D5.2, March 2021

Renewable energy financing conditions in Europe: survey and impact analysis

Insights on cost of capital, significance of explanatory variables, and cash-flow impacts on support cost in auction and non-auction environments

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Contents

Executive Summary

This report is framed within the discussions on the costs of capital for renewable energy projects and the implementation of auctions for renewable energy sources in Europe. The sections of the report provide qualitative and quantitative insights intended to contribute to a better understanding of renewable energy financing and energy and climate policy in the European Union.

Several interviews were conducted between September 2019 and April 2020 and the results show that there is still a considerable gap between EU Member States regarding their Weighted Average Cost of Capital (WACC) for wind and PV projects, where some countries as Germany and Denmark present low WACC values and countries as Greece and Latvia have instead higher costs of capital. However, compared to 2014 levels, most of EU countries reduced their WACC dramatically, which is a positive sign for a further deployment of RE projects. The analyses showed that multiple reasons are behind the observed WACC decreased. Not only lower interest rates, technology improvements and lower country risks explain the downward trend, but other surprising reasons are also part of the picture. Interviewed experts pointed out to three phenomena. First, capital is not only raised from EU sources, but it is also flowing from international sources, such as North America and Asia markets, which could generate spill over effects in EU countries where the costs of capital are higher than the costs of international investments. Second, the non-standard monetary policy of the European Central Bank after the 2008 crisis has resulted in abundant capital which triggered lower loan fees and increased competition for business cases. Third, new market players, such as energy intensive companies, are under policy and regulatory pressure to green their portfolios and are consequently shifting to RE through, for example, corporate Power Purchase Agreements, which could add more competitive pressure on the market.

An econometric analysis complements these findings. A set of variables potentially explaining the rise and fall of the WACC are derived from literature and interviews, and comprised risk aspects as well as market aspects and learning effects. The results confirm findings of the interview: main driver of the WACC is the country risk, but experiences with renewables are also significant: The introduction of auctions did not increase the WACC, rather the opposite, increasing experiences in auctions seem to have a dampening effect on the WACC. Similarly, experiences of a country with deployment of renewables tend to reduce cost of capital. Finally, even though the variable of remuneration schemes displays no significance, the schemes indirectly reveal an effect through their impact on the significance of auctions, suggesting, that remuneration schemes that reduce the exposure to market risks tend to have a decreasing effect on the WACC.

To estimate the effects of different financing conditions on support costs, we developed a cash flow model that calculates minimum bid levels and debt shares, given several optimisation constraints. Based on this we find that Member States should mainly focus on de-risking debt financing, as this would deliver the largest support costs savings and WACC reduction. Interest rates have decreased in Europe largely due to the expansionary monetary policy of the ECB. However, instead of additionally/marginally decreasing cost of debt, de-risking policies should also aim at increasing loan maturities and debt size. Such debt de-risking could be best achieved by adopting remuneration schemes that decrease the volatility of the projects cash flows, such as contracts for difference. Furthermore, we find that de-risking cost of equity – through relaxing pre-qualification requirements, reducing bid bonds, prolonging realisation rates etc. - would not yield very large additional benefits in terms of support cost reduction. Therefore, policymakers should de-risk auction designs in the pre-bidding stage – decrease bid bond levels, relax pre-qualification requirements etc. – only if they have policy goals other than cost-efficiency, such as increasing actor diversity.

1 Introduction

This report presents the main results of the survey and in-depth interviews conducted between September 2019 and April 2020 in all the EU Members States and the United Kingdom. The interviewees partners were mainly RE project developers, bankers, financial experts and other RE related stakeholders.

Through the survey and interviews, data on relevant financing variables of concrete RE projects in Europe was collected. In particular, the variables asked were: Weighted Average Cost of Capital (WACC), its components Cost of Debt and Cost of Equity (CoD and CoE), the Debt to Equity Ratio, the Loan Tenor, and the Debt Service Coverage Ratio (DSCR). The report presents the main figures for these variables and it also raises discussions on the main reasons explaining the observed trends.

The report is completed by two quantitative exercises on the field. On the one side, an econometric analysis that investigates factors driving the WACC. These factors are derived from literature. On the other side, a cash flow model that calculates the effects of the different financing conditions on bid levels and support costs.

