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Davy Decarbonization

Corporate Finance

Irish Solar's Time to Shine

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Fergal McNamara has more than 30 years' experience in the electricity industry. He was Group Manager for Regulation and Policy at ESB, Ireland's leading utility, and has vast experience of the reforms of the energy industry in Ireland and the EU. Fergal was the Chairman on the Distribution Committee at Eurelectric, the trade body representing the industry to the EU institutions; Senior Energy Advisor in the Irish Government Dept. of Environment, Climate and Communications; and Head of Capacity Market Design in the UK Government Dept. of Energy and Climate Change. He also worked in the transmission sectors in Canada and the USA.

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Key Takeaways

Solar as a renewable resource will play a major role and provide a key contribution in the energy transition. It currently has a global share of 2% of electricity production, but the growth in solar investment globally has been exceptional with 151 GW added in 2021, according to the **International Energy Agency.** Costs have plummeted by some 85% towards a levelized cost of US$30-40/MWh.

The EU has set a target for solar of 600 GW by 2030 (up from 224 GW installed in 2022), which will require annual investment of 45 GW – a significant step-up from the current rate of 26 GW/year. Solar is predicted to be the predominant source of electricity from c.2040 onwards.

A series of planning reforms are in train in Ireland that will be of assistance to investors in energy projects. In the solar sector, planning exemptions for rooftop solar installations are already in place; this bodes well for growth.

In the **National Climate and Energy Plan,** Ireland has pledged an overall 2030 national renewables share of 34.1% of total energy consumption. In the electricity sector, an overall target of 80% has been set – which includes an 8 GW target for solar, i.e. the Total Addressable Market. From this, Davy estimates the remaining Serviceable Available Market for commercial development at 3-4 GW, requiring investment of €3.75-4.5 billion.

Davy views three practical routes-to-market for solar: government supports, commercial and grants. Government supports are allocated by means of public auctions. Two auctions have taken place to date and a third is planned for 2023. **Davy foresees that solar will be the predominant competing technology in this auction.**

The solar market in Ireland is currently fragmented and mainly a domestic play. Projects to date are small, albeit increasing in size, with market consolidation expected in time.

Introduction

The global transition to net-zero is now well underway, and it is a given that this requires a major switch to renewable energy resources. Solar as a renewable resource will play a major role and provide a key contribution in this transition.

The Global Solar Atlas publication of the **World Bank** remarks:

"the potential for electricity generation from solar photovoltaic sources in most countries dwarfs their current electricity demand"

The **International Renewable Energy Agency** estimates that a fourfold annual increase in Photovoltaic (PV) and more than a sixfold increase in solar thermal deployment are needed to limit the global temperature rise to 1.5 degrees. Solar also has an important role to play in international development[1] and to assist countries in meeting the **Sustainable Development Goals.**

The growth in solar investment has been exceptional: 710 GW have been installed to date globally, corresponding to approximately 3.5% of total energy production. A total of 125 GW was added in 2020 alone and, according to the **International Energy Agency**, 151 GW in 2021. Costs have been declining rapidly; over the past decade, the global weighted-average levelized cost of electricity for utility-scale solar PV projects has fallen by 85% for a levelized cost of energy in the region of US$30-40/MWh.

1 The World Bank found in its report (ibid) that almost all nations with lower Human Development Index rankings show outstanding PV potential.

Policy Targets and Planning Reform will Support Accelerated Solar Deployment

The ongoing drive of the energy transition, combined with the recent energy crisis, has accelerated ambition. The EU has identified solar as an integral part of the transition. Moreover, the Irish government has recently increased its targets for solar capacity, and changes in the planning regime will help to accelerate the rollout.

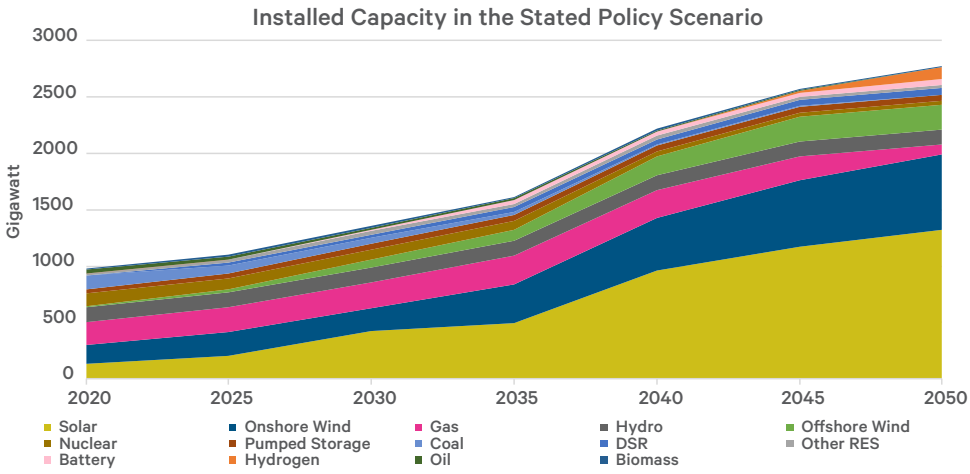
The EU, as the first continent to provide a legal strength net-zero pledge by 2050 in the **European Green Deal,** has set out ambitious plans for renewable deployment in general and solar in particular. The first legislative phase of the Green Deal is a policy compendium known as **Fit-for-55,** referring to 55% emission reduction by 2030 compared to 1990. An EU-wide target for renewable energy of 40-45% by 2030 is currently being finalised by the co-legislators. It is expected that this will ultimately be legislated by way of amendment to the **Renewable Energy Directive.**

