The RESS-2 Evaluation Correction Factor for Solar PV

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The ECF is intended to reflect a more holistic benefit to society than simply that from strike prices alone

Background

- Irelend has adopted a 70% renewables penetration target for 2030, with Northern Ireland likely to introduce its own targets at the end of 2021.
- In order to stimulate investment in renewable generation, Ireland has introduced the Renewable Electricity Support Scheme ("RESS"), a technology neutral 2-way CfD scheme.
- The benefits to society of any particular renewable technology cannot be captured simply by looking at CfD auction strike prices.
- This has been recognized by DECC in the draft Terms & Conditions ("T&Cs") for the second RESS auction ("RESS-2"), which proposes technology-specific Evaluation Correction Factors ("ECF") other than 1.0 to capture the additional benefits to society that are not captured within the strike price.

Issue

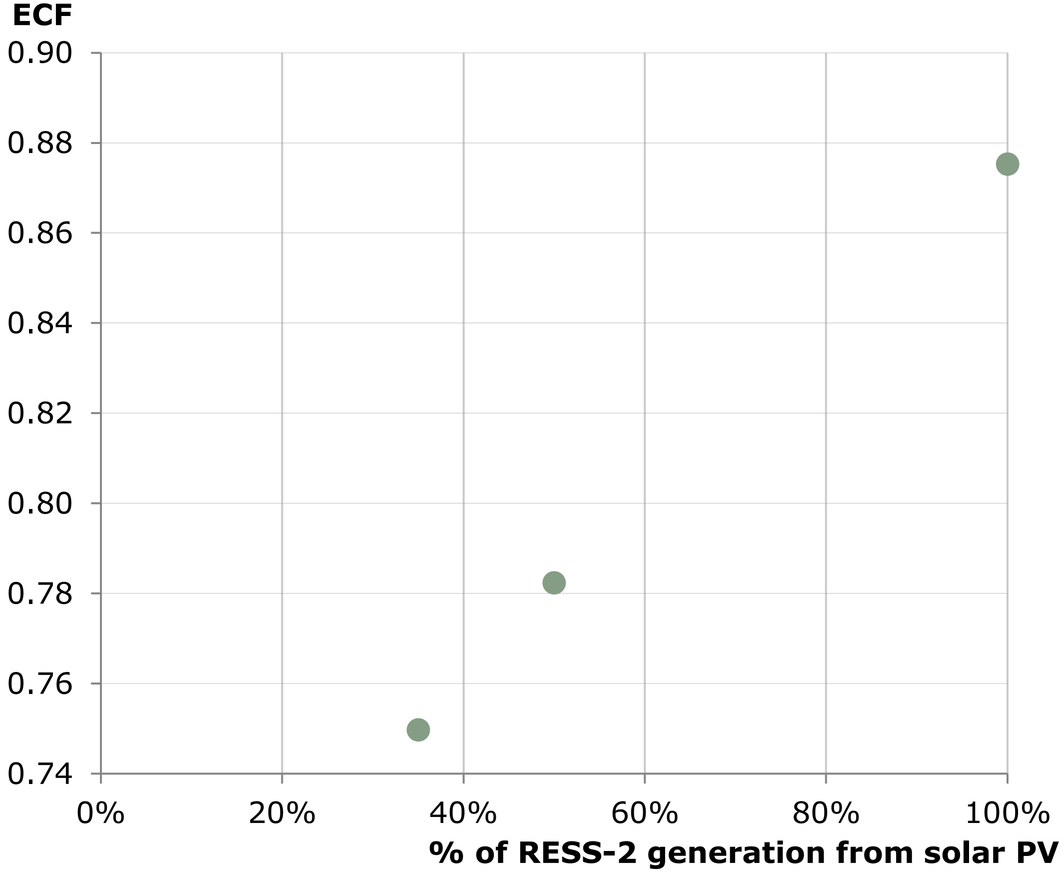
- ECFs have not yet been determined and quantification will support the determination of the appropriate RESS-2 ECFs.

Key Question

- What could the RESS-2 specific ECF for solar be based on benefits that are not captured within the strike price?

The ECF for solar that reflects an equivalent benefit from solar and onshore wind ranges 75%-88% depending on the expected relative deployment

THE RESS-2 ECF FOR SOLAR RELATIVE TO ONSHORE WIND



Notes: this study is done comparative and assumes an ECF of 1.0 for onshore wind. The ECFs are calculated from the scenario make up as that which provides an equivalence between the technologies; the scenario make up is not the modelled outcome of the ECF as an input.

COMMENTARY

- The modelled ECF for solar ought to be less than 1.0 to provide an equitable comparison between technologies, rather than using strike price comparison alone, covering:
  - the cost of RESS-2 support, reflecting that strike prices and capture prices vary for wind and solar;
  - the cost of meeting electricity demand, reflecting different wholesale prices with greater levels of solar deployment;
  - the cost of other support, as wind capture prices will be higher and curtailment will be lower with more solar deployment; and
  - reduced emissions with more deployment of solar.
- As a result of the diminishing benefits from incremental RESS-2 solar generation to society, the more solar is procured, the higher the ECF for solar that would provide for equivalent comparison between solar and wind.
  - If the ratio of RESS-2 onshore wind and solar generation is similar to RESS-1 (i.e. c. 65% and 35% respectively), then this study finds an ECF of 75% for solar.
  - If all RESS-2 generation is from solar, which is a scenario with c. 6GW of solar by 2030 and 7GW by 2040, this study still finds an ECF of 88% for solar.

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We have used three scenarios to investigate the RESS-2 specific ECF for solar PV, with a reference scenario reflecting no solar PV procured in RESS-2

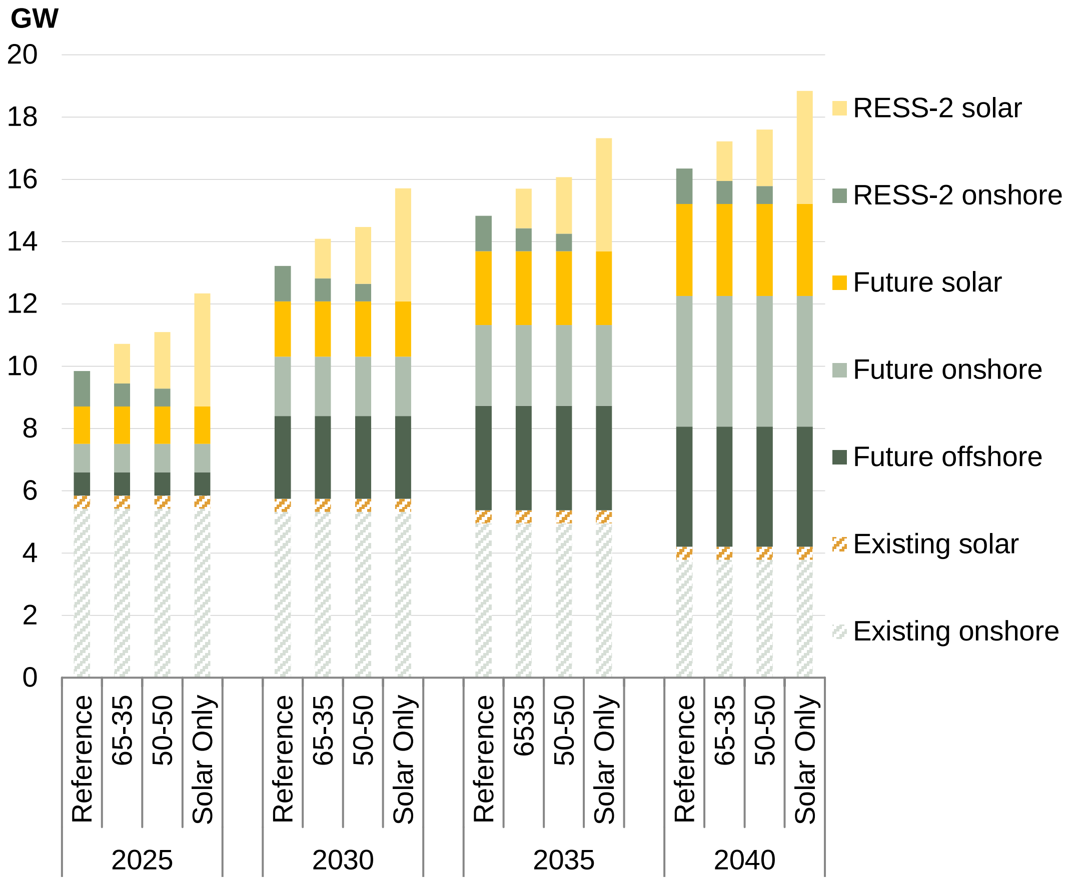
ANALYTIC APPROACH

- The basis of our analysis is to posit a Reference scenario of what the power system would look like if RESS-2 supported renewables generation were onshore wind only and how outcomes compare if a range of mixes of solar / wind were developed under RESS-2 instead.
- By keeping all other variables constant, we isolate the impact of building onshore wind and/or solar under RESS-2 support.
- The analysis assumes 3.5TWh (out of 1-3.5TWh) of pre-curtailment renewables generation is procured under RESS-2.

SCENARIOS

Reference	– All RESS-2 renewables are onshore wind (3.5TWh = 1,142MW). – No RESS-2 solar
65-35	– 65% of the RESS-2 renewable generation is from onshore wind (2.275TWh) and the other 35% is from solar PV (1.225TWh).
50-50	– 50% of the RESS-2 renewable generation is from onshore wind (1.75TWh) and the other 50% is from solar PV (1.75TWh).
Solar Only	– All RESS-2 renewables is from solar PV (3.5TWh = 3,632MW). – No RESS-2 onshore wind

RENEWABLE CAPACITY BY SCENARIO (GW)



The load factor assumptions are similar to the RESS-2 draft Terms and Conditions (i.e. 45% for offshore wind, 35% for onshore wind and 11% for solar).

The ECF should consider the cost of meeting electricity demand, the cost of supporting future and existing renewables and the cost of emissions

Capture price effect		– The capture price effect reflects difference in RESS-2 support payments between onshore wind and solar PV **within each scenario**. – If more solar is procured under RESS-2, capture prices of wind and solar could converge; hence the difference in RESS-2 support payments per MWh between onshore wind and solar PV could converge as well.
Additional net benefits to society relative to the Reference scenario	**Cost of meeting electricity demand at wholesale electricity prices**	– Wind and solar typically generate at different times (i.e. night time/winter for wind and day time/summer for solar) – Consequently, adding a more balanced mix of wind and solar could lead to higher electricity prices and thereby to higher costs of meeting electricity demand at wholesale electricity prices.
	Cost of supporting future renewables capacity (excl. RESS-2)	– A more balanced mix of solar and wind generally results in higher wind capture prices than when only RESS-2 wind would be added to the system. – Hence, the PSO cost for future capacity (excl. RESS-2) could also be lower in this case.
	Cost of supporting existing renewables capacity	– A more balanced mix of solar and wind results in higher market revenues for REFIT wind than when all RESS-2 renewable capacity is wind. – Hence, the PSO cost for existing REFIT wind capacity would be lower in this case.
	Cost of emissions	– Wind often generates when demand is low (e.g. overnight) with limited and often more efficient thermal to displace. – Solar will often displace less efficient thermal generation during the day when levels of demand are high. – Hence, a balanced mix of wind and solar could help reduce total carbon emissions.

