to 2015.
60. Average jobs supported in any year.
61. Cumulative 2017-2030, discounted at 5% to 2015.

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Economic benefits to Ireland

6.8/ Gross and net impacts

The impacts estimated in this study are gross impacts of the development of the solar PV industry. Net impacts would take into account the knock-on impacts of the expansion of the solar industry, including activity displaced and responses to prices. Capturing all of the net impacts in an analytically robust way is difficult. To understand the likely net impacts in a rigorous way, a comprehensive and integrated modelling exercise would need to be undertaken which would consider:

- Likely displacement of fossil fuel and other renewable energies.
- How prices would be affected with and without different renewable technologies and carbon prices.
- How people respond to changes in energy prices.
- How money spent on support might otherwise be allocated.

We have not undertaken a comprehensive modelling exercise, however drawing on existing research, we are able to indicate what the net impacts of solar deployment might look like.

6.8.1/ Displacement

Work done by the SEAI on onshore wind deployment has looked at the impact of a renewable technology displacing energy from fossil fuel with the jobs and supply chain spend it brings. They suggest that the displacement of employment is likely to be relatively small[62]. Ireland imports fossil fuels so jobs lost in mining and refining as a result of lower demand will be incurred abroad. Whilst the required generating time for fossil fuel plants will also fall, capacity payments provide the necessary revenue for plants to remain operational, meaning that reductions in operations and employment are likely to be imperceptible, although reductions in economic employment may occur in transport and logistics from a reduction in the throughput of fossil fuels.

A reduction in fossil fuel output will lead to a reduction in revenue and hence GVA. However, a larger proportion of the GVA from producing solar energy is captured in Ireland compared to fossil fuels, given that fossil fuel power stations have to import their biggest input. As a result a significant portion of the GVA of the solar industry will likely be net additional. The GVA from capital spend will also be additional in so far as it doesn't mean there is a symmetrical reduction in investment in fossil fuel energy. The same logic also applies to employment.

There will, however, be direct displacement of some tax revenues; notably the tax on electricity, which will directly replace the same taxes on electricity produced by other sources. The other taxes will be additional in so far as GVA and employment are additional.

6.8.2/ Deadweight

When interpreting our findings of economic impact as the impact of a form of policy support, we have to consider to what extent investment would have occurred in the solar sector without it. This is the 'deadweight'. Our belief is that without a policy support mechanism there will be no significant deployment before 2030, meaning any deadweight will be small.

6.8.3/ Behaviour change

In our calculations we do not consider any changes in behaviour as a result of increases in taxation required to fund the support. Increased taxation will tend to reduce overall economic activity, although the predicted impact on consumer bills is small. Moreover, we do not consider the impact of potential future price reductions resulting from having solar contributing a larger share of the Irish energy mix; which will tend to stimulate economic activity.

Source: 62. http://www.seai.ie/Publications/Statistics_Publications/Energy_Modelling_Group_Publications/A-Macroeconomic-Analysis-of-Onshore-Wind-Deployment-to-2020.pdf

/07

Support mechanisms

In this section we assess the potential policy options which the Irish Government could implement to support solar PV at both large and small scales. In other countries, support mechanisms for solar PV have been in place for a number of years, and these have evolved as governments seek to strike the optimum balance between incentivising the technology and ensuring value for money for consumers. Our assessment draws on the experiences of other countries in order to explore what would work best in the Irish context. It also discusses other ways of supporting solar PV besides direct support.

7.1/ Direct support

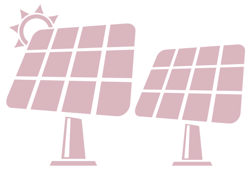
The two main options for supporting solar PV are either a Contract for Difference (CfD) or some form of Feed in Tariff (FIT). A CfD ensures a guaranteed revenue ('strike price') to the generator by topping up the revenue received from sales of electricity in the market with a support payment. A Feed in Tariff instead fixes the support payment element of the generator's revenue, with total revenue varying according to movements in the electricity price.

The choice between a CfD and a FIT will depend upon the market segment concerned, and the policy priorities for the Irish Government. A CfD is only practical for large-scale projects selling their electricity back into the grid, where a single 'reference price' for electricity can be set in order to calculate required top-up payments. For embedded generation with significant levels of onsite use, it becomes harder to set a single 'reference price' due to differences in the retail electricity price faced by generators. Furthermore, with large numbers of installations, calculating top up payments would become a complex administrative undertaking The effect of these transaction costs means that CfDs are most appropriate for larger projects and not small ones.

Given these administrative considerations, **it is evident that some form of FIT should be the preferred mechanism for the domestic and commercial rooftop segments of the market in Ireland**. Some key design questions for a Feed in Tariff scheme for rooftop solar PV in Ireland are as follows:

Banding: the costs of rooftop solar PV vary significantly according to scale of project, such that a tariff which provides a fair return for domestic scale installations is likely to overcompensate larger projects with lower capital costs. Tariff bands can increase the likelihood of deployment across all scales of project, although this relies on the Irish Government having sufficiently accurate cost information for all scales of project. Despite quite granular tariff bands in the UK's FITs scheme, it has nevertheless proved difficult to drive deployment of the commercial rooftop sector in the UK, where deployment has tended to focus on the domestic and large-scale utility sectors of the market;

Cost control: solar PV is a technology which can be deployed very quickly, and whose costs have proved liable to fall in a short space of time. In European markets such as Italy and Greece, tariffs have failed to fall in line with technology cost reductions, leading to very high amounts of deployment followed by very sharp falls in tariffs leading to 'cliff edges' where deployment fell almost to zero. Some form of progressive tariff reduction, where tariffs fall in line with reductions in the cost of solar PV, will allow for the sustainable growth of the Irish PV sector. Reductions in tariffs (so called 'degressions') could be linked to either volumes of deployment (as currently occurs in the UK) or to the cost of solar PV modules (through monitoring of a global market index). As with tariffs, degression should be banded, to allow for different segments of the market to develop at different rates. In other words, a surge in deployment in



ground mount solar should not lead to a reduction in support for rooftop solar if rooftop deployment remains low.