The EU renewables target is continent-wide; pursuant to the **Governance Regulation,** each member state has committed to individual targets, set out in **National Climate and Energy Plans**. In the case of Ireland, it has a target of 34.1% of energy to be met by renewable sources by 2030 – addressing a Union-wide target of 32%[2]. If/when a new EU target is agreed, Ireland's target will likely require revision. Accordingly, the European Commission's **Impact Assessment** addresses a 40% target; it is therefore expected that Ireland's target would also be (the numerically coincident) 40%.

The **EU Solar Energy Strategy** sets out an ambition to deploy 320 GW by 2025 and to double that to 600 GW by 2030, up from 224 GW installed capacity in 2022. To meet this, the rate of investment must therefore accelerate significantly. The EU estimates that 45 GW of additional solar will need to be deployed annually, which will be a significant step-up from the 26 GW installed in 2021. By 2040, solar is expected to become the top source of power generation in Europe (as shown in Figures 1 and 2).

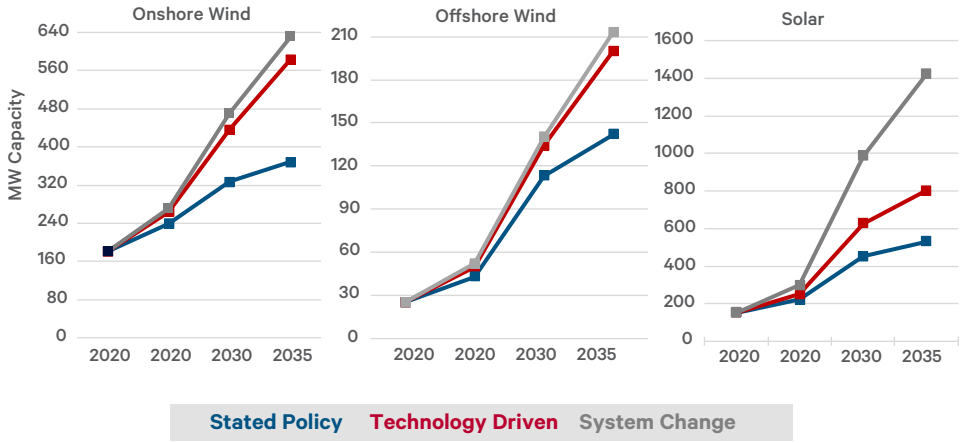
2 The first targets were set in 2009 requiring 20% renewable energy by 2020, which was sub-divided into binding targets for each member state; Ireland received a target of 16%. The target structure was changed to Union-wide by the Clean Energy for all Europeans legislative package and in 2018 reset at 32%; Ireland was expected to pledge at least 31%. As part of the Green Deal/Fit-for-55/REPowerEU initiatives, the target is being renegotiated and has variously been increased to 40% and 45%.

Figure 1: Generation Installed based on stated policies of the EU-27:
The chart shows the installed generation pathway where solar is seen to predominate from c.2040 onwards.



Source: World Economic Forum, New Generation: Building a Clean European Electricity System by 2035

Figure 2: EU renewable electricity projections by technology
(where the blue lines correspond to Figure 1).



Source: Ember, European Clean Power Pathways Explorer

In the **REPowerEU** communication, the European Commission has proposed that member states establish 'Renewable GoTo Areas' (to be supplied and serviced by utilities) not unlike that advanced by EirGrid as the 'developer led' option in its **"Shaping our Electricity Future"** paper. Viewed from the perspective of offshore wind development, this is also similar insofar as areas of seabed will be pre-identified or zoned for wind development and hence serviced by grids.

Planning Reforms

More recently, the Commission has proposed a temporary Regulation laying down a framework to accelerate the deployment of renewable energy to speed up permitting for renewable energy projects. The Regulation is being made by the Council alone under Article 122 of the Treaty, justified by the urgent need to address the reduced dependence on imported Russian fossil fuels. It is expected that, in time, these provisions will endure by a revision of the **Renewable Energy Directive**[3] to be made normally by co-decision, including the European Parliament. Broadly – concerning planning, construction and operation of

3 There are also provisions in this directive addressing a two-year permitting timeline.

renewable energy plant (and related grid and storage assets) – the Regulation provides the following:

- **Time Limits:** An expectation is set that the permitting processes for certain configurations of solar energy equipment should not exceed three months and be exempted from the requirement or determination to carry out an environmental impact assessment. A cut-off of six months is provided for the permitting of repowered renewable energy projects, and one-month negative assent will apply to solar installations with a capacity of 50 kW or less.