1.1 Background of AURES project

AURES II (AUctions for Renewable Energy Support II) aims at ensuring the effective implementation of auctions for Renewable Energy Sources (RES) in EU Member States. The main focus is on the different auctions design elements and options that policy makers can decide upon and by analysing their policy performance, recommendations on their use are provided.

The principal objective is, therefore, to provide support to European Member States and Energy Community countries in improving the effectiveness and cost-efficiency of financial support schemes for RES. To this end, communicating and disseminating our main results to generate discussions and knowledge exchange with stakeholders is a key step in achieving the project´s objectives.

1.2 This report

1.2.1 Overview on chapters

This report is structured as follows. First, Section 2 presents the main results of the surveys and interviews conducted with renewable energy experts, bankers, project developers, and other relevant stakeholders across the European Union (EU) between December 2019 and April 2020. Three technologies were covered: onshore wind, offshore wind, and solar PV. The section presents a series of maps and figures with the results of the following key financing variables: Weighted Average Cost of Capital (WACC), Cost of Debt (CoD), Cost of Equity (CoE), Debt to Equity Ratio, Loan Tenor, and Debt Service Coverage Ratio (DSCR). The historic evolution of these variables between 2014 and 2019 is also presented. Finally, RE project financing in the context of the Covid-19 pandemic is addressed.

Secondly, an econometric data analysis was conducted and the main findings are discussed in Section 3 of the report. Considering the relevance that WACC has for RE projects, the developed model addresses how the introduction of auctions and other RE policies can have an impact on the WACC values.

Third, Section 4 presents a cash-flow-modelling to calculate bid levels for onshore wind and solar PV, based on the data collected through surveys. This section presents the main findings regarding the effects that auctions and auction design have on support costs.

Last, final remarks and conclusions are presented in Section 5 of the report.

1.2.2 Methodology

For Section 2 of the report "WACC Survey Results", the data was collected through 93 semi-structured interviews across the EU Member States (and the United Kingdom) with bankers, project developers, investors, among other stakeholders. After a qualitative analysis the data collected was validated with RE experts.

In Section 3 "Econometric Data Analysis" aims at identifying those factors that have a significant impact on the WACC. As dependent variable the WACC derived from the survey is used. The explaining variables adopt different perspectives for example, of the project or micro level, the meso-level or sector and macro- level. They cover different aspects such as risks, market and societal aspects as well as learning effects of deploying renewables. They are derived from different sources as indicated in the section.

In Section 4 "Cash-Flow-Modelling" we developed a cash flow model that used Excel Solver to minimise bid levels, while optimising the debt share. We calculate debt shares for the different DSCR values that we collected. After calculating the bid levels, we discount support costs of the projects over their lifetime. Finally, we test the sensitivity of support costs on financing conditions and other investment variables, based on four countries including Denmark, Germany, Greece and UK. We selected these countries because they represent different remuneration scheme designs and different levels of country and policy risk.

A more detailed description of the methodology used is presented in each sections of the report.

1.3 Introduction to cost of capital for RE projects

One of the most important financial variables for low-carbon infrastructure is the Weighted Average Cost of Capital (WACC). When developing a RE project, investors can raise capital mainly in two ways: by borrowing it (debt) or by using equity, i.e., the owner´s investment in the company. When debt and equity are aggregated, considering their relative weights, the WACC is obtained (Dukan et al., 2019). Costs of capital can be understood as the costs under which different capital providers are willing to invest and lend money to a business or an undertaking (Dukan et al., 2019, p. 16). Besides, it can be defined as "the return that must be provided for the use of an investor's funds" (Fabozzi & Peterson Drake, 2009, p. 396).

RE projects are not only more capital intensive than carbon technologies, but they are also characterized by relatively higher up-front capital expenditures and lower operating expenses. Therefore, RE projects must invest heavily in initial stages, which demands abundant capital. The WACC is, hence, an essential variable in RE financing. In Figure 1 it can be observed how investment in a RE project takes place almost entirely up-front, whereas a gas power plant is more distributed across the lifetime of the installation.

Leveraging debt is one of the strategies to raise the necessary capital at initial stages. Besides, it is assumed that an increased debt-to-equity-ratio will lead to a decrease in overall WACC because debt is typically less costly than equity. Hence, projects with a higher debt share will therefore have lower cost of capital (WACC) (Dukan et al., 2019).