For large-scale projects, the revenue certainty provided by a CfD partially de-risks the project, meaning costs of capital tend to be lower than under a FIT regime. This in turn implies that total support payments will be lower under a CfD mechanism than under a FIT for a given amount of generation. However, the risks around revenue are actually transferred to Irish electricity consumers (assuming they meet the costs of support payments under the Public Service Obligation), as providing revenue certainty to generators means that the level of support payment is uncertain, and will be determined by movements in the wholesale electricity price. Given that wind will continue to be the dominant renewable technology in Ireland, meaning that payments to solar PV generators would be unlikely to cause major variations in the Irish electricity price, the risk of major fluctuations in Irish electricity prices due to CfD payments to solar PV seems limited.

For all electricity technologies, there are strong asymmetries of information between government and project developers, which makes it hard for governments to set support levels to provide fair returns. For large-scale solar PV projects, where a relatively small number of projects will deploy in any given year, it makes sense to introduce an auction process, where projects bid for a given quantity of CfD or FITs contracts on offer. This will aid the process of price discovery, and help ensure value for money for Irish energy consumers. In designing the auction

IRELAND CAN ENJOY THE BENEFITS OF SOLAR PV, WHILE LEARNING FROM THE POLICY EXPERIENCES OF OTHER COUNTRIES

process, the Irish Government must decide on the extent of competition between solar PV and other technologies, or whether it wants to set aside funding exclusively for a solar PV auction. Greater competition between technologies will favour the technology with the lowest cost: this may create short-term savings, but in the longer term it may prevent more expensive technologies from deploying in sufficient volumes to create cost reductions through learning, and may not ensure sufficient diversity in the Irish energy mix.

At current costs, solar PV is not competitive with wind, meaning that a specific budget for solar is necessary to kick start the development of the Irish solar sector.

ANY SUPPORT MECHANISM SHOULD SEEK TO ENSURE VALUE FOR MONEY FOR IRISH ENERGY CONSUMERS AND TAXPAYERS

/07
Support mechanisms

7.2/ Other means of support

7.2.1/ Taxes and regulations

The analysis in this report indicates that, while direct support will be necessary to build volume in the Irish solar PV market, given falling technology costs and rising electricity prices, it will start to become an attractive investment on its own terms. Here, some additional means of incentivising solar PV deployment are considered.

Even though there is currently no direct support mechanism for solar PV in Ireland, there are nevertheless several policy levers in place that could help drive the development of solar PV, for example:

- The energy contribution of a solar PV array may be included in the calculation of the renewable energy contribution within a building to comply with Part L of the Building Regulations for new buildings.
- The contribution of a solar PV array to reducing a building's annual electricity demand and CO_2 emissions is included in the Building Energy Rating.
- Solar PV products meeting the required European and international standards are listed on the SEAI Triple E Register for accredited energy-efficient equipment. Listed solar PV products qualify for a favourable depreciation regime for corporation tax under the Accelerated Capital Allowances scheme and for VAT refunds when installed for agricultural use by farmers.
- Solar PV arrays have been provided with exemption to the requirement for planning permission for smaller installations occupying less than 50 metres squared[63].

In the domestic rooftop sector, there is scope for the Irish Government to consider mandating the installation of PV on all new buildings, thereby linking new PV installations to the churn rate of property capital stock. This initiative will create a steady demand stream for the sector and can drive efficiency in design and innovation (and hence reduce installation costs even further). Especially in social housing, PV can contribute immediately to lower bills for lower income groups, thereby contributing into mitigating fuel poverty. There are also further opportunities to incentivise solar PV through the tax system. Potential measures could include:

- Reductions/exemptions on local property tax for properties with solar PV, and on Stamp Duty when properties are bought or sold;
- Exemptions or reductions to VAT for households purchasing PV systems;
- Making revenue from solar PV subsidies exempt from income tax.

Source: 63. http://www.seai.ie/Renewables/Microgeneration/Conditional_Planning_Exemptions/50 metres squared would be sufficient for an installation of approximately 10kW.

7.3/ Export metering

With the roll out of smart meters due to complete in Ireland in 2019, domestic and small commercial properties will be able to have accurate metering of PV electricity. 'Export metering' is the practice of measuring 'import' and 'export' electricity, so that import electricity is credited to suppliers and export electricity is credited to 'pro-sumers' (electricity consumers who also generate and sell electricity back into the grid). If there is an export surplus, the type of credit can either be a payment or rolling credits that can be used in forthcoming periods, when the export surplus becomes a deficit. Under many FITs schemes for small-scale installations, exported electricity is 'deemed' (i.e. estimated) and a tariff applies. Smart metering will enable to be made precise payments to eligible pro-sumers, provided that a system of rules apply for the applicable tariff to be credited. In countries with high penetration of PV, export metering is currently considered in various forms, so that it can provide a known, certain revenue to eligible users.