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The ECF for solar PV, combined with the strike price, should reflect a more holistic benefit of solar PV to society than the strike price alone

- The ECF has been calculated in two steps:
  - **Capture price effect**, which are based on difference in RESS-2 support payments (per MWh) between onshore wind and solar PV within each scenario; and
  - **Additional societal benefits**, which are based on the capture price effect as well as additional net benefits relative to the Reference scenario.
- The additional net benefits per additional MWh of RESS-2 supported solar generation has been calculated comparing the “Reference” scenario with the “65-35” scenario, the “50-50” scenario or the “Solar Only” scenario for the modelled years (2025, 2030, 2035 and 2040).
- We have interpolated linearly between the modelled years and have assumed that the net benefits remain at 2040 levels until:
  - the end of the solar lifetime (assumed at 30 years) for the cost of emissions and for the cost of meeting demand at wholesale electricity prices; and
  - the end of the support contract (15 years) for RESS-2 and all other future renewables.
- Subsequently, NPVs have been calculated of: (1) the difference in RESS-2 support payments per MWh between onshore wind and solar; and (2) the net benefits of the additional solar relative to the Reference scenario.
- These NPVs have been converted into constant payments over the duration of RESS-2 contracts.
- By dividing those constant payments by the strike price of the RESS-2 supported solar, the discount is obtained that should be prescribed to solar auction bids (i.e. the complement of the ECF).

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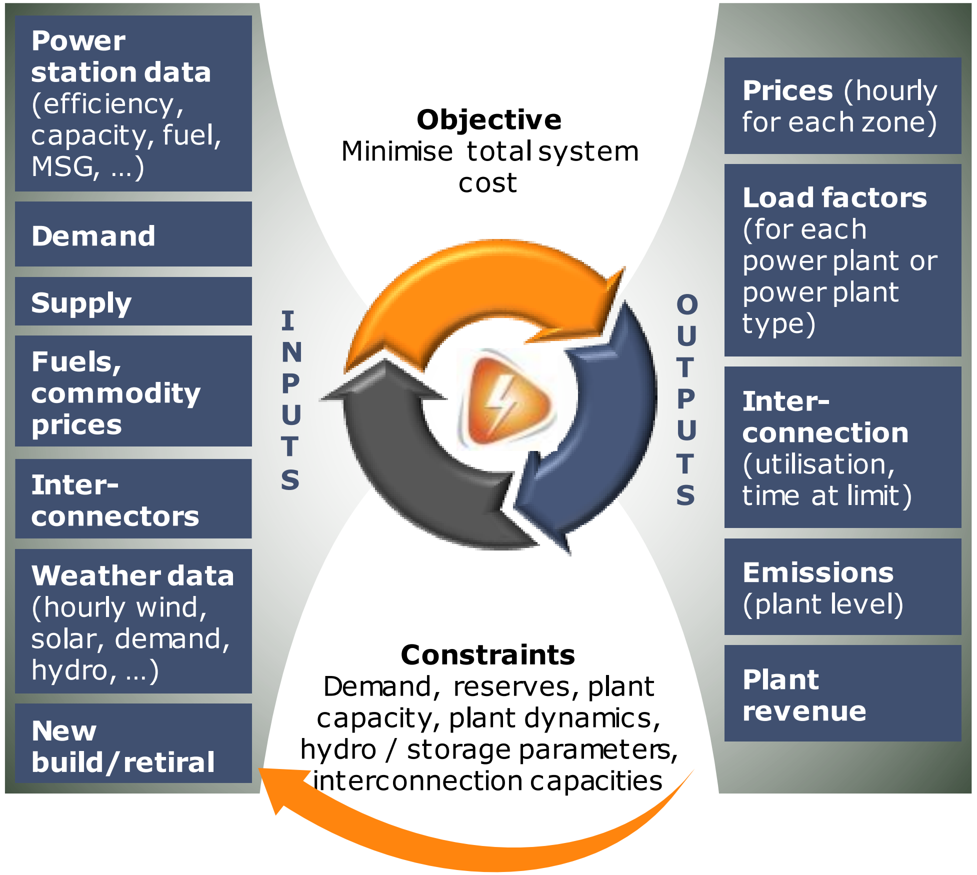
The modelled ECF is based on ex-post net benefits of solar to society given a set of assumed scenarios

- The modelled ECF for solar is relative to onshore wind, with the ECF for onshore wind assumed at 1.0.
- The modelled ECF does not reflect an optimisation of the ECF such that the final outcome will result in maximised social welfare.
  - In order to maximise social welfare by means of the ECF, a full auction bid stack would be required and this is outside the scope of this work.
  - Given that the ECF will be determined prior to the auction without knowledge of the auction bids, this approach would not happen in practice either.
- As such, this study determines the ECF based on ex-post net benefits of solar to society given a set of specific scenarios (or, market outlooks).
  - In other words, the ECF is a function of the scenario assumptions rather than a variable that is optimised.
- The scenarios that are considered in this study span a range of plausible outcomes, including the extremes:
  - solar is not procured at all in RESS-2 (i.e. the Reference scenario); and
  - all the RESS-2 generation procured is from solar (i.e. the Solar Only scenario).

BID3 is our proprietary power market modelling tool and is used to model dispatch and redispatch in European power markets

OVERVIEW OF BID3

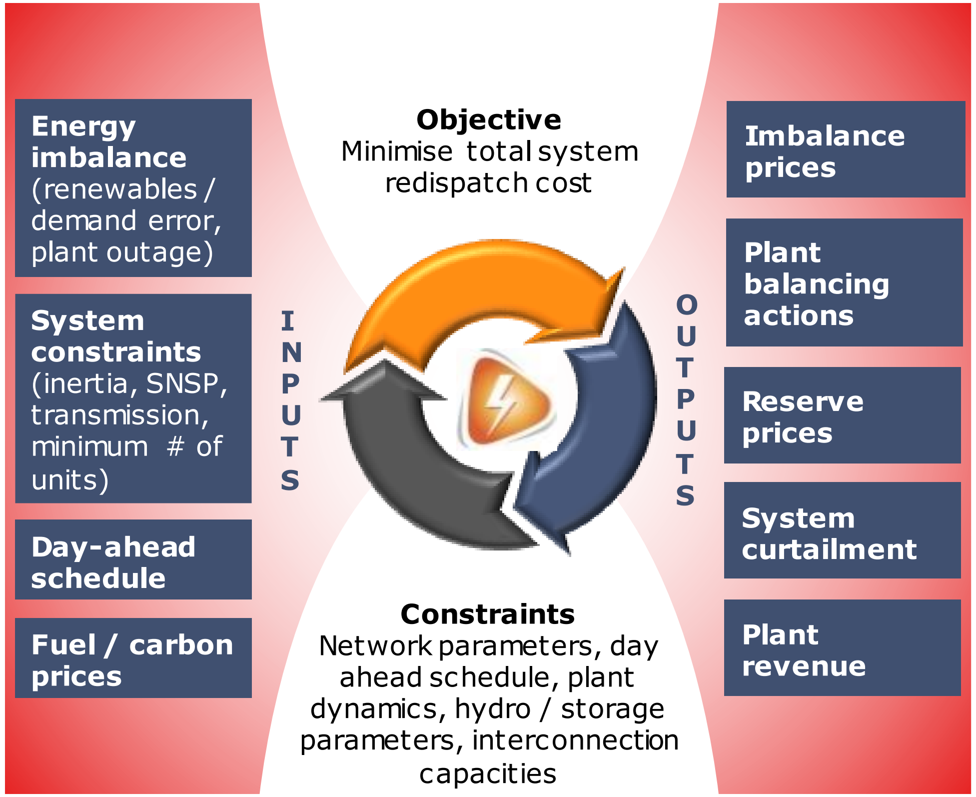


BASICS OF BID3

- BID3 is an optimisation which minimises the system cost in a year subject to constraints
- Models all 8760 hours of the year and accounts for varying renewables, demand-side management, hydro and pumped/battery storage
- BID3 has the following key plant dynamics
  - Start-up, Part-loading (no-load), Minimum Stable Generation
  - Minimum on- and off-times
  - Temperature dependent start cost
  - Ramping
  - CHP and co-firing
- It has been specifically designed to address:
  - Intermittency of wind, solar, hydro
  - Reserve constraints
  - The Balancing Market
  - Capacity expansion (new build and retiral)

We model the Irish Balancing Market at hourly resolution to reflect the impact system constraints can have on the economics of renewables

REDISPATCH MODELLING IN BID3



BID3 REDISPATCH

- In some markets (e.g. GB and the SEM) we extend our regular Day Ahead Market modelling into the balancing timeframe.
- This involves redispatching from the ex-ante schedule to account for renewables / demand imbalances as well as major system constraints.
- The resulting outputs allow us to assess a range of factors, most importantly, for the purposes of this study, levels of wind and solar curtailment.
- Because curtailment is not currently compensated in the SEM, it is critical for this study to reflect the impact of hourly curtailment of wind and solar. Without this, a true picture of the PSO Levy costs is not possible.

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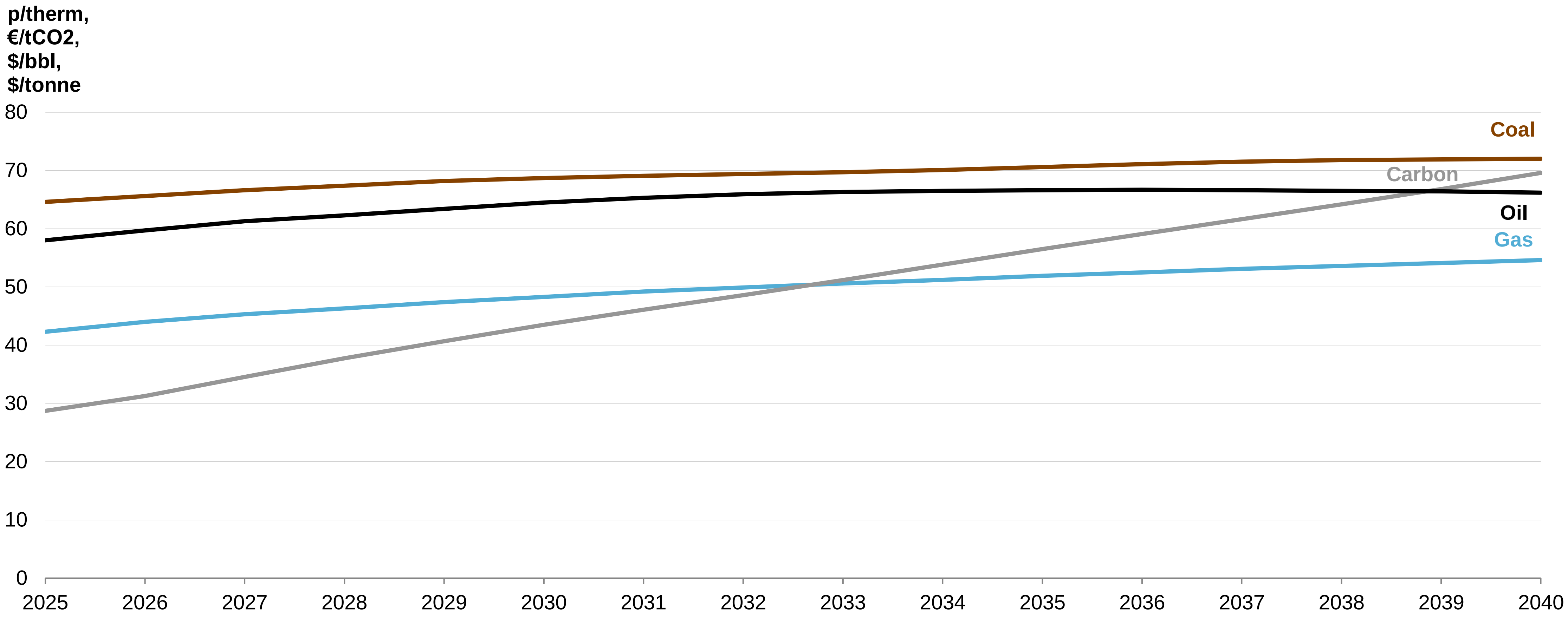
Commodity prices have been taken from National Grid's Central scenario of the 2021 Future Energy Scenarios study