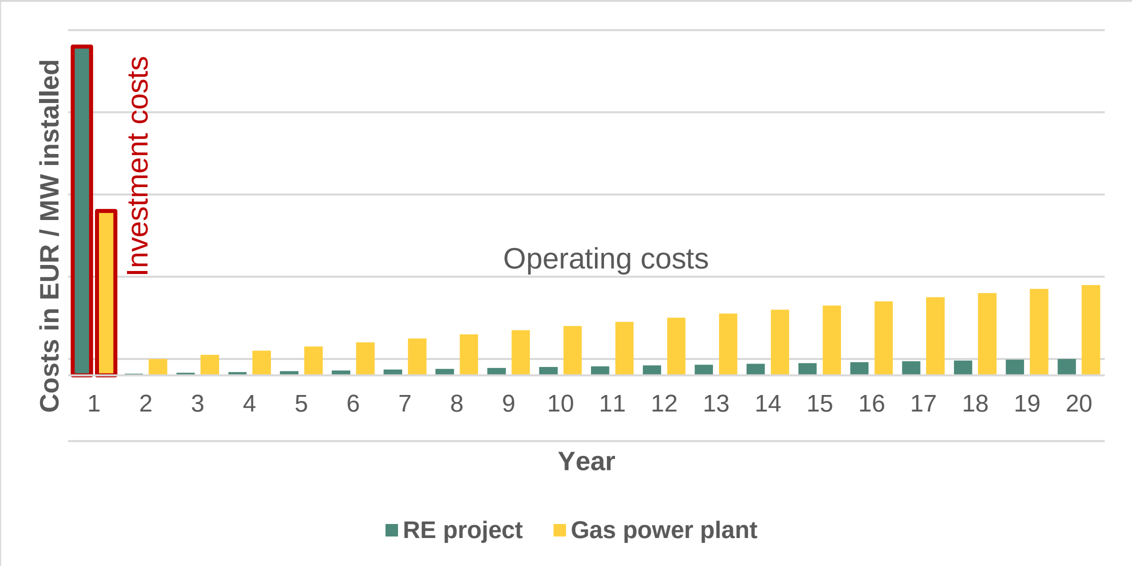


Figure 1. Investment costs and operating costs of RE project vs. Gas power plant. Own elaboration, based on UNDP Report (Waissbein et al., 2013).

Besides, the costs of producing electricity, or the Levelized Costs of Electricity (LCOE) are sensitive to changes in the WACC level, not only for renewable energy technologies, but this holds for all carbon technologies too. Hirth & Steckel (2016) demonstrated this sensitivity through modelling and concluded that LCOE of wind power is more sensitive to a WACC increase, compared to coal and gas power plants. Therefore, due to the strong impact of the WACC on the LCOE, having a low WACC is of tremendous importance.

Multiple variables can have an impact on the WACC values, but specially risks and interest rates play a key role. On the one side, RE investors always face risks when planning and developing a project. There are different risk categories reported in the literature, such as political, economic, regulatory, policy, social, among others. These business risks faced by investors are then reflected in the costs of raising capital: debt and equity costs (WACC). In an investment environment with higher risks, a higher WACC will be observed (Egli et al., 2019; International Renewable Energy Agency (IRENA), 2015).

At the EU level, the widespread use of auctions has to do, not only with the Guidelines on State Aid for Environmental Protection and Energy 2014-2020 and the EU Directive 2018/2001 (RED II) but also with the fact that auctions allow reducing information asymmetry, regulating the expansion of renewables and controlling costs of support and (Haufe & Ehrhart, 2016; EU Commission, 2014; EU Commission, 2018). Regarding commitments and transparency, auctions result in a contract between two entities that clearly states the commitments and liabilities of each party. Moreover, auctions are flexible in their design, allowing the possibility to combine and tailor different design elements to meet deployment and development objectives (IRENA and CEM, 2015). Auctions, as policy tools, could be implemented to achieve other objectives such as supporting the integration of higher shares of variable renewable energy and ensuring greater participation of communities and small players and maximizing the socio-economic benefits of renewables (International Renewable Energy Agency (IRENA), 2019). This report explores, therefore, the possible impacts that the introduction of auctions and its design elements could have on the WACC values and other financing conditions in the RE market. As of December 2020, the following countries have conducted auctions for RE, some of which have resulted in record-low prices for different technologies: Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxemburg, Malta, Poland, Portugal, Slovenia, Spain, The Netherlands, and United Kingdom.