Many wider benefits are possible with export metering, as Ireland continues with a rollout of an increasingly smart grid. Smart metering will mean bills can be tailored far more closely to when electricity is consumed, allowing for tariffs to be lower at times when overall system demand is lower. Householders could programme many of their household devices to consume on-site generation when prices are low and export surplus when prices are high.

Export metering has been introduced for solar PV in a variety of countries around the world. These include the Netherlands, where the introduction of an export metering scheme is attributed with a sharp increase in solar PV installation rates, with sales in the first half of 2015 around 70-100% higher compared to the same period in 2014[64].

Source: 64. http://cleantechnica.com/2015/07/26/dutch-solar-booms-for-a-remarkable-reason/.

/08

Conclusions

Solar PV is emerging as the lowest cost and fastest growing new build renewable technology worldwide. Costs are falling quickly (estimated at 70% over the last five years) and are expected to continue falling. Solar PV is relatively easy and quick to install at both utility and building scale levels and is making a rapidly increasing contribution to the achievement of national decarbonisation targets. By 2014, across Europe for example, Germany had 38.2GW providing 7% of generation, while Italy had 18.2GW providing 7.9% of generation. Ireland provides no direct support to solar PV, and only a very marginal amount has been deployed.

Solar energy can provide a significant economic boost to the Irish economy, and provides a good fit with key economic drivers. Solar enjoys wide public support, and is also the most popular renewable energy technology among British electricity consumers. The development of an Irish solar sector would support a significant numbers of jobs (we estimate up to 7,300 a year in the early 2020s) and Ireland's attractive business environment could attract major players in the global solar market looking for a European base. In addition, solar PV provides a potential means of income diversification for Irish farmers, and offers the possibility of dual land use, where solar projects are installed in fields that continue to be used for grazing.

Solar energy costs are falling rapidly. Significant future cost decreases are forecast for solar as the cost of components falls and efficiency improves. Effective asset lifetimes of more than 25 years are forecast, offering strong long term potential to add to the future renewable energy mix both at commercial and domestic levels. Assuming incentives to kick-start development are put in place, solar PV is expected to reach 'grid parity' in Ireland in around 10-15 years' time.

Solar PV can improve Ireland's security of supply. As a native source of energy whose main potential in Ireland is close to the main sources of demand, solar PV can reduce Ireland's dependence on imported fossil fuels while reducing the stresses on the electricity grid. Its complementarity with onshore wind, as well as with key technologies of the future such as energy storage, will help future proof Ireland's energy system against the challenges posed by increasing amounts of intermittent generation.

Solar PV can make a key contribution to meeting Ireland's environmental targets. A key characteristic of solar PV is that it can be built much quicker than other electricity generating technologies, and so can be deployed at short notice to meet any shortfall in Ireland's renewable generation capacity in the run up to 2020. In the longer term, as costs fall, solar can play a major role in meeting Ireland's 2030 renewable targets once these are finalised, and any commitments that may emerge from the COP21 conference this December.

As a form of distributed energy, solar PV can empower Irish consumers and communities to take control of electricity production and consumption. Alongside emerging energy storage technologies and smart meters, solar PV can increase consumers' awareness of their energy use, and potentially drive behavioural change and greater energy self-sufficiency, both at a household and a community level.