COMMODITY PRICES (p/therm (NBP), €/tCO2 (EU ETS), $/bbl (Brent), $/tonne (ARA CIF), real 2020 money)



Source: National Grid's 2021 Future Energy Scenarios

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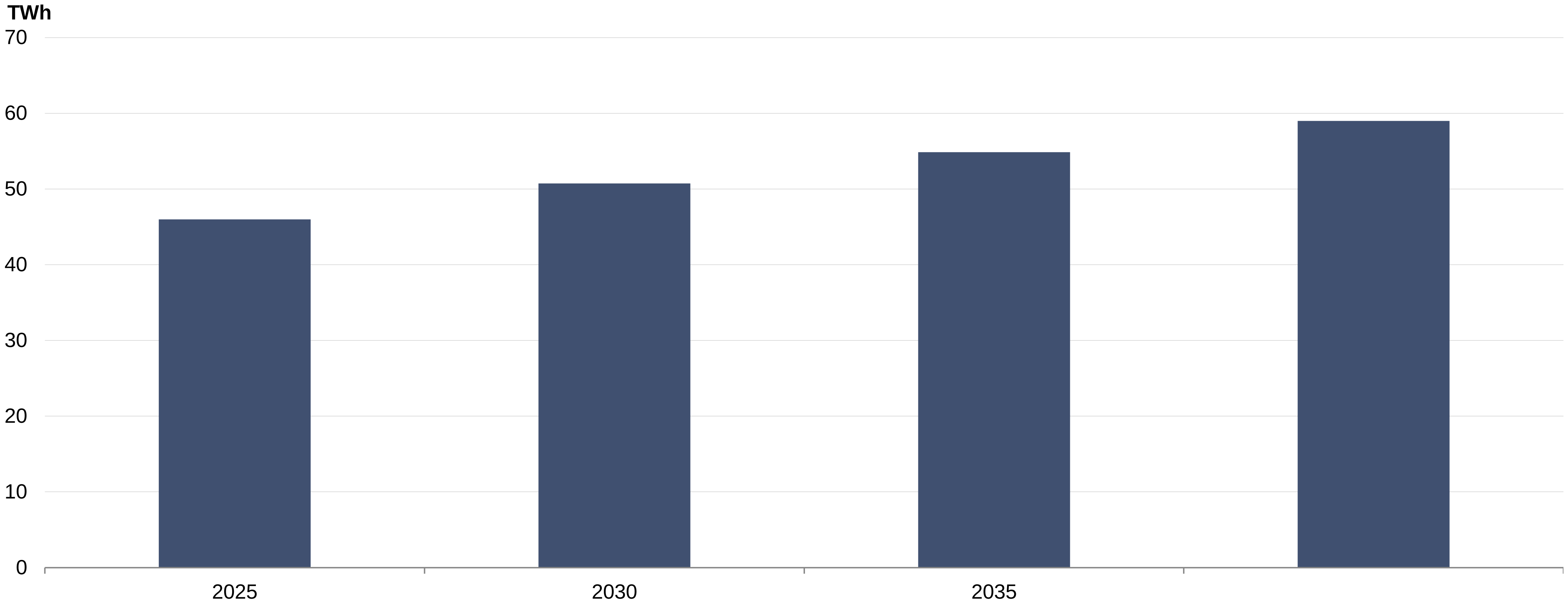
Annual demand has been taken from EirGrid’s 2020-29 Generation Capacity Statement and 2019 Tomorrow’s Energy Scenarios

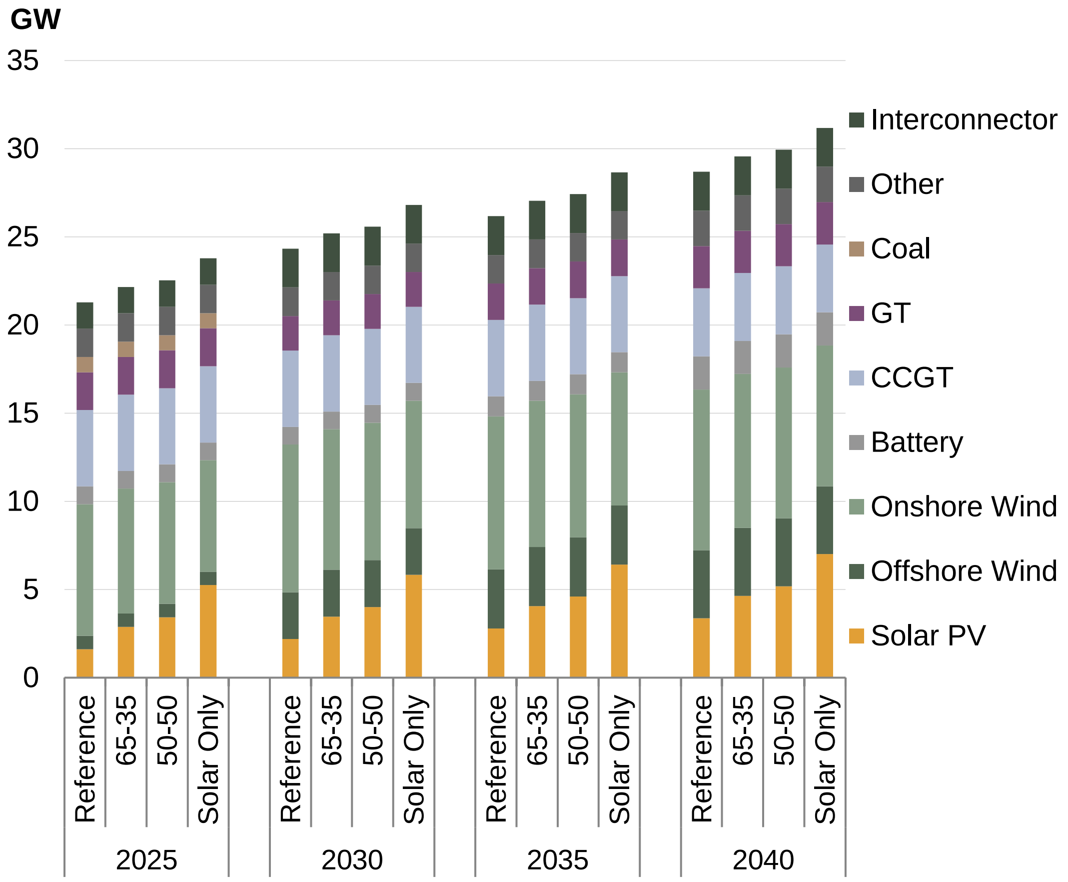
ALL-ISLAND ELECTRICITY DEMAND (TWh)



Source: projections are based on EirGrid/SONI’s 2020-29 GCS Median scenario and 2019 TES Centralized Energy scenario and combined with AFRY’s hourly profiles

The capacity mix only varies amongst scenarios by the level of RESS-2 onshore wind and RESS-2 solar

CAPACITY MIX (GW)



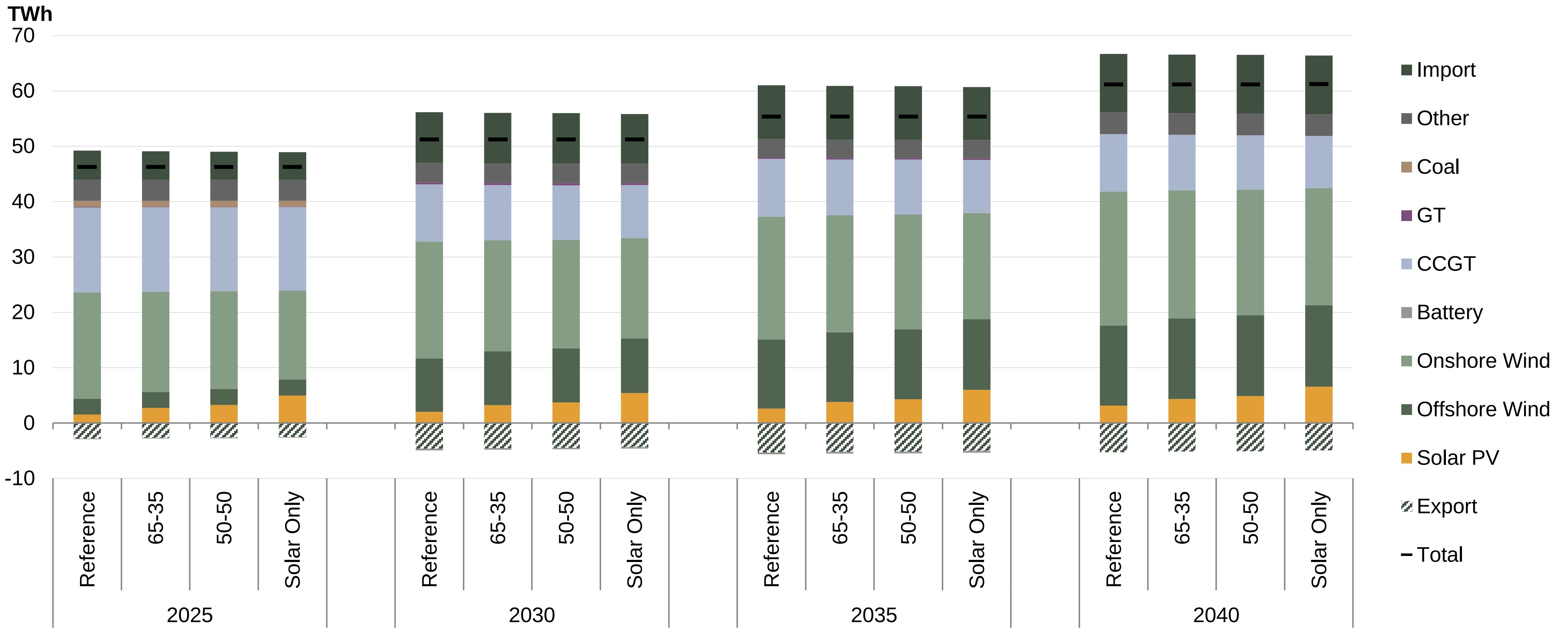
Notes: GT refers to Gas Turbine and CCGT refers to Combined Cycle Gas Turbine.