2 WACC Survey Results

2.1 Methodology

Between September 2019 and April 2020, 93 semi-structured interviews[1] on the costs of capital, financing conditions, and auction designs[2] in the EU Member States were conducted. Five countries (Denmark, Germany, Portugal, Spain, and Greece) were selected as Focus Countries, where eclareon conducted in-depth interviews. The interviewees were generally investors, banks, project developers and other finance experts in the area of Renewable Energies.

The semi-structured interviews were based on a predeveloped interview template[3] organized as follow:

- Information on the interviewee background and experience in RE investment
- Information on specific RE projects developed between 2018-2019: WACC, CoD, CoE, DSCR, Loan Tenor, Technology, Size of the project, type of financing, completed construction, among others.
- Exclusively for focus countries, a qualitative semi-structured discussion took place, where experts were asked about changes in financial indicators before and after the introduction of auctions. Besides, the reasons behind the changes in those indicators were discussed. Last, they were asked which and how specific auction design elements (such as auction format, penalties, remuneration scheme design, etc.) affect their financing conditions.

The Weighted Average Cost of Capital (WACC) is a crucial variable for renewable energy market players and, in consequence, data collection presents numerous hurdles that need to be overcome. Two main limitations were encountered throughout the research process.

First, access to reliable WACC values was very challenging for researchers since the WACC is considered to be a trade secret and is highly confidential, difficulty that has been also pointed out in recent literature (Steffen, 2019). Therefore, all the interviews took place under the Chatham House Rule to ensure the quality and confidentiality of answers, meaning that "participants are free to use the information received, but neither the identity nor the affiliation of the speaker, nor that of any other participant, may be revealed" (Chatham House, n.d.).

Second, certain Member States present very little or no development of wind power projects in the period 2017-2019. In these cases, arranging interviews was even more challenging. To assure transparency and reliability, the results and graphs account for these situations. Table 1 shows the wind power capacity development in the last years (onshore and off shore combined).

New wind power capacity installed per year (MW)							
	2013	2014	2015	2016	2017	2018	2019
Germany	3466	6187	6013,4	5443	6440	3374	2074
Spain	175	55	0	38,2	95	394	2148
United Kingdom	1888	1265.5	867.5	739	2783	1407	2177.6
Italy	444	107.5	295	282.6	359	549	281.8
France	630	1042	999	1346	1798	1558	1361
Denmark	656.6	68	160	225	373	657	28
Portugal	193	183.4	132	235	0	67	69.7

[1] 93 interviews were conducted with participants from 90 different organisations. The interviewees provided a total of 240 estimates for financing conditions and costs of capital for solar PV, onshore wind and offshore wind projects.
[2] As of December 2020, the following countries have conducted auctions for RE: Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxemburg, Malta, Poland, Portugal, Slovenia, Spain, The Netherlands, and United Kingdom. Hence, the values presented for countries without auction schemes in place do not represent the effect of introducing auctions.
[3] The template can be found on Annex I.

Sweden	725.4	1050.2	614.5	493	226	809	1684
Poland	892.8	444.5	1264	682	650	16	150.9
Netherlands	303.2	139	535	788.5	81	162	120
Romania	637	438	23	52.1	4	0	0
Ireland	131.7	222.4	224	324.7	538	246	451
Greece	115.2	170.8	171.8	238.6	171	235	729.9
Belgium	329.3	306	274	231	465	385	565.3
Austria	307	411	323	228	195	187	58.3
Bulgaria	7.1	10.1	0	0	0	0	0
Finland	162.3	184	379	570	515	0	243
Hungary	0	0	0	0	0	0	0
Croatia	119.2	85.8	81.1	34.2	44	0	59.9
Estonia	10.5	54.7	0	10	0	0	10
Lithuania	54	0.5	142.3	71	12	3	1
Czech Republic	12	16.6	4	0	0	1	20.8
Cyprus	0	0	10.8	0	0	0	0
Latvia	2	0	0	0	0	0	0
Luxembourg	2.3	0	4.7	36.2	0	0	4.1
Slovakia	0	0	0	0	0	0	0
Slovenia	0	1	0	0	0	0	0
Malta	0	0	0	0	0	0	0
Totals	11263,6	12443	12518,1	12068,1	14749	10050	12238,3

Table 1. Wind power capacity installed per year per country (onshore and offshore combined). Source: (EurObservER, 2020)

2.2 Survey results

2.2.1 WACC results

2.2.1.1 Wind onshore (2018-2019)

In the present section, the wind onshore WACC results for all EU Member States are presented. Certain interesting and surprising country cases and trends are further discussed separately. WACC figures are after tax and nominal.