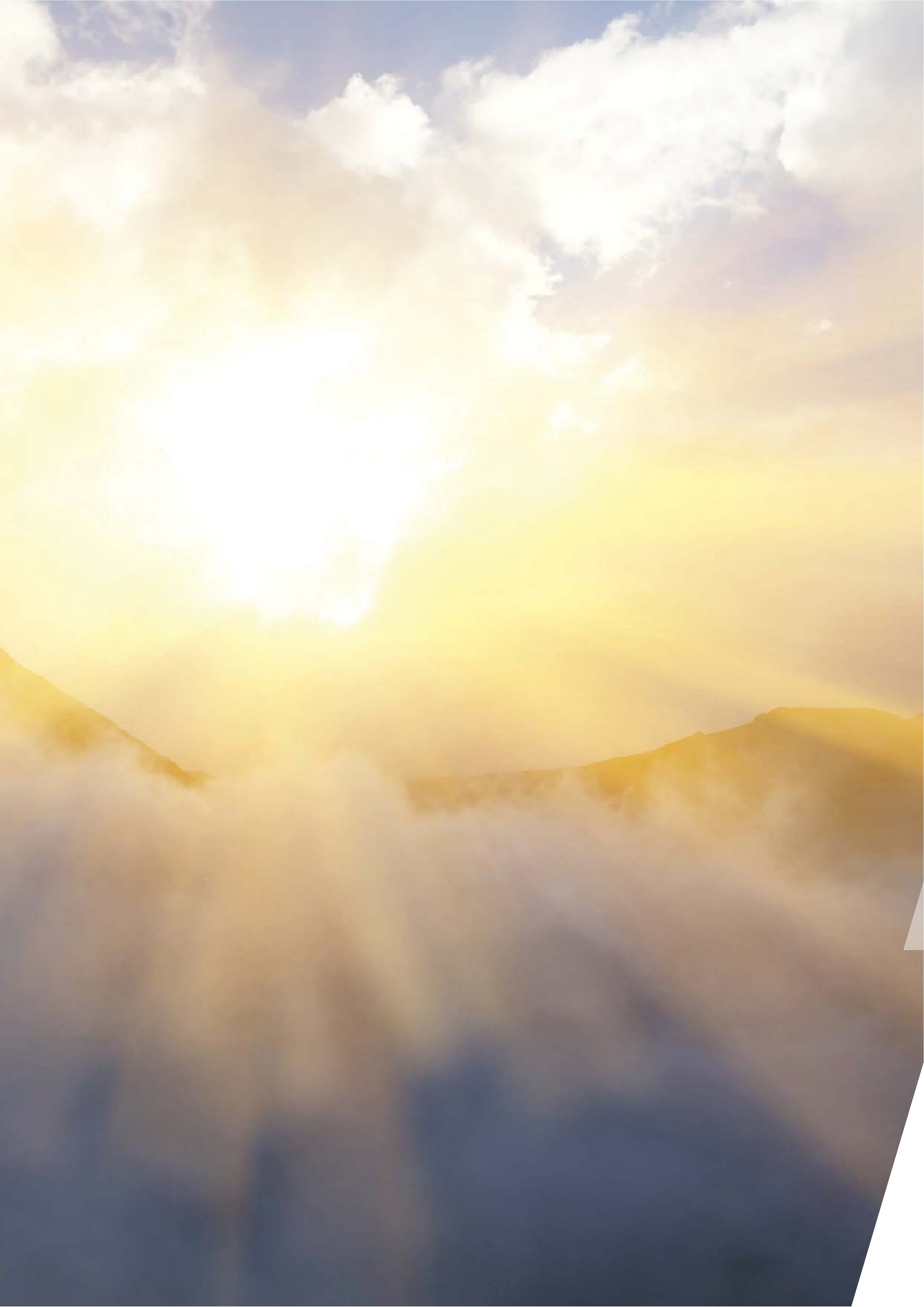
As well as considering the position of solar PV alongside competing technology costs, other key factors relevant to the deployment of solar in the Irish energy market include opportunities and limitations in relation to availability of grid connections, availability of suitable sites, system operation restrictions imposed by significant levels of intermittent generation, system demand, and interconnection to international energy markets. Solar deployment rates in Ireland are difficult to forecast unless a target and associated incentives are set. We have modelled a 3.7GW solar PV deployment scenario to 2030 as a central case, with associated high and low scenarios.

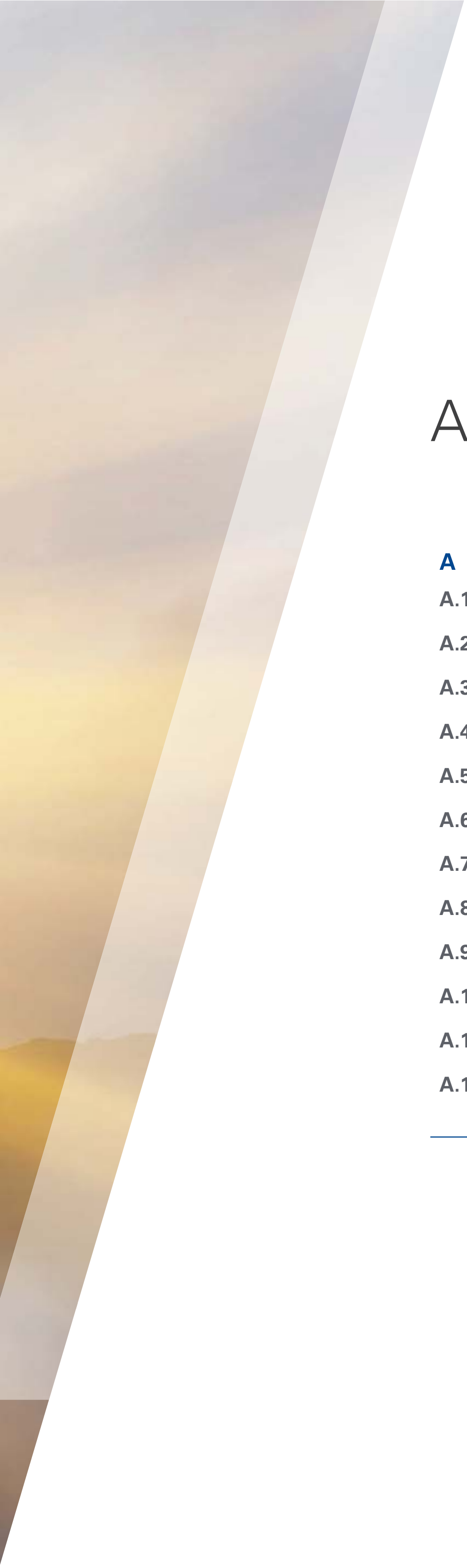
If the Irish solar PV industry is encouraged to grow smoothly at this rate, **we forecast there will be significant economic benefits to Ireland**. Based on the three scenarios described in this report, accelerated development of the solar industry would support jobs, value added and tax revenues. We estimate that with the appropriate incentives, over the period from 2017-2030, the solar industry in Ireland has the potential to provide support for:

- **€2.0 billion in GVA**
- **Up to 7,300 jobs annually**
- **€0.8 billion in tax revenues**

We have calculated the potential incentives that would be required to grow a solar industry in Ireland over the next 15 years and beyond. **For our central case, for every €1 invested, there would be a benefit to the economy of €3.** Ensuring value for money of such incentives, as solar costs fall, could be realised through competitions for larger scale subsidies, and automatic reductions for smaller scale ones.