COMMENTARY

- Only RESS-2 capacity varies among the scenarios based on the 3.5TWh of pre-curtailment renewables generation.
- In the absence of publicly available post-auction attrition rates, all RESS-1 capacity is deployed. If attrition had been considered, the ECF for solar would have been lower.
- The scenarios reach a renewables penetration of 70% in both Northern Ireland and the Republic of Ireland by 2030. After 2030, a conservative assumption has been taken on the renewables penetration for the purpose of this RESS-2 assessment and to reflect uncertainty in renewables deployment after 2030 (e.g. due to policy clarity or alternative technologies). Northern Ireland maintains 70% after 2030. The Republic of Ireland reaches 75% by 2040: primarily driven by the government’s target on offshore wind (reaching 3.5GW by 2040); but also driven by onshore wind and solar deployment after RESS-2 (c. 75MW/year).
- In order to maintain adequate capacity margins, new build capacity has been added when appropriate. By 2040, there is 673MW of 4-6hr battery capacity the Republic of Ireland and 116MW in Northern Ireland on top of 682MW of reserve providing batteries. By 2040, there is c. 2.4GW of GT capacity.

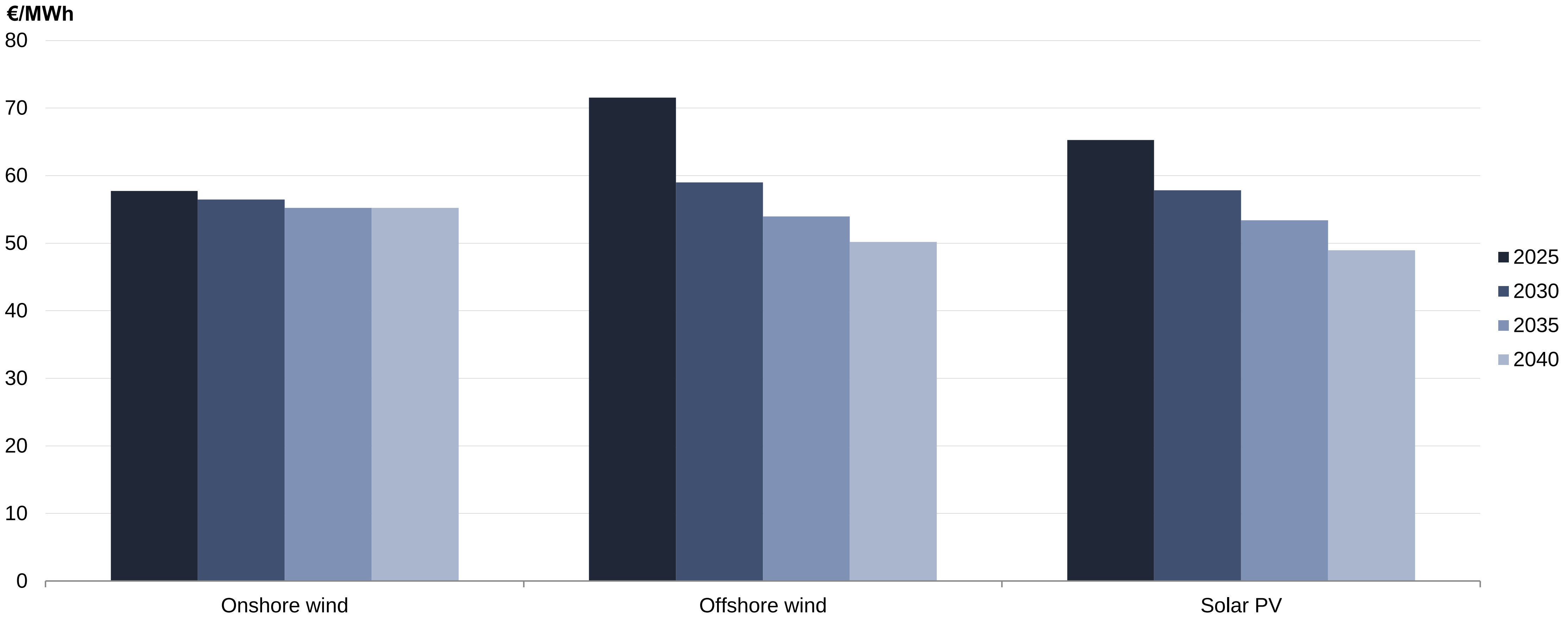
The generation mix across the scenarios follows a similar pattern to the capacity mix

GENERATION MIX (TWh)



LCOE per renewable technology are derived from BEIS' 2020 electricity generation cost report, multiplying wind by 1.1 and solar by 1.3 for the SEM

LCOE (€/MWh, real 2020 money)



Notes: Wind is multiplied by 1.1 and solar by 1.3 to reflect Irish market conditions. The Central scenario of the Electricity Generation Cost report has been used.

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Constraints have been taken from EirGrid’s 2019 Tomorrow’s Energy Scenarios (Centralized Energy scenario), except the SNSP limit in 2025

CONSTRAINTS ASSUMPTIONS

Constraint	2025	2030
SNSP limit	85%	95%
NI dynamic stability	2 high-inertia units on-load at all times	2 high-inertia units on-load at all times
ROI dynamic stability	3 high-inertia units on-load at all times	2 high-inertia units on-load at all times
Primary / secondary reserve	375MW (75% of largest infeed, i.e. Greenlink IC)	525MW (75% of largest infeed, i.e. Celtic IC)
Tertiary reserve	500MW (100% of largest infeed, i.e. Greenlink IC)	700MW (100% of largest infeed, i.e. Celtic IC)

2035 and 2040 use the same assumptions as 2030 and the SNSP limit in 2025 is based on the PR5 incentive for EirGrid.

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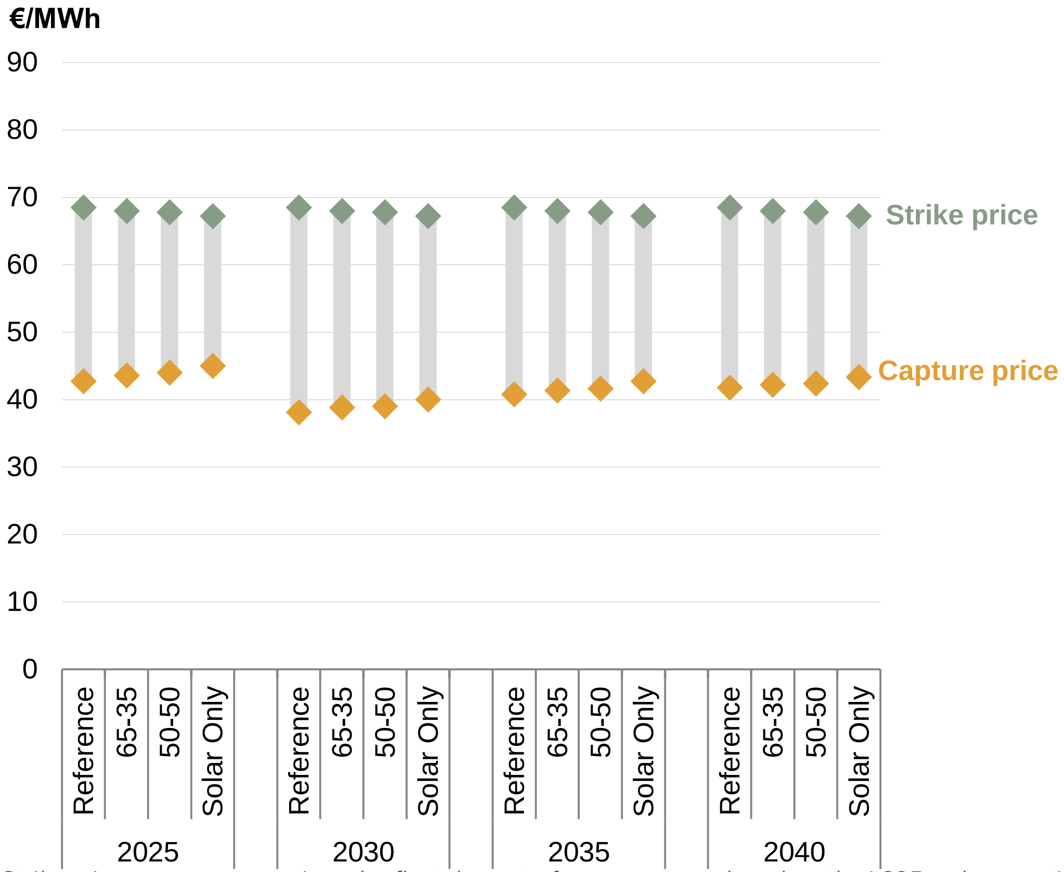
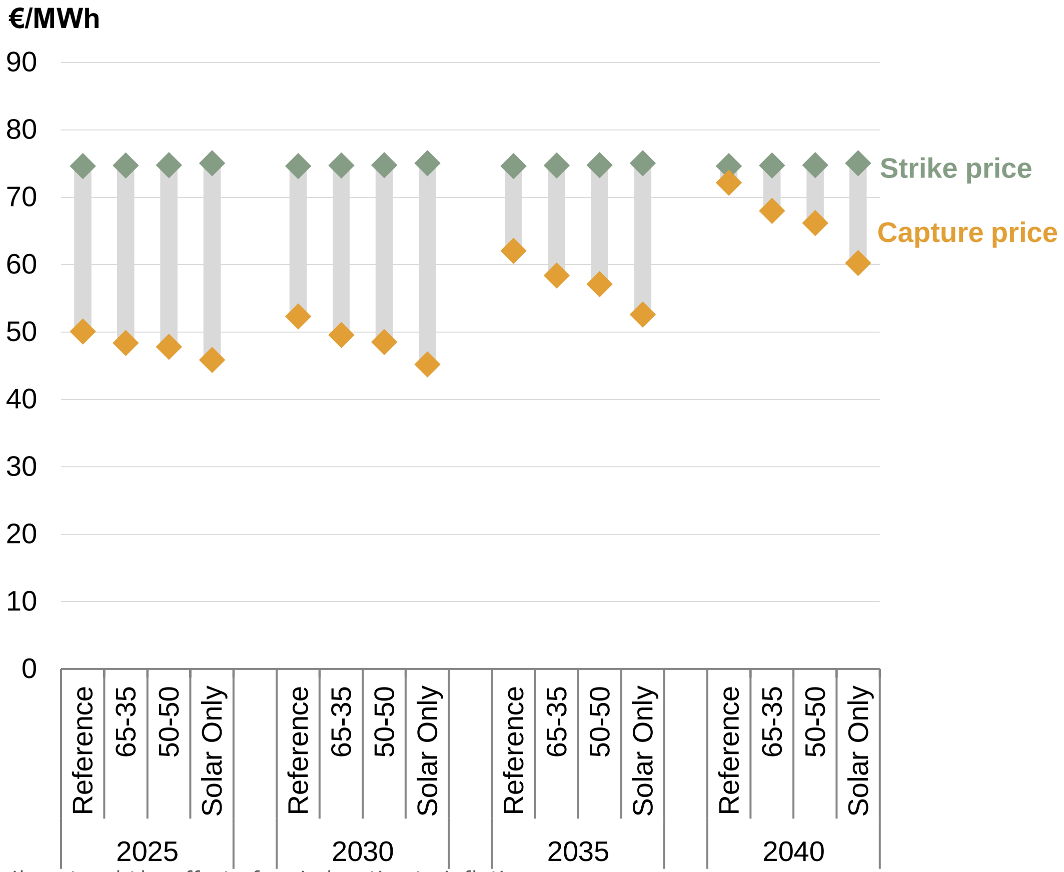
The spread between capture prices and strike prices is notably higher for onshore wind than solar because of relatively high presence of wind capacity