In figure 2 the reported WACC values for 2019 are presented on a European map, which allows to have a general overview on the wind onshore costs of capital of each Member State, as well as comparing regions and trends. For each country, the minimum and maximum WACC values are included and the colour indicates a scale, ranging from dark green (lower WACC) to red (higher WACC).

The relevance and reliability of the WACC results depend to a certain extent on actual wind onshore projects being developed. Hence, the map highlights in red the borders of countries that present a wind power capacity increase lower than 3% in the period 2017-2019 (see Table 1 in Methodology section).

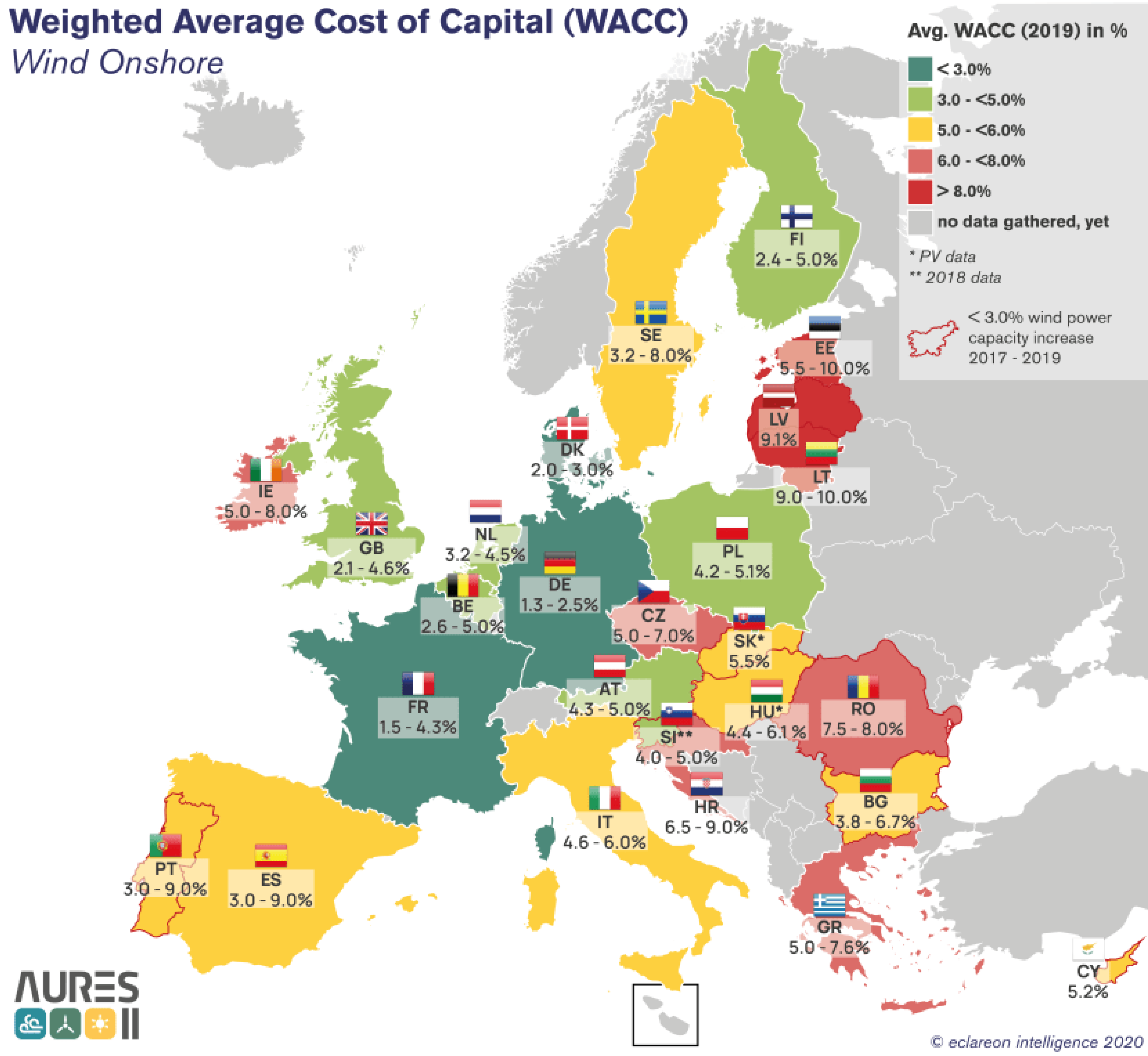


Figure 2. Overview on WACC for wind onshore 2019.

After a thorough internal analysis, followed by a validation with external experts and interview partners, different conclusions can be drawn.

In general terms, a considerable gap is observed between European regions with respect to the WACC values. On the one hand, certain central-western countries as Germany, Denmark and France present the lowest WACC values, around 1.3% - 4.3%. On the other hand, the Baltic states and some south-eastern countries as Romania and Greece show WACC values higher than 7.0% and up to 10.0%.

More specifically, certain countries present unanticipated results that are worth a closer look.

First, Sweden presents a higher-than-expected *maximum* WACC value (8.0%), especially if compared with its neighbouring countries, such as Finland (5.0%) and Denmark (3.0%). One important rationale behind this high WACC might be some reported issues with the Swedish RES quota support scheme (green certificates) and low market prices.

In the DiaCore project (Noothout et al., 2016), it was found that the risks induced by support schemes (as the quota system) were perceived as most pressing for developers. Although support schemes are implemented with the goal of de-risking and creating a starker environment for business cases, when they do not work properly, other unintended risks and consequences may arise.