In the future, **the role of PV will be maximised if it is operated in conjunction with energy storage and demand response, electric vehicles and smart metering**. The energy system of the future will be more distributed in nature, and the versatile nature of solar PV will allow it to be included in new products and services offered to customers, thereby contributing to lower bills, and secure low carbon supplies.





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APPENDIX A

Technical assumptions

A.1/ Capex assumptions

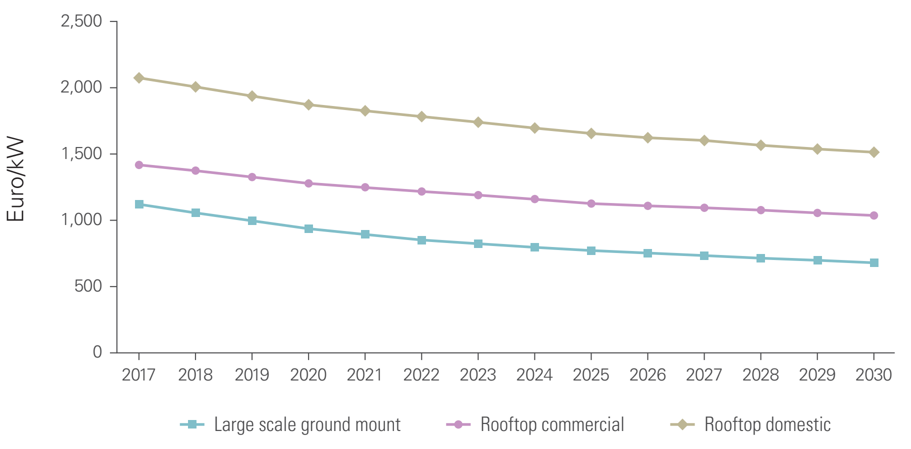
There is not an extensive evidence base regarding the costs of solar PV installations in Ireland due to low levels of deployment. The starting point for estimating current costs of Irish projects is data gathered from UK developers as part of KPMG's project for the REA in the UK for each of the principal solar PV market sectors (domestic rooftop, commercial rooftop, large-scale ground mount).

The costs of Irish projects are likely to be greater than those of similar size in the UK. For rooftop projects, capex assumptions for UK projects (in sterling) have been converted into Euros using current exchange rates. Given that the £:Euro exchange rate is significantly above its long-term average, it is assumed that the currency conversion will capture differences in costs between Ireland and the UK. For large-scale ground mount installations, Irish grid connection costs have been added to UK capex, and a 'novelty premium' has been added for projects commissioning from 2017 to 2022, to capture developers' initial lack of experience in developing large, complex projects under Irish conditions. The novelty premium is modelled as starting at 10% for 2017 installations, and gradually falling to 0.

For the purposes of calculating solar PV investment, capex is assumed to decrease according to the levelised cost profile developed by DECC for solar PV in the UK (plus the reduction in novelty premium for the large-scale ground mount sector)[65].

Chart 12:

Capex reduction profile 2017-2030



Source: KPMG.

A.2/ Opex assumptions

As with capital costs, there is little evidence to inform estimates of operating expenditure for solar PV projects in Ireland.

Opex assumptions for domestic rooftop installations are based on a recent Parsons Brinckerhoff (PB) report for DECC[66] in the UK. PB assert that there are no significant O&M costs for domestic solar installations besides inverter replacement, and assume that inverter replacement is required every 10 years, and that each replacement would cost £1,000 for 0-4kW installations, and £1,200 for 4-10kW installations. These costs are then annualised across the life of the project. No additional O&M costs for domestic installations in Ireland have been identified, or any evidence that inverter replacement would be more/ less expensive in Ireland, so the UK assumption has been adopted here.

For commercial installations, the cost of inverter replacement will be much lower on a per kW basis. However, there could be additional O&M costs, especially around remote monitoring of security and electricity production. In addition, Parsons Brinckerhoff do not appear to have considered business taxes as a component of opex. Evidence submitted to the DCENR by ISEA indicates that this would be a significant part of a project's annual costs at around €7/kW. The approach taken here has been to take the Parsons Brinckerhoff assumptions and add Irish business rates. Additional O&M costs e.g. those relating to remote monitoring have not been included as they may not be applicable to all installations[67].

Source: 65. See DECC, 'Electricity Generation Costs Update', December 2013.
66. Parsons Brinckerhoff, 'Small scale generation costs update', August 2015.
67. Installations that are owned by the business whose premise they are attached to (rather than by a third party investor) may not incur additional security costs for solar panels beyond their regular security costs for the property, and may not require detailed monitoring of the performance of the PV unit.

The operating costs of large-scale ground mounted installations are likely to vary by country, due to differences in land rental values, tax systems and grid fees. We have therefore used evidence submitted to the DCENR by ISEA[68] which estimates opex for a 5MW installation in 2017 as €155,445, which equates to €31.1/kW.

There is not a great deal of evidence regarding potential future reductions for opex in Ireland. PB estimate that there will be small decreases in the UK due to reductions in the price of inverters and more automated monitoring, with reductions plateauing once grid parity is reached. There is no reason why these factors would not apply in the Irish market, therefore the PB assumptions have been used here.

A.3/ Load factors

Solar GIS data for six potential 5MW projects in different parts of Ireland was provided to KPMG by BNRG. On the basis of this information, an average load factor was calculated. This gives a central load factor assumption of 884kWh/kW/yr. This has been used in the calculation of required support rates. Given the variance in load factor for different regions of Ireland, levelised cost sensitivities based on load factors have also been calculated and are presented in Chart 5. This gives low and high load factor assumptions of 793kWh/kW/yr and 1,000kWh/kW/yr respectively.