- **Presumption of overriding public interest:** The projects are presumed to be of overriding public interest. This can be of assistance to the planning authorities in member states as they process individual cases and specifically enables the projects to benefit from derogations in other EU environmental legislation (specifically the **Water Frameworks Directive,** the **Habitat Directive** and the **Birds Directive**).

The Irish government has already put in place planning reforms related to the installation of solar on domestic rooftops and is more broadly engaged in a complete overhaul of the planning system. Primary legislation is pending or in process.

A pair of regulations on this subject has already been enacted that permits solar to be installed on domestic rooftops, industrial buildings, business, educational buildings, places of worship, health buildings, libraries and certain public utility sites and farms without planning permission (with the exception of designated solar safeguarding zones to protect aviation).

More broadly, there are currently two pieces of legislation being moved before the Oireachtas related to reform of the planning system, which is widely regarded as constraining the implementation of the **National Development Plan** and **Project Ireland 2040.**

- **Planning and Development Foreshore (Amendment) Bill 2022:** provides for the ability of the appointment of members to **An Bord Pleanála (ABP)** and clarification about the definition of the foreshore.

- **Planning and Development Bill (2023):** a bill to consolidate and modernise the planning system is awaited that includes: (a) focusing and front-ending debate into overarching planning documents (of which there are hierarchies and extended durations); (b) timelines for the processing of cases by ABP, starting first with strategic infrastructure and energy; (c) the Board is to be renamed and restructured **(An Coimisiún Pleanála)**; and (d) changes to the Judicial Review process.

Moreover, it is worth nothing that the Department of Public Expenditure and Reform has been renamed as the Department of Public Expenditure, **NDP Delivery and Reform**, placing emphasis on this.

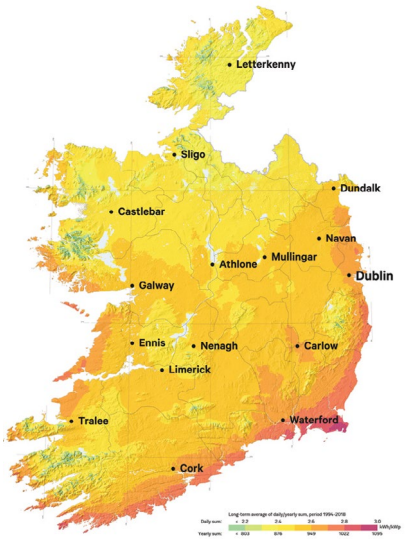
Addressable Market for Solar in Ireland Implies Significant Growth Opportunity

The EU and Irish government will increasingly rely on solar in the years ahead as a means of achieving renewable targets. This is evidenced in the recent auction, with solar accounting for 70% of total allocations. We believe this will be repeated in the forthcoming auction. This, combined with a growing corporate power purchase agreement (PPA) and domestic market, supports the total addressable market for solar in Ireland of 8 GW.

The **Energy Sector Management Assistance Program** of the **World Bank** has published an online global solar atlas, a report that uniformly assesses the country-level PV potential and contains country (including Ireland) factsheets. Informatively, the report assesses the practical solar PV potential by taking into consideration various factors including air temperature, terrain horizon, etc. For example, Ireland's solar irradiance is relatively low, but this is offset by colder temperatures that improve the output of the panels.

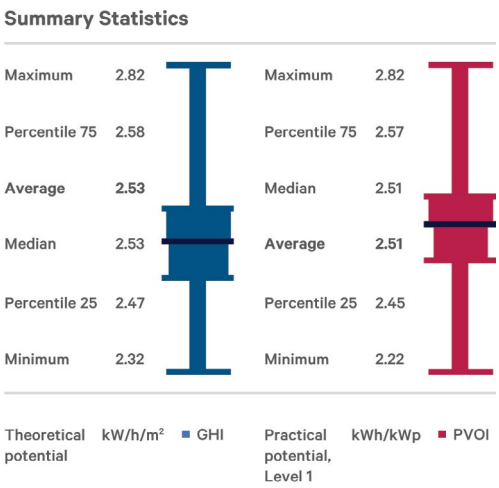
The map reproduced in Figure 3 shows the average electricity output from a 1 kW grid connected solar power PV plant, and the findings are summarised in Figure 4. The long-term average production that could be expected from a 1kW PV plant in Ireland is between 2.22kWh and 2.82kWh (with an average of 2.51kWh) per day. Interestingly, the report also cites the case of Ireland (at the low end) by contrasting it with Namibia (at the high end), with the difference surprisingly less than a factor of two.

Figure 3: Photovoltaic Power Potential in Ireland: the colouring represents the long- run average daily output and yearly totals (in kWh) that can be expected from a 1kW PV plant.