Interviewed experts and developers from Sweden explained that wind onshore projects financed under the green certificates scheme are riskier and, hence, with higher WACC, if compared to projects that secure a PPA for the long run, which benefit from a stronger price stability and consequently present a lower WACC. The reason is that green certificate prices are low and volatile. Therefore, the green certificate revenues are not enough for producers to compensate the (also) low market price they received when selling the power directly to the market. This situation brings on more price and policy uncertainty for long term projects and investments.

Secondly, according to interviewed experts, Ireland presents a higher-than-expected WACC, i.e., ranging from 5.0% to 8.0%. A plausible reason is the absence of support schemes for wind onshore projects during the period under analysis (2017-2019). Support schemes, such as Feed-in Tariff or Feed-in Premium, can reduce the exposure to market prices of wind onshore projects, which in turns means lower risks and consequently lower WACC. They are also fundamental for the debt financing conditions of RES projects, since they define the project´s cash flows (Dukan et al., 2019).

Between 2012 and 2015, Ireland implemented the Renewable Energy Feed-in Tariff programme (REFIT 2) for small and large scale onshore wind projects (eclareon GmbH et al., 2019). Under the REFIT 2 scheme, successful wind onshore producers entered into a Power Purchase Agreement (PPA) with a licensed supplier (eclareon GmbH et al., 2019). After the phase-out of the REFIT 2 programme, there was no support scheme for wind onshore projects. The government encouraged the celebration of PPAs but without the expected success. In December 2019, the Irish government announced a new multi technology tender scheme (Renewable Electricity Support Scheme) that includes a two-sided sliding feed-in premium (CfD). The first round under the new scheme took place in July 2020, therefore, its results are not included in the report.

2.2.1.1.1 Closer look: WACC spread

The high spread between minimum and maximum WACC values of certain countries is remarkable. Figure 3 shows that Spain, Portugal, Sweden and Estonia are the countries with the largest difference between their maximum and minimum WACC values, in percentage points (pp):

- The Iberian countries have a difference of 6.0 pp (3.0% - 9.0% WACC)
- Sweden presents a difference of 4.8 pp (3.2% - 8.0% WACC)
- Estonia shows a difference of 4.5 pp (5.5% - 10.0% WACC)