For rooftop installations, there is little available evidence regarding likely load factors in Ireland. It is likely that differences in load factor between the UK and Ireland for large-scale ground mount installations are likely to be similar to those for rooftop installations. Rooftop load factors have therefore been estimated by taking the assumptions used in KPMG's report for REA in the UK, and reducing load factors by 10% (the difference between KPMG's assumption for large-scale UK projects and the Irish average from the GIS data).

This gives load factor assumptions of 809kWh/kW/yr and 816kWh/kW/yr for commercial and domestic rooftop installations respectively.

Table 8:

Opex, 2017 installations (2015 prices)

Market segment	Opex (€/kW/yr)
Large-scale ground mount	31.1
Commercial rooftop	23.3
Domestic rooftop	44.8

Source: KPMG, DECC, ISEA.

Table 9:

Opex cost reduction assumptions, by market segment

Market segment	Opex percentage reduction per annum
Large-scale ground mount	0.3% until grid parity is reached, thereafter 0%
Commercial rooftop	0.3% until grid parity is reached, thereafter 0%
Domestic rooftop	0.2% until grid parity is reached, thereafter 0%

Source: DECC.

Source: 68. http://irishsolarenergy.org/wp-content/uploads/2015/09/ISEA-Submission-DCENR-18.09.2015.compressed.pdf

/A
Technical assumptions

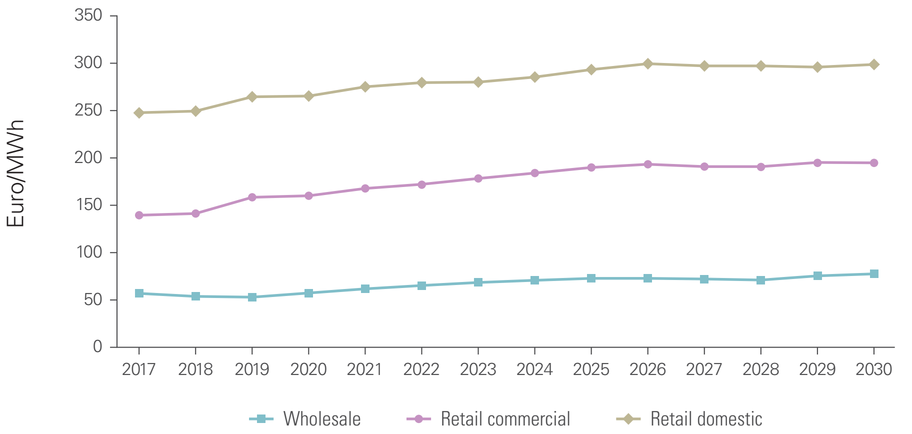
A.4/ Electricity prices

There are no publicly available projections for future Irish electricity prices. Our approach has therefore been to take current Irish wholesale and retail prices, and project these forward based on UK price movements as set out in DECC's UEP series[69].

Average baseload wholesale electricity prices in Ireland and the UK have been closely aligned in recent times, as gas-fired generation continues to be the cost-setting technology[70]. The recent increase in the level of the carbon price floor in the UK[71] will drive a wedge between wholesale prices in Ireland and the UK, but otherwise there are no compelling reasons to believe that wholesale prices in the two countries will move differently in future, especially given the interconnection between UK and Irish markets.

Chart 13:

Irish electricity price projections, 2017-2030



Source: KPMG, SEAI, DECC.

For retail prices, European Commission analysis suggests that for industrial customers, the split of the overall price between the three main components (taxes and levies, network costs, energy and supply costs) was roughly the same in Britain and Ireland as of 2012[72]. Their analysis for domestic consumers suggests that energy and supply costs make up a larger proportion of the retail price in the UK, with taxes and levies making up a greater proportion of the price in Ireland. However, domestic retail prices in Ireland have increased in line with UK prices over recent years, with a total increase of around 25% from 2008 to 2014[73].

To derive current electricity prices, the starting point is 2014 price data for the Irish market[74] and applied a small increase based on the Irish Consumer Price Index[75]. This is in line with market data that suggests Irish electricity prices have been largely flat between 2014 and 2015[76].

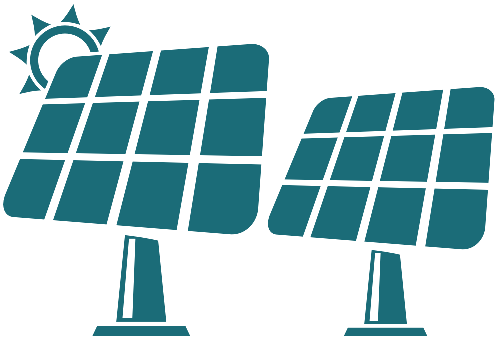
SEAI present retail prices in several 'bands' for both domestic and commercial consumers. For the purposes of calculating required support for domestic installations, we have taken the price for the band where there are the largest number of consumers[77]. For the commercial rooftop sector, we have sought to cross-check the banded SEAI prices with Eurostat's broader measure of the price faced by 'industrial' customers in Ireland[78] to give a 'typical' price faced by non-domestic consumers[79].