RESS-2 ONSHORE WIND STRIKE AND CAPTURE PRICES (€/MWH, NOMINAL MONEY)



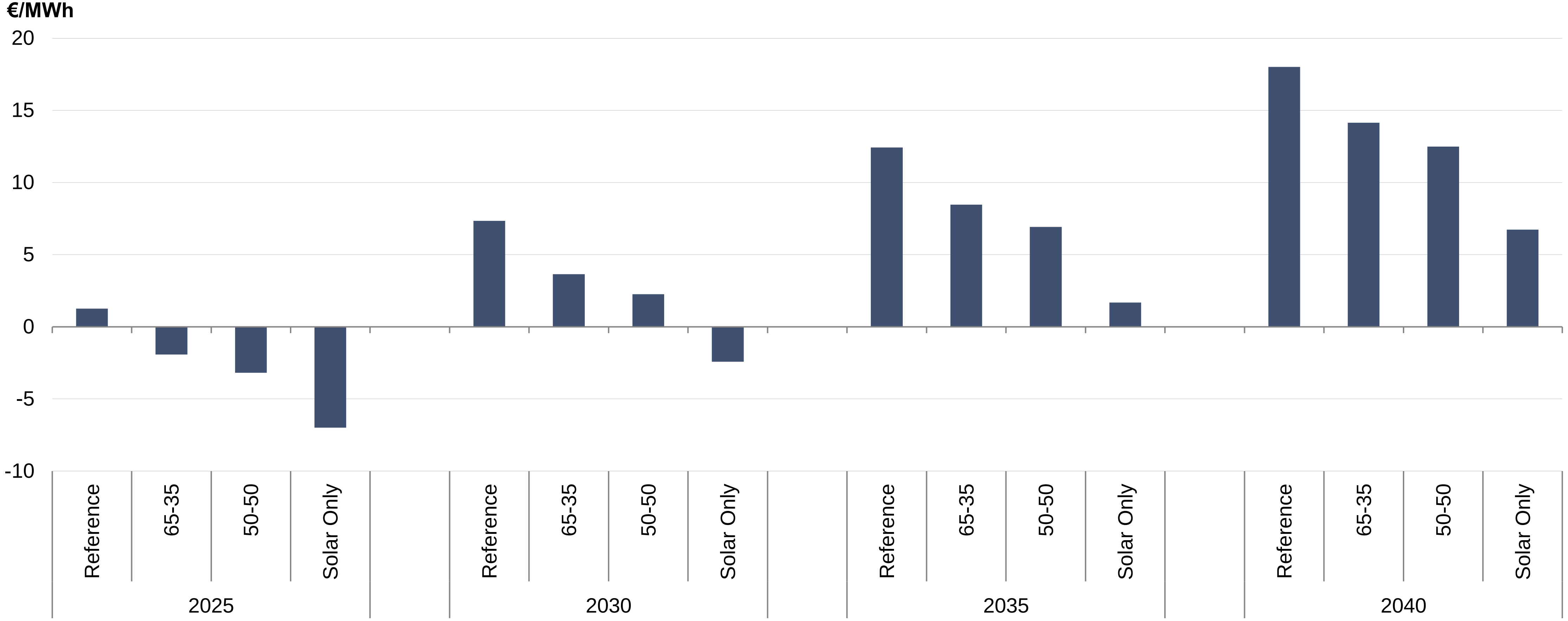
RESS-2 SOLAR PV STRIKE AND CAPTURE PRICES (€/MWH, NOMINAL MONEY)



Strike prices vary per scenario and reflect the cost of a new entrant, based on the LCOE and accounting for curtailment and the effect of no indexation to inflation.

The more RESS-2 solar is procured, the smaller the difference in support payments per MWh of generation between RESS-2 onshore wind and solar

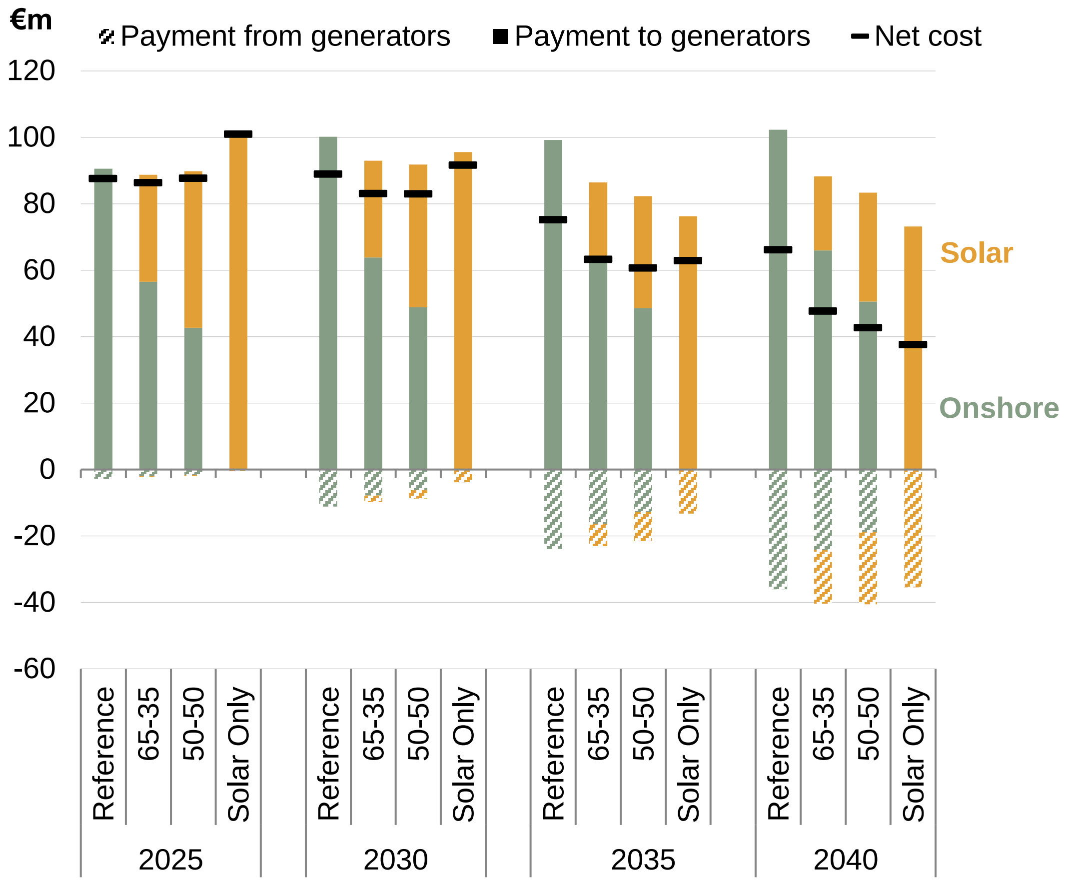
DIFFERENCE IN RESS-2 SUPPORT PAYMENTS BETWEEN ONSHORE WIND AND SOLAR (€/MWh, real 2020 money)



The differences are calculated as the support payment per MWh for onshore wind minus the values for solar.

As more solar is procured, the total support payments for RESS-2 decrease up to a tipping point beyond which additional solar becomes more expensive than onshore wind

TOTAL SUPPORT PAYMENTS FOR THE RESS-2 GENERATION (€m, real 2020 money)



COMMENTARY

- Because RESS-2 projects are assumed to be operational by 2025 reaching a renewables penetration of c. 55%, the mix of wind and solar is balanced quite well. As such, there is limited difference in total support payments between the Reference, the 65-35 and the 50-50 scenario in 2025.
- After 2025, as the renewables penetration rises further (primarily driven by the government's offshore wind target), additional RESS-2 solar result in lower total RESS-2 support payments.
- However, there is a tipping point, when incremental solar generation becomes more expensive than onshore wind. This phenomena can be seen in the Solar Only scenario, which reflects a scenario with a high level of solar deployment (i.e. all RESS-2 generation would come from solar with almost 6GW of solar by 2030 and 7GW by 2040).
- 2040 is an exception to the above. Due to capacity inadequacy, more 4-6hr batteries are deployed. The additional solar generation in combination with the batteries can facilitate greater levels of generation during the day (when demand tends to be higher) than the alternative onshore wind generation with batteries could, resulting in higher capture prices for solar and thereby lower support payments..

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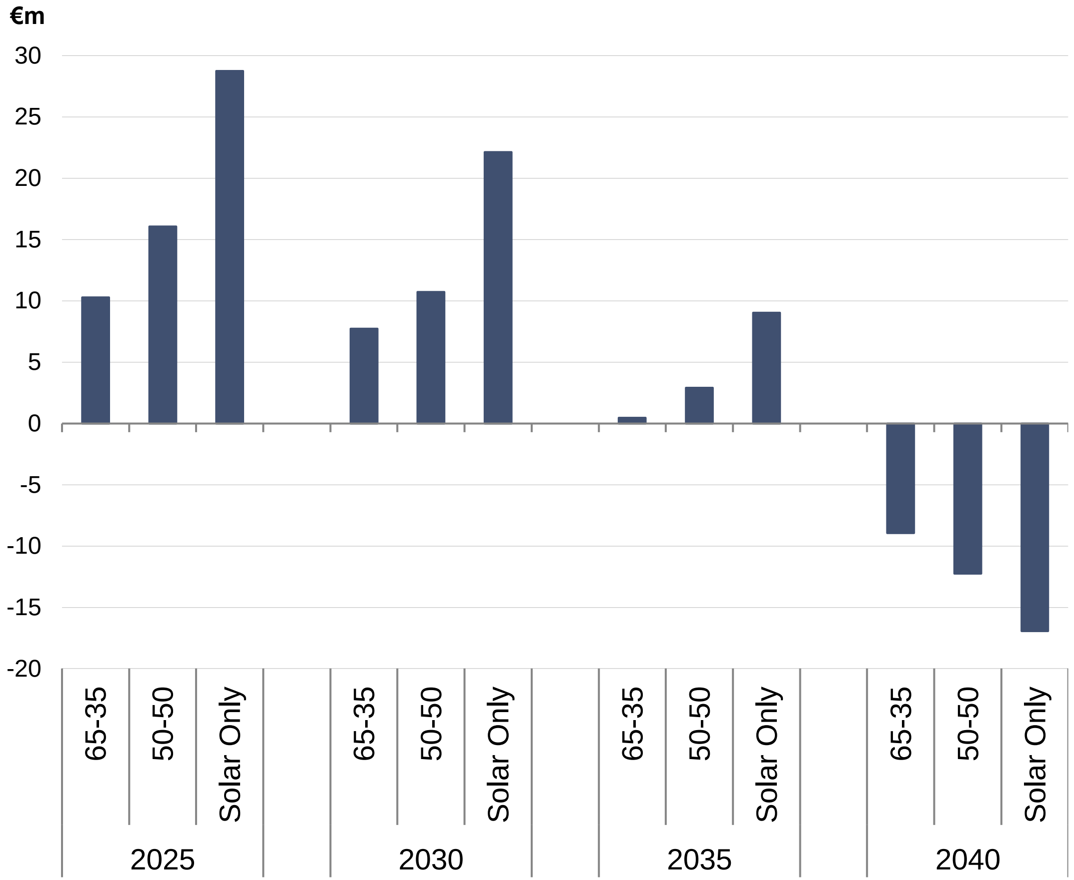
The cost of electricity demand tend to increase, as electricity prices are generally higher when a more balanced mix of wind and solar is deployed