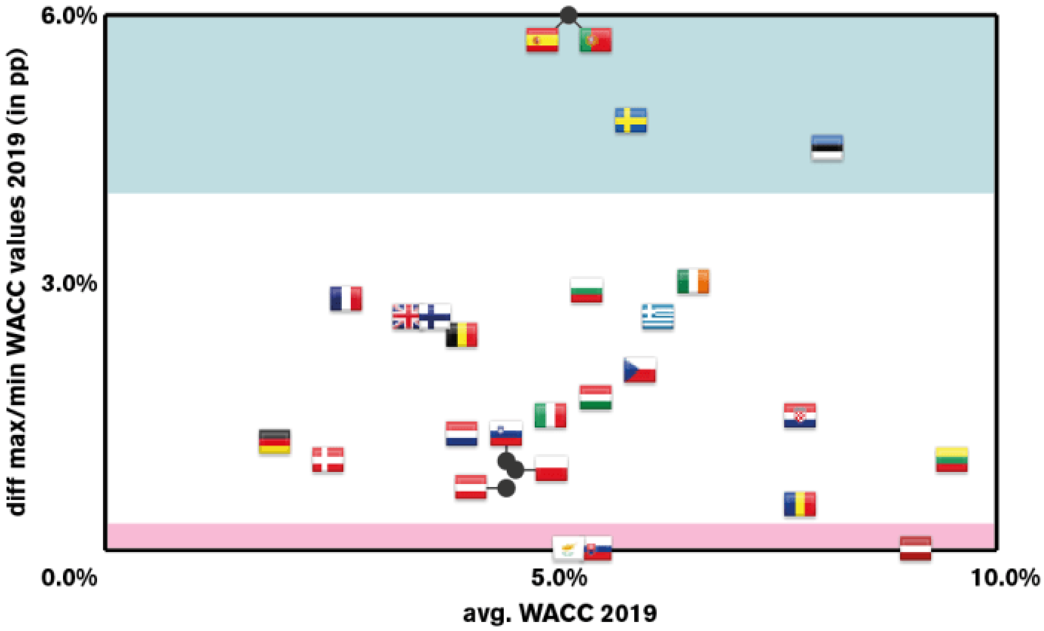


Figure 3. Average WACC (2019) vs. difference in percentage points (pp) between minimum and maximum

WACC value.

In Sweden (Figure 4), as introduced previously, there are mainly two different business cases: RE producers under the green certificate support scheme generally face higher risks (and higher WACC) than those producers who structure their businesses with PPAs. The former option implies a greater exposure to merchant risk because the certificates´ prices have been rather low and therefore insufficient to compensate the also low electricity market prices. Instead, the latter option allows producers to ensure long term and stable revenues while improving the bankability of project financing (Brunnberg & Johnsen, 2019).

In addition, based on the DiaCore and Re-Frame projects´ data, May & Neuhoff (2017) estimated that tradable green certificates can be associated with increases in the wind power risk premium by about 1.2 percentage points, compared to a base scenario with Feed-in Tariffs (at a 1 percent significance level). The risk premium was calculated subtracting the risk-free rate (average government bond yields) from the WACC.

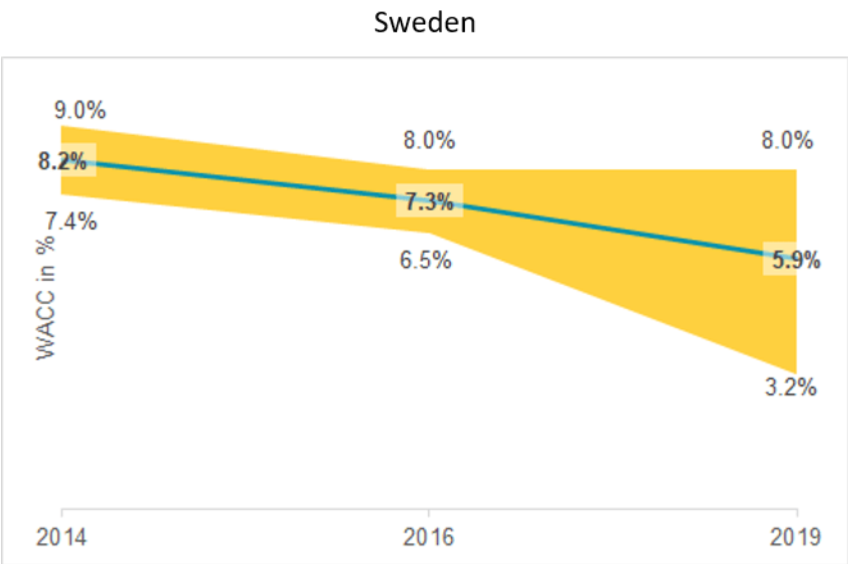
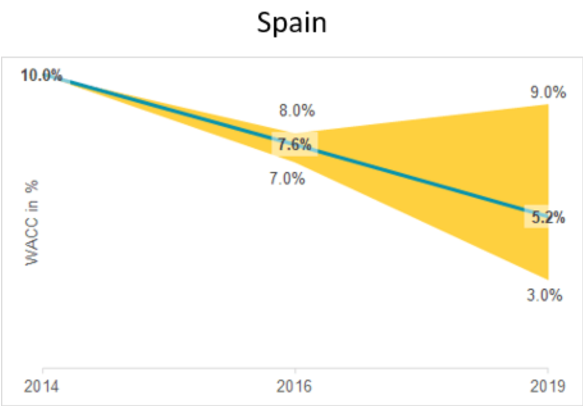