Source: World Bank Group

Figure 4: Long-Term Average of Solar Irradiance and Practical Output (Ireland): The global horizontal irradiance (GHI - blue) is the sum of the direct and indirect irradiance; the long-term average practical output (kWh per kW installed) is shown in red.



Source: World Bank Group

For Irish solar, the targets for 2030 are illuminated by the following:

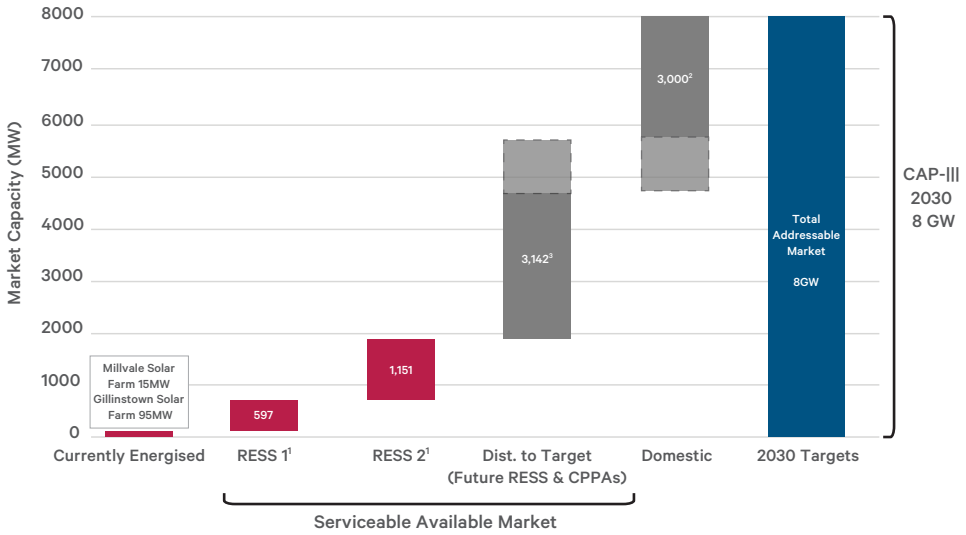
- The recently published and therefore most authoritative source is the **Climate Action Plan** (3rd edition), which contemplates 8 GW installed (with an interim target of 5.5 GW by 2025).
- The EirGrid **Generation Capacity Statement** contemplates 1.5 GW installed (and a further edition is awaited); and
- Government publications, alongside the decision setting of the Sectoral Emissions Targets, contemplate 5.5 GW.

Beginning with CAP-III, a target (for 2030) of 8 GW is established. The Davy view is that approximately 2-3 GW will come to market by way of domestic installations, leaving a 5-6 GW **serviceable market**. Furthermore, two government auctions have taken place to date, and facilities are already becoming energised. Notwithstanding, it is to be expected that not all of the projects awarded contracts will eventually become energised; this is discussed below. Davy estimates the overall auction withdrawal rate at 25%, meaning that approximately 1.8 GW will eventually become energised on foot of these two auctions.

This means that the total gap-to-target, i.e. the difference between what has been allocated in past auctions and the 5-6 GW serviceable market, is therefore 3-4 GW. This will be achieved by a combination of future government-run auctions and Corporate Power Purchase Agreements **(CPPAs)**.

This is depicted in Figure 5. Given that development/construction costs are of the order of €700-800/MW, that side of the remaining market is €3.75-4.5 billion.

Figure 5: Total (Solar) market breakdown. The remaining serviceable available market for commercial development is in the range of 3-4 GWs or €3.75-4.5 billion.



1. Net of 25% RESS withdrawal as per Davy Sector Research | 2. Estimated at between 2-3 GWs |
3. The Distance to target (for RESS - 3 and others) is estimated at 1-3. 1GW

Source: EirGrid, ESB, Department of the Environment, Climate and Communications, Davy Proprietary Research

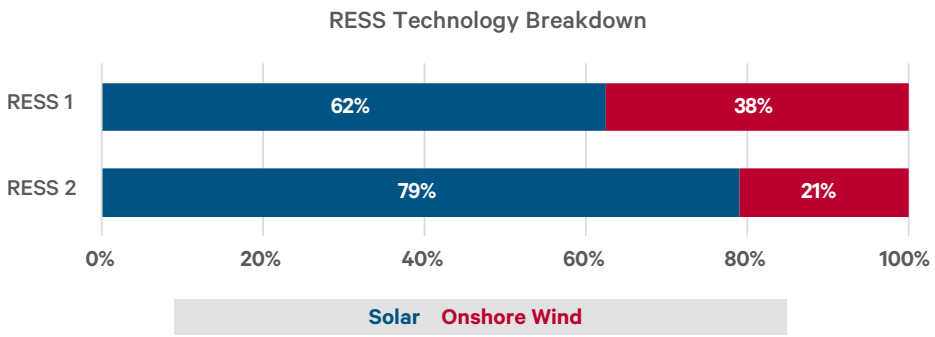
Multiple Routes to Market

There are three practical routes-to-market for solar: government supports, commercial and grants.