NET COST OF MEETING ELECTRICITY DEMAND AT WHOLESALE ELECTRICITY PRICES VS REFERENCE (€m, real 2020 money)

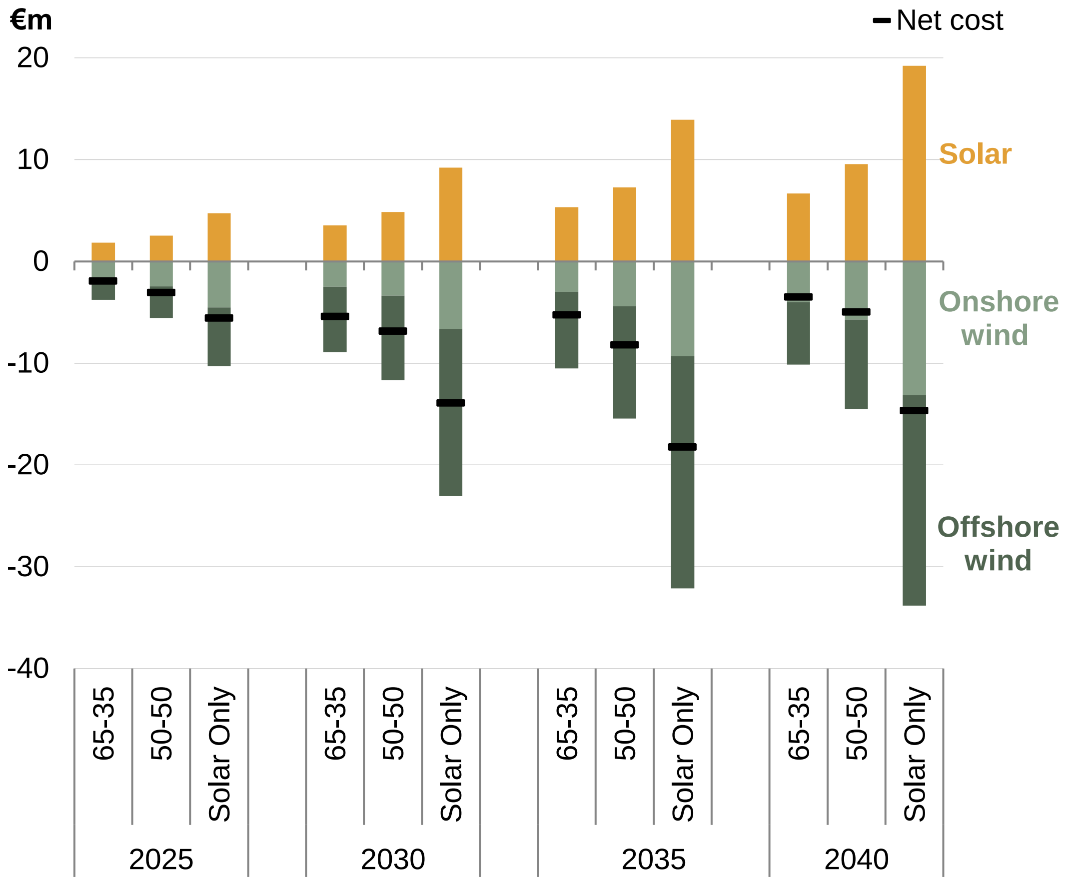


COMMENTARY

- A more balanced mix of wind and solar better reflects the shape in demand, which generally results in higher wholesale prices.
- However, as demand and the renewables penetration continues to rise (primarily driven by offshore wind), the impact of the RESS-2 solar on the cost of meeting electricity demand at wholesale prices diminishes. Eventually, even daytime prices get cannibalised when solar generates.
- By 2040, due to capacity inadequacy, more 4-6hr batteries are deployed, which tend to arbitrage electricity prices better with solar than with onshore wind. Consequently, the additional solar generation in combination with the batteries can facilitate greater levels of generation during the day (when demand tends to be higher) than the alternative onshore wind generation with batteries could, resulting in lower prices.

Future renewable capacity excluding RESS-2 has a lower PSO cost when more RESS-2 solar is procured

NET COST OF SUPPORT PAYMENTS FOR FUTURE RENEWABLES EXCL. RESS-2 VS REFERENCE (€m, real 2020 money)

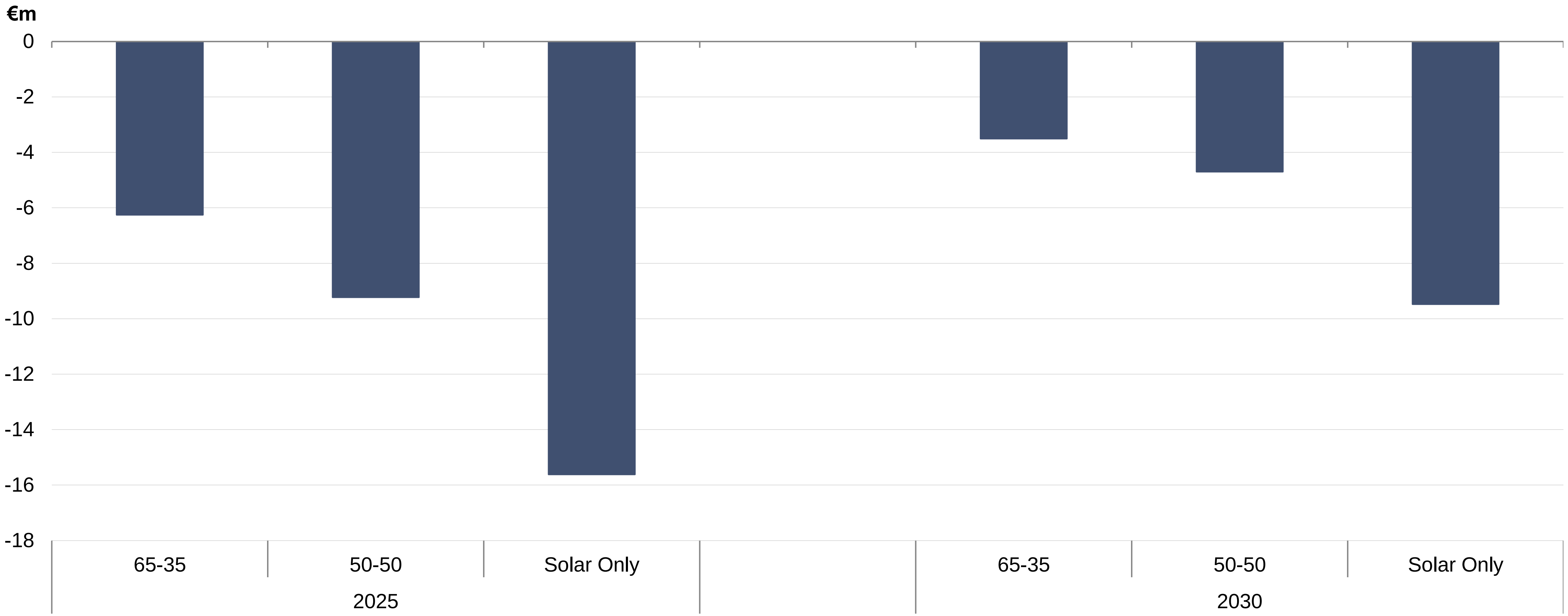


COMMENTARY

- PSO costs for supporting future renewable capacity is highest when only wind is procured in RESS-2 (i.e. the Reference scenario).
  - The main reason for this is because further adding more wind to the system to achieve a renewables penetration of 70% results in increased cannibalization of (onshore and offshore) wind capture prices.
  - Lower capture prices therefore result in higher levels of support being paid, which is particularly the case because of the high level of onshore wind already on the system and the increasing presence of offshore wind over time, and because the hours when wind generation are high are often when demand is low (e.g. overnight).
- In contrast, the 65-35, 50-50 and Solar Only scenarios avoid some of the increase in PSO costs, as these scenarios avoid some decline in wind capture prices seen when only RESS-2 wind would be procured.
- By procuring more solar, the decrease in support payments of future wind (excl. RESS-2 supported onshore wind) more than offsets the increase in the support payments for solar.

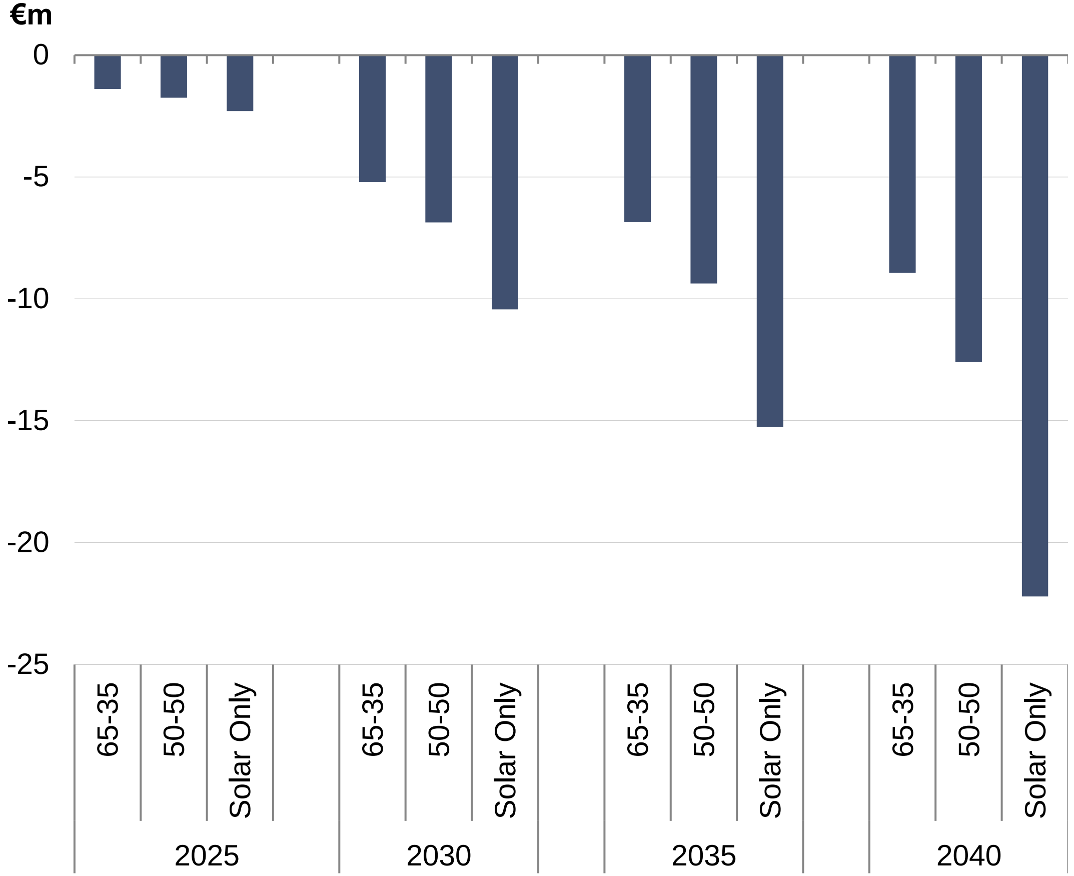
Similarly, PSO costs for REFIT-supported renewables are lower when more RESS-2 solar is procured