A.5/ Export fraction

The export fraction is defined as the amount of electricity a rooftop solar PV installation exports back to the electricity grid[80]. There are considerable variations in the proportion of electricity that is exported back to the grid, due to differences in the demand patterns of different types of building occupant. For example, a professional couple who are out at work during daylight hours will use a lower proportion of the electricity generated by solar panels on their roof than will a business whose main hours of operation are during the day. Indeed, Parsons Brinckerhoff's recent report for DECC reported a variation in export fraction for domestic rooftops alone of 33 to 80%.

Footnote/Sources:

69. For more details on DECC modelling, see https://www.gov.uk/government publications/updated-energy-and-emissions-projections-2014
70. See DG Energy, 'Quarterly report on European electricity markets (Vol.8)'.
71. This increased from £9.55/Mt to £18.08/Mt on 1 April 2015.
72. European Commission, 'Energy Prices and Costs Report', 2014.
73. DG Energy, 'EU Energy in Figures 2015'
74. Retail price data taken from SEAI, 'Price Directive 2 Semester 2014' and wholesale price data taken from SEM, 'Single Electricity Market: Market Update January – March 2015'.
75. Inflation assumption taken from CSO Consumer Price Index.
76. For example, see DG Energy, 'Quarterly report on European electricity markets (Vol. 8)'.
77. This is Band DD for domestic customers.
78. http://ec.europa.eu/eurostat/statistics-explained/images/9/9f/Energy_prices_YB2015.xlsx
79. The SEAI price band closest to the Eurostat price for industrial users is Band IC, which has been used in the analysis here.
80. Ground mount installations by definition export all of their electricity due to the lack of on site demand.



An export fraction of 53% for rooftop installations has been assumed in this report, in line with Parsons Brinckerhoff's recent report for DECC, since there are no strong reasons to believe that Irish patterns of electricity consumption will be significantly different to those in the UK (for example neither country will have significant demand during the day due to household air conditioning systems).

A.6/ Technology lifetime

Given that widespread solar PV deployment has been relatively recent, it is uncertain what the lifetime of installations is. Given this uncertainty, we have assumed that the lifetime of solar PV installations is 25 years in all market segments. This corresponds to assumptions made in analysis of solar PV levelised costs by the Fraunhofer Institute[81].

A.7/ Investor hurdle rates

Hurdle rates in Ireland are likely to be higher than in other, more mature solar markets due to financial institutions' lack of familiarity with the technology. Hurdle rate assumptions from the UK[82] has therefore been uplifted to account for this (see Table 10).

Table 10:

Investor hurdle rates (pre-tax, real) by market segment, UK and Ireland

Market segment	Hurdle rate (UK)	Hurdle rate (Ireland)
Large-scale ground mount	6.2%	7%
Commercial rooftop	7%	8.5%
Domestic rooftop	6.2%	8%

Source: KPMG, DECC.

Source: 81. Fraunhofer ISE, 'Current and Future Costs of Photovoltaics'.
82. UK assumptions are taken from Parsons Brinckerhoff, 'Small scale generation cost update' for rooftop installations and from DECC, 'Electricity Generation Costs Update' for large scale ground mount installations.

/A
Technical assumptions

A.8/ Capex breakdown

For the purposes of the macroeconomic analysis, a breakdown of capex into its component parts was developed. For large-scale ground mount installations, this was based on the assumptions developed by the Fraunhofer Institute for their recent study of solar PV levelised costs. Given the lack of a third party source for the capex breakdown for rooftop installations, data from KPMG's study for the REA in the UK has been used.

A.9/ Emissions factors

The SEAI reported that the carbon intensity of electricity supply in Ireland was 469g CO_2/kWh in 2013, and that the historic annual reduction in carbon intensity between 1990 and 2013 was 2.8% per year[83]. We have therefore applied this reduction to future years to give a profile for reduction in carbon intensity.

A.10/ Carbon prices

DECC's projections for future EU ETS prices has been used in this analysis[84].

A.11/ Input-Output modelling

Input-Output models are based on Input-Output tables, which organise the business sector of an economy in terms of who makes what outputs and who uses what inputs. They allow us to estimate how an increase in demand for a product of one industry could impact other industries and the economy as a whole, including impacts on GVA, employment, taxes and employee compensation by 2-digit NACE sector.

The Input-Output model uses multipliers which are applied to direct impacts in order to calculate the indirect and induced impacts. We calculated these multipliers based on the data and guidance published by Eurostat[85]. The Central Statistical Office[86] also publishes indirect multipliers for the republic of Ireland; which we used to cross-check our calculations. As relatively small, open economy the multipliers tend to be lower for Ireland that countries such as the UK or Germany.

The key inputs to the Input-Output model are the revenues and spending (Capex and Opex) of the solar PV industry.

Table 11:

Capex breakdown, large scale ground mount installations

Aspect of capex	%
Module	55%
Inverter	11%
Mounting system	8%
Installation	5%
Cable	5%
Infrastructure	4%
Transformer	3%
Grid connection	6%
Planning/documentation	4%

Source: Fraunhofer Institute.

Table 12:

Capex breakdown, rooftop installations

Aspect of capex	%
Module	37%
Inverter	8%
Frame	11%
Cable, meters, isolators	3%
Scaffold, landscaping	12%
Installation costs	18%
Other (pre-development, legal, design)	10%

Source: KPMG.