Government supports – Government supports are allocated by way of a competitive process known as the Renewable Energy Support Scheme **(RESS)**, which is funded by a Public Service Obligation levy on electricity customers. This scheme has state aid approval from the European Commission for the period 2020-2025, a budget of €7.2-12 billion and the terms permit the implementation of a preference for solar. Two rounds of auctions have already taken place and a third **(RESS-3)** is planned for 2023.

In this scheme, solar competes, along with other renewable technologies (e.g., wind), and the solar preference is expressed by way of an auction parameter called the **Evaluation Correction Factor**. The results from the two rounds of RESS auctions held to date are shown in Figure 6 below.

Figure 6: RESS Technology Breakdown.
Breakdown of RESS-1 and RESS-2 winning projects by technology (% capacity)



Source: Department of the Environment, Climate and Communications

It is often the case that not all the successfully bid projects will materialise as there is always attrition due to unforeseeable implementation issues, of which recent cost inflation has become material. Furthermore, as provided within the rules, others will elect to formally withdraw. Davy estimates an overall withdrawal rate, whether due to natural attrition or formal withdrawal, at 25% for the purpose of this analysis.

Table 1: Results from the Renewable Energy Support Scheme Auctions:
In the two auction rounds to date, 796 MW and 1,534 MW of solar were successful and the overall auction strike prices were €74.08/MWh and €97.87/MWh respectively. Several of these projects have subsequently changed hands, pointing to a thriving M&A market in the solar development sector.

	RESS 1		RESS 2	
	MW	% Overall	MW	% Overall
AGR / Golden Square	97	12%	-	-
Altus AG	-	-	257	17%
Amarenco	40	5%	35	2%
BNRG	32	4%	32	2%
Elgin Energy	-	-	113	7%
Enerco Energy	8	1%	13	1%
Entrust / Island Green Power	20	2%	-	-
ESB	-	-	95	6%
ESB/Bord na Móna JV	-	-	70	5%
Harmony Solar	26	3%	57	4%
Highfield Solar	247	31%	269	18%
Other	124	16%	41	3%
JBM Solar	119	15%	-	-
Lightsource bp	52	7%	-	-
Power Capital Renewable Energy	-	-	204	13%
RES	9	1%	-	-
Solas Eireann	-	-	65	4%
SSE Renewables	-	-	7	0%
Statkraft	-	-	199	13%
Strategic Power	-	-	50	3%
Terra Solar II	10	1%	27	2%
Wexford Solar / EDF	12	2%	-	-
Total	**796**	**100%**	**1,534**	**100%**

Source: Department of the Environment, Climate and Communications, Davy Sector Research

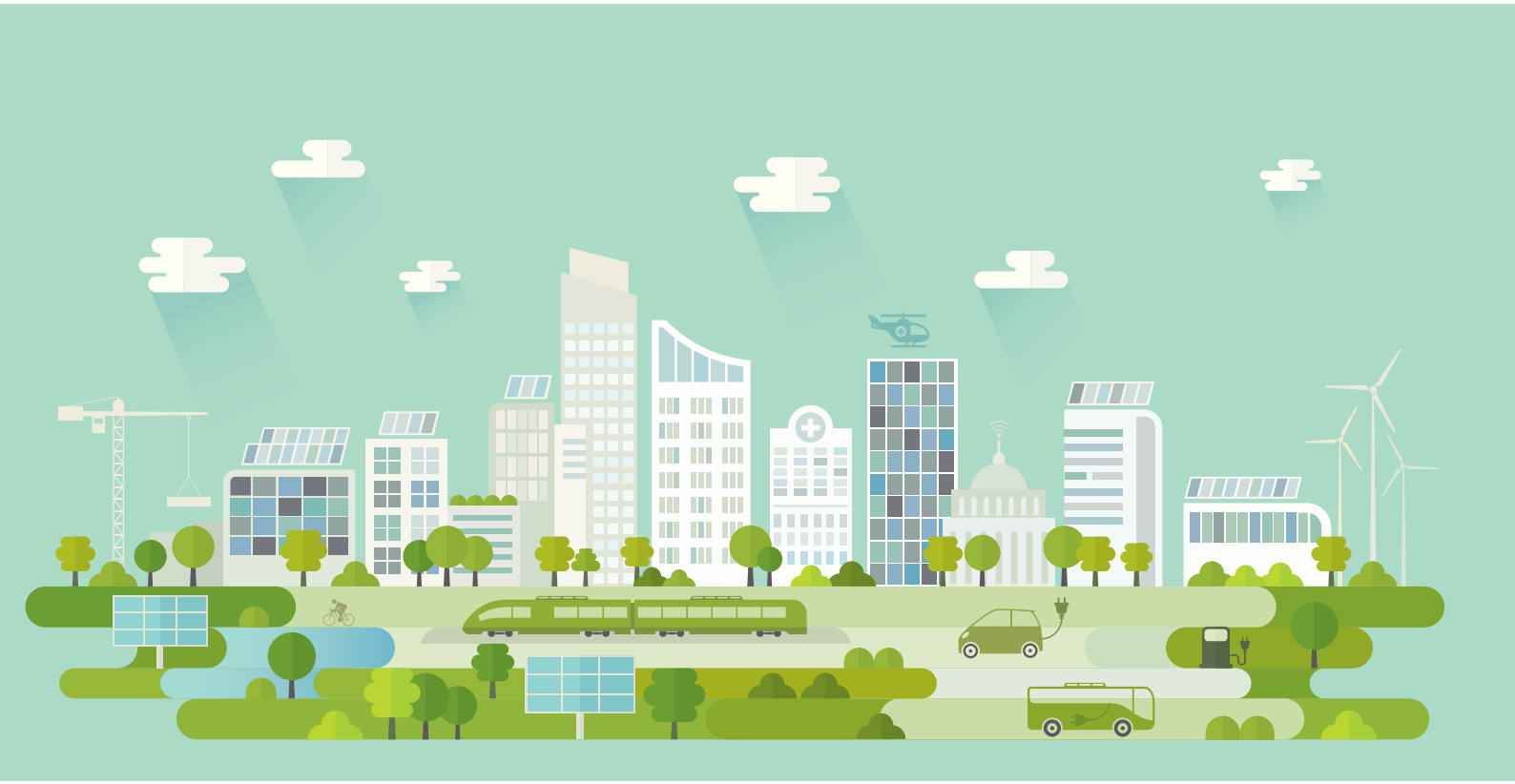
Commercial – Commercial or industrial undertakings that wish to source renewable energy may enter into negotiated CPPAs with solar developers for the purpose of securing long-term fixed price supplies. The Climate Action Plan sets a 2030 target of 15% of all electricity demand to be met by renewables covered by CPPAs (estimated at approximately 6 TWh, which would amount to 6 GW if met by solar alone). Software company Microsoft recently announced that its Irish data centres will be supported by 100% renewable power and that it had entered into 900 MW of CPPAs to further this aim.