NET COST IN REFIT SUPPORT PAYMENTS VS REFERENCE (€m, real 2020 money)



A more balanced mix of wind and solar reduces emissions by replacing daytime thermal generation, while emissions overnight only slightly increase

NET COST OF EMISSIONS IN THE POWER SECTOR IN IRELAND (€m, real 2020 money)



COMMENTARY

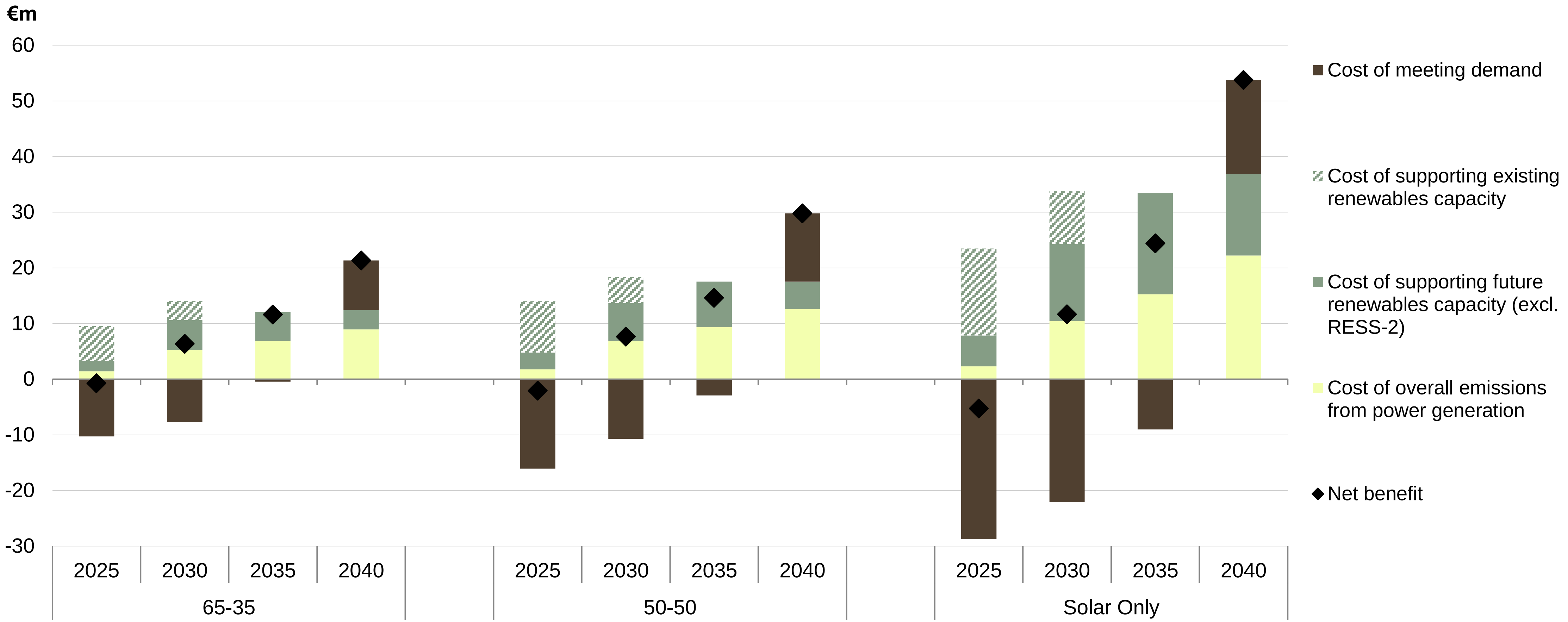
– The key driver behind lower emissions from power generation in the 65-35, 50-50 and Solar Only scenarios is the complementary nature of wind and solar generation in representing the shape of demand (i.e. the system is more self-sufficient).

– That is, solar replaces thermal generation during the day when demand is usually high, and lower efficiency thermal generation is needed. Solar also reduces the need for imports that would be required with wind generation alone.

– In contrast, the material proportion of new wind generation occurs at times when less thermal generation can be displaced (e.g. overnight). This wind generation ends up being exported or curtailed, particularly because there is already a high level of onshore wind and an increasing presence of offshore wind.

Combining the various components, we find that the more solar is procured in RESS-2, the greater the additional net benefit to society in absolute terms

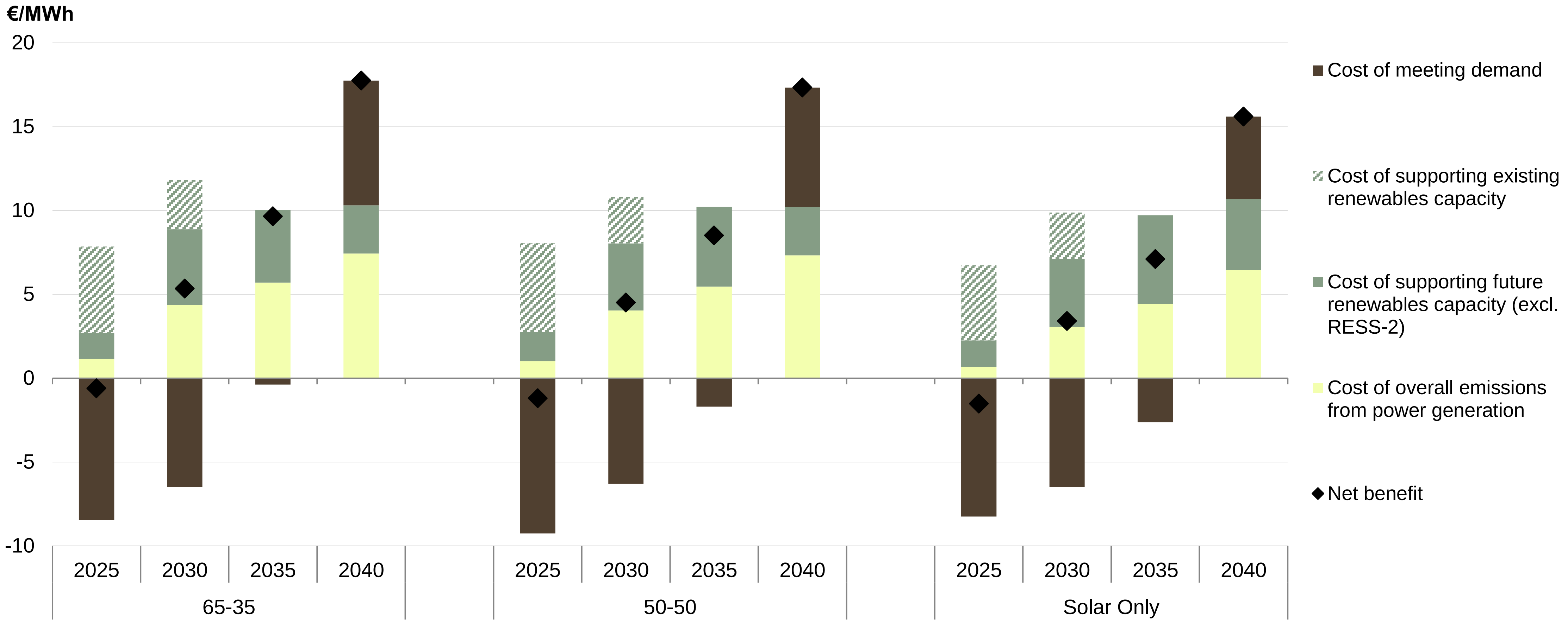
NET SOCIETAL BENEFIT IN ABSOLUTE TERMS VS REFERENCE (€m, real 2020 money)



This chart reflects the values of Reference scenario minus the 65-35, 50-50 or Solar Only scenario to represent a net benefit

Naturally, the net benefit per additional MWh of RESS-2 solar generation declines as more solar is deployed

NET SOCIETAL BENEFIT PER MWH OF ADDITIONAL RESS-2 SOLAR GENERATION VS REFERENCE (€/MWh, real 2020 money)



This chart reflects the values of Reference scenario minus the 65-35, 50-50 or Solar Only scenario to represent a net benefit

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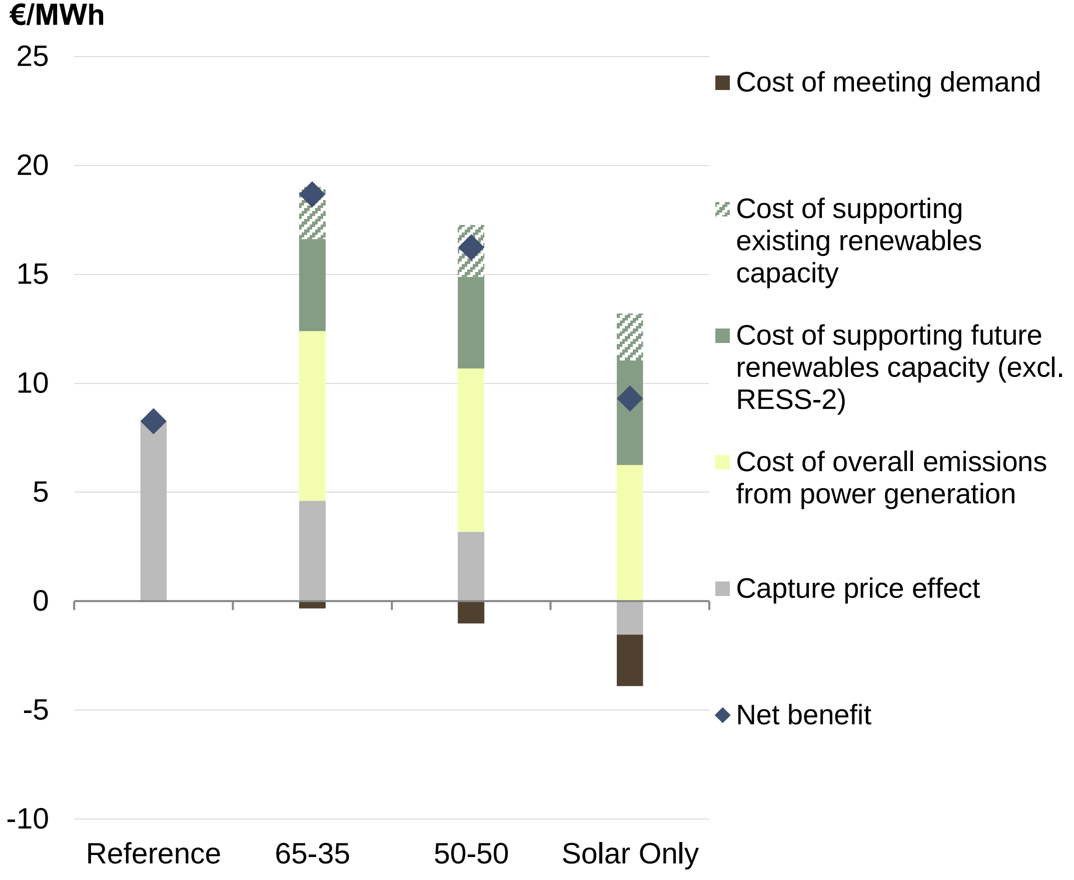
The difference in support payments for RESS-2 between onshore wind and solar as well as the additional benefits are converted into constant payments

CONSTANT PAYMENTS OF THE BENEFITS OF RESS-2 SOLAR GENERATION (€/MWh, real 2020 money)



COMMENTARY

- The constant payments combine:
  - **the capture price effect,** which are based on difference in RESS-2 support payments between onshore wind and solar PV within each scenario that arises from their difference in strike prices and capture prices; and
  - **additional societal benefits**, which is based on additional net benefits relative to the Reference scenario.
- Consequently, the Reference scenario only considers the capture price effect, while the other scenarios see additional net benefits incorporated into the constant payments.
- Naturally, the net benefits per MWh of solar generation reflected in the constant payments becomes smaller as more solar is deployed.
- Note that this assumes a WACC of 5.0% for solar in accordance with BEIS' Electricity Generation Cost Report.