Source: 83. SEAI, 'Energy in Ireland: Key Statistics 2014'.
84. https://www.gov.uk/government/collections/carbon-valuation--2
85. http://ec.europa.eu/eurostat/documents/3859598/5902113/KS-RA-07-013-EN.PDF/b0b3d71e-3930-4442-94be-70b36cea9b39?version=1.0
86. http://www.cso.ie/en/releasesandpublications/ep/p-sauio/supplyanduseandinput-outputtablesforireland2011/

Revenue

The revenues generated by the solar industry in our modelling consist of the electricity sold by ground mount plants to the grid, electricity costs avoided by owners of solar PV rooftop installations plus any revenue earned by rooftop installation owners through exporting to the grid.

Capex and Opex

The Input-Output modelling requires us to allocate the initial spending by the solar industry to sectors of the economy. For the Opex spend we only allocate intermediate goods and services to sectors as these are the only elements of the spend that has a supply chain impact. Spending on wages and rents are not intermediate inputs. Under the Input-Output framework Capex spend is treated as spending on final goods (rather than intermediate inputs), so it is allocated to an economic sector so long as that spending is on goods and services in Ireland. The allocation of goods and services to sectors is shown in Tables 13 and 14.

Table 13:

Opex spend breakdown

	% of OPEX spend	Sector of economy for I-O analysis
Rent	18.4%	Not an intermediate input
O&M parts	12.0%	Produced abroad
O&M wages	23.0%	Not an intermediate input
Insurance	10.9%	Insurance, reinsurance and pension funding (65)
Business rates	23.5%	Not an intermediate input
Distribution and Grid fees	6.9%	Electricity and gas supply (35)
Other	5.3%	Repair/installation of machinery and equipment (33)

Source: KPMG.

Table 14:

Capex spend breakdown

	% of CAPEX spend		Sector of economy for I-O analysis
	Ground mount	*Rooftop*	
Modules	55.1%	37.4%	Produced abroad
Inverter	11.0%	8.3%	Produced abroad
Frame	7.5%	11.2%	Produced abroad
Cable, meters, isolators	8.0%	2.9%	Produced abroad
Scaffold, landscaping	3.9%	11.8%	Construction and construction works (41-43)
Development costs	3.5%	10.0%	Architectural and engineering services (71)
Installation costs	5.0%	18.5%	Repair/installation of machinery and equipment (33)
Grid costs	6.0%		Construction and construction works (41-43)

Source: KPMG.

/A
Technical assumptions

A.12/ Taxes

To arrive at the total tax revenues we looked at four broad types of taxation: Labour, Product, production and profit taxes. We looked at each relevant financial stream and calculated the relevant tax rate to apply.

Taxes on Labour

Taxes on labour include income tax, PRSI, USC. We calculated the average labour tax paid using data on total revenues from labour taxes from the CSO for 2014 and dividing by the total employee compensation for that year.

Employee compensation in 2014 was calculated by multiplying average wages for 2014 (€35,768) plus other labour costs (€5,526)[87] by total employment[88]. The average wage only reflects salaried employees and not income from self-employment. However, the CSO do not publish separate data on self-employed income per person, so we have used the average wage as the nearest proxy. Total employees includes self-employed.

This results in an assumption of 20.4% for income tax plus USC and a rate of 9.1% for PRSI (employee and employer).

Employee compensation in the scenarios was calculated using an average wage rate of (€25,000) and other labour costs of (€3,750). These are lower than the average (mean) wage, however much of the employment will be outside of big cities, where wages are higher and in sectors with lower mean wages (such as installation). €25,000 is consistent with our GVA and employment modelling, however this should not be treated as a prediction of the wage in the sector, but as a conservative assumption necessary for modelling. We have not looked at wage rates in detail as part of this study. We do not include an assumption of real wage growth in our calculations, this is both because the Input-Output analysis is static and so does not account for changing prices (including wages) and because the assumptions on Capex and Opex spending do include an explicit treatment of the cost impact of real wage growth.

Taxes on production

Taxes on electricity were calculated by applying the average tax paid on electricity by total revenues earned. We calculated the average non-recoverable tax rate paid across households and industry to be 10.1% (we assume that all VAT paid by industry is recoverable). Our calculations are based on a breakdown of tax paid and energy consumed by industry and households from the SEAI[89].

VAT and other product taxes will also be paid in the supply chain of the solar PV industry. To give an estimate of these we use the Input-Output modelling to give a total for taxes and subsidies on products in the supply chain. This will be an underestimate of total product taxes in the supply chain as the multipliers reflect net taxes (taxes minus subsidies) and does not include any induced effects.

We use an assumption of €7,000 per MW as an estimate of business rates paid in any year, which equates to approximately 23% of OPEX spend. This assumption was provided by the ISEA. To calculate taxes on production in the supply chain we use the Input-Output analysis, which gives us an estimate of total taxes minus subsidies in the supply chain, but again does not include induced effects.

Corporation taxes

Given the difficulty of identifying taxable profits both in the solar sector and the supply chain without a detailed understanding of issues such as financing structures, we decided to take an indirect approach to estimating corporation taxes. This approach uses the fact that the latest revenues data (CSO 2014) show corporation tax making up around 8.4% of total tax revenue. In the latest data, labour, product and production taxes make up approximately 86% of total tax revenue. We therefore estimate corporation taxes as the total of estimated labour, production and product taxes multiplied by 8.4%/86%.

Source:
87. http://www.cso.ie/en/releasesandpublications/er/elca/earningsandlabourcostsannualdata2014/
88. http://www.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?maintable=QNQ19&PLanguage=0
89. SEAI (July-December 2014). Electricity and Gas Prices in Ireland

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