However, this market is nascent, with both the carbon tax regime and disclosure requirements novel. There is therefore an interaction and dependency between these two routes-to-market. For instance, a successful bidder in a RESS scheme could thereby become a credible negotiating party for a corporate and, upon successful conclusion, withdraw from the RESS in accordance with the rules.

Upon completion, the project can score against the national renewable target in the normal way, without government support. However, this has been criticised as being disruptive (in the context of large remaining distance-to-target) and lacking additionality as successful bidding is usually presumed to lead to fulfilment.

Grants – For domestic applications there are government grants for solar rooftop installations **(Solar Electricity Grant)** and water heating **(Solar Water Heating Grant).** Other grants and supports are available at community level and for the business and public sector. These are administered by the **Sustainable Energy Authority of Ireland** and are Exchequer funded; the overall allocation for 2023 is €355 million[4]. Davy estimates that 2-3 GW will come to market by this means.

Depending on the circumstances of the installation and whether a smart meter is installed, there are a variety of other supports available, including export tariffs **(Clean Export Guarantee** or **Clean Export Premium)** and others, such as the **Small-Scale Generation Support Scheme,** is a work in progress. Various tax incentives are also available.



4 SEAI Sub-Head B4 in REV-2023. Although budgeting is carried out on an annual cycle, Ireland has committed to the implementation of 'green budgeting' – intended to better embed climate and environmental goals within the budgetary process. Practically, the National Development Plan (2021-2030) contemplates a capital budget of €165 billion (which the Irish Financial Advisory Council states has not costed all measures) and a capital expenditure ceiling of €11,857 billion has been set to 2025 to assist multi-annual planning. Moreover, the report of the Commission on Taxation and welfare (2022) identifies sustainability as a material risk: in the 21st century, it is necessary to identify sustainability as a distinct and defining principle of taxation and welfare design. The concept of sustainability has economic, social and environmental dimensions.....the scale of the climate challenge is so profound and so systemic that sustainability has to be seen as a design principle both for taxation and for welfare. Finally, the Finance Act (2020) legislated a series of carbon tax increase out to 2020.

Competitive Environment

Market Players

The energy transition can be viewed in the context of a wider industrial strategy or transformation of the economy in Ireland and Europe. New skills are being developed in business and in universities, and jobs are shifting from the 'old' economy to the 'new'. New enterprises, ecosystems, relationships, technologies, ways-of-doing business, etc. are emerging.

In this light, it is interesting to look for common attributes of the various solar companies (set out in Table 1) that have been successful in the RESS auctions.

It is important at the outset to note that this solar sector is less mature that the wind sector but that trends in that sector may well be informative. Davy conducted an analysis on where these companies are based, using company registrations, with the application of some arbitrary judgement on beneficial ownership. This is set out in Table 2 below.