The modelled ECF is calculated as the complement of the constant payments divided by the strike price of solar

CONSTANT PAYMENTS AND STRIKE PRICES FOR SOLAR (€/MWh, real 2020 money) AND THE ECF FOR SOLAR (% OF STRIKE PRICE)

		Reference	65-35	50-50	Solar Only
Constant payments	Capture price effect	8.3	4.6	3.2	-1.5
	Cost of overall emissions from power generation		7.8	7.5	6.3
	Cost of supporting future renewables capacity (excl. RESS-2)		4.2	4.2	4.8
	Cost of supporting existing renewables capacity		2.4	2.4	2.2
	Cost of meeting demand		-0.3	-1.0	-2.4
	Total	**8.3**	**18.7**	**16.2**	**9.3**
Strike price		**74.6**	**74.7**	**74.8**	**75.0**
ECF for solar		**89%**	**75%**	**78%**	**88%**

The reference scenario shows an ECF without additional benefits, so it is purely based on the capture price effect.

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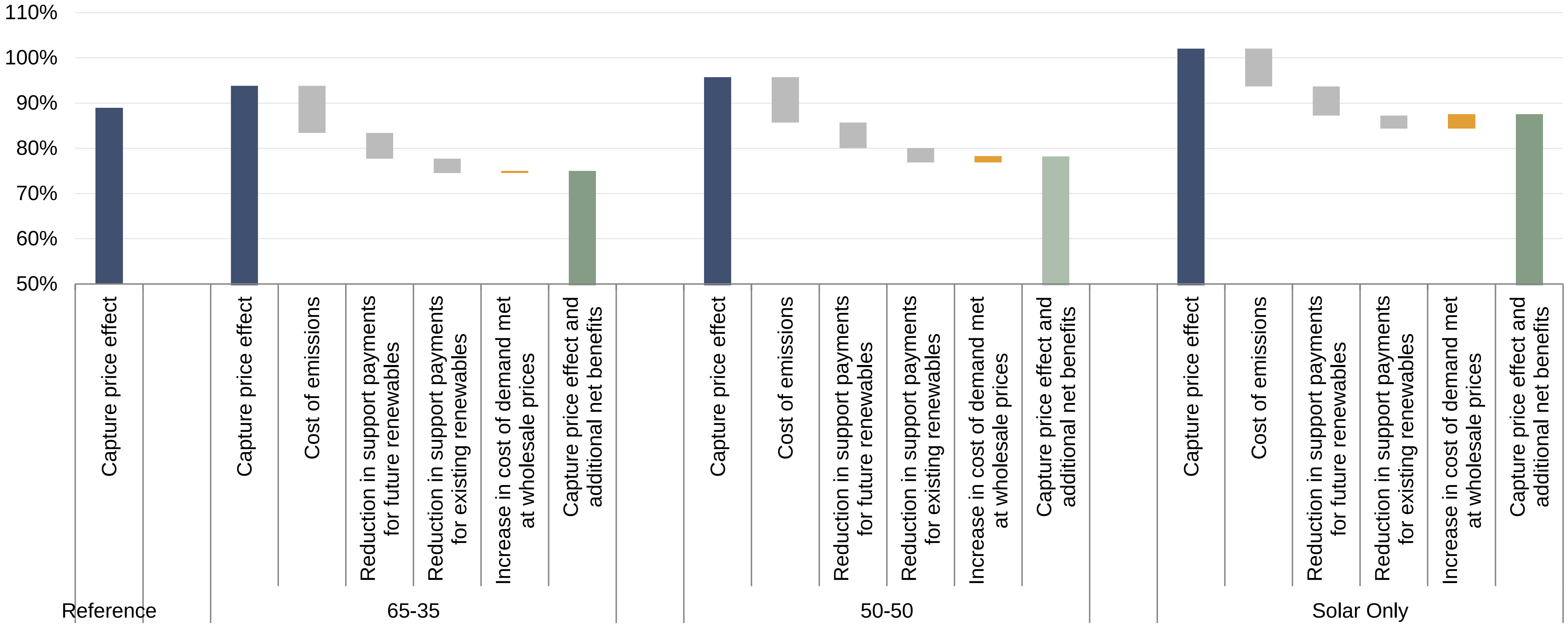
The net benefit from emission reduction has the biggest overall impact on the ECF for solar



Notes: We have used the carbon price projections by National Grid. The societal cost of carbon would be even higher and would therefore lead to even lower modelled ECFs.
The reduction in support payments for future renewables is excluding RESS-2 support payments.

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The ECF for solar that reflects an equivalent benefit from solar and onshore wind ranges 75%-88% depending on the expected relative deployment

- In conjunction with the Value of Solar in Ireland report, this study shows that a more balanced mix of wind and solar is beneficial for:
  - consumers, due to lower expected PSO costs that more than offset the higher wholesale prices;
  - the wind industry, due to lower curtailment and higher capture prices;
  - EirGrid/SONI, because there is less curtailment to deal with; and
  - the government, due to lower emissions.
- Based on the considered scenarios, this study finds that the more solar is deployed, the greater the benefits to society in absolute terms, even in the scenario with 100% solar from RESS-2 that reaches almost 6GW of solar by 2030 and 7GW by 2040. In other words, the scenarios have not reached a tipping point where additional solar would result in a net cost to society relative to onshore wind. If these benefits are considered per MWh of additional solar generation, then naturally the net benefits becomes smaller as more solar is deployed (i.e. the law of diminishing marginal returns).
- Consequently, when reflecting those net benefits as ECFs, this study finds that the ECF for solar that reflects an equivalent benefit from solar and onshore wind ranges between 75% and 88% depending on the expected relative deployment. As a result of the diminishing benefits of incremental solar generation, the more solar is procured, the higher the ECF for solar:
  - If the ratio of RESS-2 onshore wind and solar generation is similar to RESS-1 (i.e. c. 65% onshore wind generation and 35% solar generation), then this analysis finds an ECF of 75% for solar.
  - If theoretically all RESS-2 generation comes from solar, then this analysis finds an ECF of 88%.
- Because the ECF is calculated relative to the strike price of solar, the assumed strike price has a significant impact on the ECF. As shown in the annex, even if all strike prices of solar are €8.3/MWh higher in real 2020 money than originally assumed (incl. a RESS-2 solar strike price of €83/MWh), solar would still have an ECF smaller than 1.0.
- Given the nature of this analysis, the assumptions play a crucial role in determining the ECF. For example, if post RESS-1 auction attrition would have been accounted for, the lower solar deployment would have resulted in even lower ECFs.

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ANNEX A – ADDITIONAL SENSITIVITY ANALYSIS ON STRIKE PRICES

Because the ECF is calculated relative to the strike price of solar, the assumed strike price has a significant impact on the ECF

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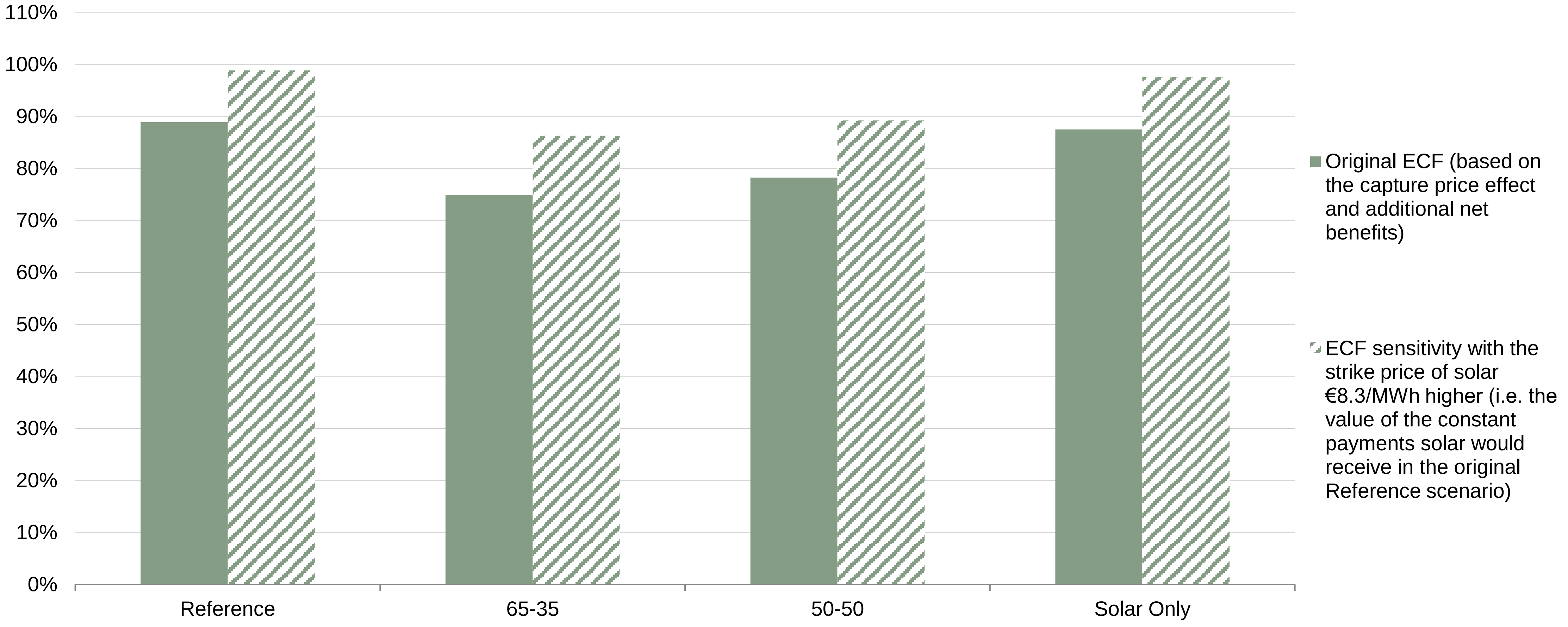
Even if all strike prices of solar are €8.3/MWh higher in real 2020 money than originally assumed, solar would still provide a net benefit to society



The strike price of all future solar (incl. RESS-1, RESS-2 and other future solar in Ireland) are assumed to be €8.3/MWh higher.

If RESS-2 contracts had strike prices indexed to inflation, strike prices would be lower, and consequently the ECF would be lower as well