The sample size is limited as there have been only two auctions; nevertheless, in broad terms, the following observations can be made:

- The solar sector consists of relatively smaller projects, although the size has increased perceptively from RESS-1 to RESS-2.
- There is a plurality of players, and the market is fragmented.
- It is largely a domestic play: Irish companies represented approximately 70% of the capacity, falling marginally to 67% in RESS-2. The balance is inward investment from Norway, UK and EU countries (Germany and France)[5].

There are a wide range of possibilities for the evolution of this sector, including, for example, consolidation or perhaps the emergence of various downstream business models and solar-as-a-service. Other innovations are in prospect, including leasing models for rooftop solar (some of which are discussed in the Appendix).

Table 2: Domestic and International Players in RESS-1 and RESS-2:
The majority of successful participants (c.70%) are Irish headquartered.

Equity Headquarters	RESS 1		RESS 2		Total	
	MW	% Overall	MW	% Overall	MW	% Overall
Domestic	478	71%	998	67%	1,476	68%
International	194	29%	496	33%	690	32%
Total	**796**		**1,534**		**2,165**	

Source: Davy Sector Research

5 Inward investments are of course freely permitted from EU countries, European Free Trade Agreement countries (e.g. Norway) or the UK via the Trade and Cooperation Agreement. However, it is notable that Foreign Direct Investment may be screened in the future pursuant to the Screening of Third Country Transactions Bill (2022) and/or coordinated with other EU member states pursuant to Regulation (EU) 2019/452.

Solar the Likely Winner in RESS-3

As previously outlined, Davy estimates the remaining Serviceable Available Market for solar in Ireland at 3-4 GW. This is a core element of the national target to deliver 80% of electricity generation from renewable resources by 2030. To facilitate this, a third RESS scheme auction is planned for 2023 and consultation is currently underway on terms and conditions. Davy believes that solar will likely receive the majority of capacity awarded.

A notable change under consideration is the possible inclusion of a factor to adjust prices for inflation. RESS-3 will be taking place in a general inflationary environment where there are material and labour shortages in addition to issues with global supply chains. There are two industry-specific inflationary pressures:

- In the USA, the **Inflation Reduction Act** provides for an extensive range of generous (US$400 billion) renewable subsidies and is predicted to ignite interest and create strong global competition[6] for materials; and

- In the EU, in light of wider concerns about geopolitics, strategic autonomy, supply chain resilience and environmental, governance and society concerns, efforts are underway to develop indigenous manufacturing capability **(Solar Photovoltaic Industry Alliance)**; this alliance has a manufacturing target of 30 GW/year by 2025 and is predicted to increase the cost of panels. A Sino-EU trade-related dispute on this very subject only ended as recently as 2018[7].

An inflation adjustment mechanism, depending on its precise construction and efficacy, **could de-risk bidding** and result in better outcomes in the overall public interest. Moreover, inflation adjustment provisions in RESS contracts imbue them with the characteristics of index-linked financial instruments – perhaps making them of greater interest to a wider pool of capital than otherwise (for example, pension funds). This would improve the prospects for solar developers selling an operational RESS asset and thereby recycling their capital and improving the liquidity of the market.

6 The US subsidies are mainly contingent on 'made-in-America' upstream content which can be understood in the wider context of geopolitical competition and a US desire to re-shore manufacturing. Principal-based reservations have been expressed by Europe as to whether EU manufactured products can be eligible, pointing to trade policy concerns and the applicability of the World Trade Organisation rules. A recent US Treasury White Paper has been conciliatory on interpretation flexibilities.

7 A Sino-EU trade dispute took place between 2012/18 and plurilateral negotiations took place at the World Trade Organisation on trade in Environmental Good Agreement, although negotiations are now suspended.

A second notable change under consideration is that successful bidders must complete and perform on the contracts, i.e., they cannot withdraw from the scheme as was permitted in RESS-1 and RESS-2. In other words, formal withdrawal (as discussed above) will no longer be permitted.

A prerequisite across all auctions is that bidders must have a connection offer rendered to them pursuant to the Enduring Connection Process. Davy carried out an analysis of the published results of the various offer rounds (discounting the oldest ECP-1 round) to obtain a view of the **approximate relative roles** that solar and the main other renewable resource (wind) may play in the upcoming RESS-3 auction.

In this analysis, judgements were applied to the published categories[8] to arrive at overall order-of-magnitude figures and, accordingly, only broad interpretations are sound. All ECP rounds (excluding the most recent ECP 2.3 publication - November 2022) collectively fed into RESS-1 and RESS-2, by which some were awarded contracts and the remainder (as an upper bound) are 'live' for RESS-3.

When combined with the latest ECP round (i.e. ECP 2.3 *ibid*), this provides a good view of the bidding population for these two technologies. The results are shown in Table 3.

Table 3: Domestic and International Players in RESS-1 and RESS-2:

Technology	Onshore Wind	Solar	Total
Carry Overs (ECP-2.1/2.2)	690	2,000	
ECP-2.3	420	1,850	
Total	**1,110**	**3,850**	**4,960**

Source: EirGrid, ESB, Department of the Environment, Climate and Communications, Davy Proprietary Research

Within the terms of this analysis, it is evident that solar is likely to form the predominant proportion of bidders in the RESS-3 'auction room'. There are approximately 5 GW of wind and solar capacity eligible with 3.8 GW of solar and 1.1 GW of wind, along with other technologies not shown. There will likely therefore be strong competitive pressures given the size of the total addressable market and the yet-to-be- decided auction 'lot'.

From Davy analysis, solar is likely to be the predominant renewable technology entering RESS-3.

8 For example, solar alone is published as a category but also appears as 'Hybrid Solar and Battery" and "Hybrid Wind and Battery" and so on.

Davy Decarbonization Corporate Finance

Davy recognises the importance of decarbonization in the fight to protect our environment. We also know that it will take a lot of innovation and investment to achieve the ambitious targets set by Governments across Europe and the world. That is why we have set up our Decarbonization Team to help existing and new businesses develop and fund decarbonization strategies and solutions.

Our expertise includes:

- Fundraising for public and private companies across the capital structure
- Mergers and acquisitions
- Strategic advice
- Sector expertise

The team's focus is on the decarbonization of five core sectors:

- Power Generation and associated supply chains
- Commercial & Industrial processes
- Transport
- Built Environment
- Agriculture

Contact Us

For further information, please contact the team at **decarbonization@davy.ie.**

Appendix – Technology and Deployment Configurations

The Technology

Broadly, solar technology is of two kinds: **Photovoltaic (PV),** which uses solar cells to convert sunlight directly into electricity; and **Concentrated Solar Power (CSP)**, which uses mirrors to concentrate solar rays generating heat that can be directly used in an industrial process or further processed into electricity.

The latter (which generates heat) has the advantage that it is also a form of storage, insofar as the heated medium retains heat for later use (for example, after sunset). The former can be attached to buildings (rooftops and/or facades) or can be integrated within the fabric or cladding in what is known as **Building Integrated Photovoltaics.** There are numerous other applications beyond the current scope, for example mountings on sound barriers of highways or railway cuttings, integrated in electric vehicles or marine vessels or perhaps floating on lakes or the near shore. Mini or micro solar panels are familiar on standalone posts, kerbside parking meters or road signage. The applications are numerous.

In summary, renewable solar energy can (a) be converted to heat and applied directly on-site; and/or (b) converted to electricity used on-site say by a household, business to industrial facility and/or placed on the public grid. Solar energy can therefore score against renewable electricity and renewable heat targets.

Deployment Configuration

At the business or industrial level, this can manifest in a similar way. A self-contained unit could be an **autoproducer** or this could extend to nearby enterprises, be organised within a contiguous industrial campus, an airport complex or an industrial estate. It might involve **private wires** or use of public grids. This could also be enabled by so-called hybrid connections (including usages made by multiple legal entities) where many technology types could share a single connection point. An interesting recent development along these lines are **Energy Parks** or **Hubs** where, for example, data centres (or other enterprise) could co-locate with solar farms and miscellaneous other distributed energy resources. New business models are emerging, for example, akin to **infrastructure-as-service** i.e. solar-as-a-service.

A typical domestic deployment could involve the installation of rooftop solar which would in the first instance supply electricity to one's own home appliances, thereby offsetting purchases of electricity suppliers. This might be accompanied by a transformation of domestic dwellings to include (deep) energy retrofits, installation of heat pumps, battery storage, electric vehicles, smart meters, all integrated by software and including smart connected devices and appliances in the **internet-of-things.** This is often referred to as **smart homes** or **superhomes** and enables citizens to have greater control over their energy use and to participate in, and lend their support to, the energy transition.

This can then evolve even further in the **sharing economy** to communal schemes (neighbourhoods or multi-unit developments); for example, rationing scarce grid capacity for electric vehicle charging, in-kind supply of surplus energy to neighbours or availing of the export tariffs (above) or perhaps including micro commerce enabled by blockchain technology.

The above could also be thought of as 'behind the meter' installations, which we will refer to for the purpose of this paper. A report prepared by **MaREI for the Irish Solar Energy Association** quantifies that if 1 million Irish homes installed six rooftop panels (2.4 kW) 'behind the meter', that would amount to 2.3 GW of capacity. The government estimates that 1 million solar planes would result in 380 MW installed.

A standalone, larger scale solar farm or solar park will become increasingly common. This could be stand-alone 'power plants' connected to the public grids or as part of a V**irtual Power Plant** (the integration by software and other processes of a wide range of distributed energy resources).

Finally, depending on the circumstances, the installations may be able to offer grid services to the TSO/EirGrid (DS3 or successor programme) or DSO/ESB Networks (via the **National Networks, Local Connections**) or eventually in pan-European harmonised arrangements organised by an upcoming **Network Code**.

In short, the configurations are many and varied and are increasingly becoming mainstream across industrial and societal applications.

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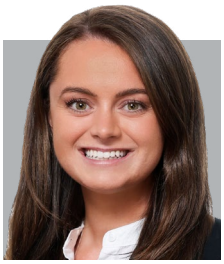

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