Figure 4. Minimum and maximum WACC values over time for onshore wind in Sweden.

However, the PPA option has its own drawbacks. In Sweden, it was reported that the vast amount of PPAs have made the price and level of the agreements very low, leading to fewer developers choosing to sign a PPA. Although a PPA would lower risks, the lower revenue of the PPA would not be enough incentive to choose this option. This market particularity contributes to explain why not all producers use the -cheaper-PPA option. Therefore, the WACC large spread is partly due to the coexistence of these two main business model options.

Besides, the diversity of market players can shed light on the large WACC spread observed in the Iberian Peninsula (Figure 5). Experts pointed out that stakeholders as big utilities can apply a WACC of 3% approximately; whereas other stakeholders such as pension funds would apply a WACC around 5%, Independent Power Producers (IPP) 7%, and a private equity investor 9%. For instance, in Spain, the larger development of new RE capacity attracted a wider range of investors to the market, which are characterized with different return expectations, hence, different WACC levels as observed in Figure 5.



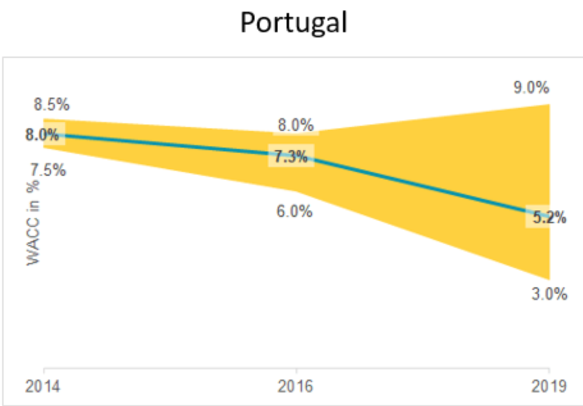


Figure 5. Minimum and maximum WACC values over time for onshore wind in the Iberian Peninsula.

In the four cases, the large spread found in their WACC values was also found in their cost of equity (CoE) values. In relation to the cost of debt (CoD), however, the large spread is only replicated in the case of Estonia.

At the bottom of Figure 3, three countries have no spread at all: Latvia, Slovakia, and Cyprus. At the same time, these countries present very little development of wind onshore capacity in the period 2017-2019, hence, the values may not fully depict the real spread between minimum and maximum WACC values.

2.2.1.2 Wind offshore (2018-2019)

For numerous historical, technical, financial and strategic reasons, wind offshore is less developed compared to its onshore counterpart. Within the European Union (and the UK), the eleven countries that count with installed wind offshore projects, in order of magnitude, are: United Kingdom (9785 MW), Germany (7507 MW), Denmark (1700.8 MW), Belgium (1548 MW), Netherlands (957 MW), Sweden (192.5), Finland (72.7 MW), Ireland (25.2 MW), Portugal (8.4 MW), Spain (5 MW), and France (2 MW) (EurObservER, 2020).

Although interviews were conducted in the eleven countries mentioned above, given the relative lower number of wind offshore projects, WACC data was collected in six countries: United Kingdom, Germany, Belgium, Netherlands, Ireland, and France. The figures are presented below in Figure 6. Therefore, the results are based on a rather small number of datapoints.

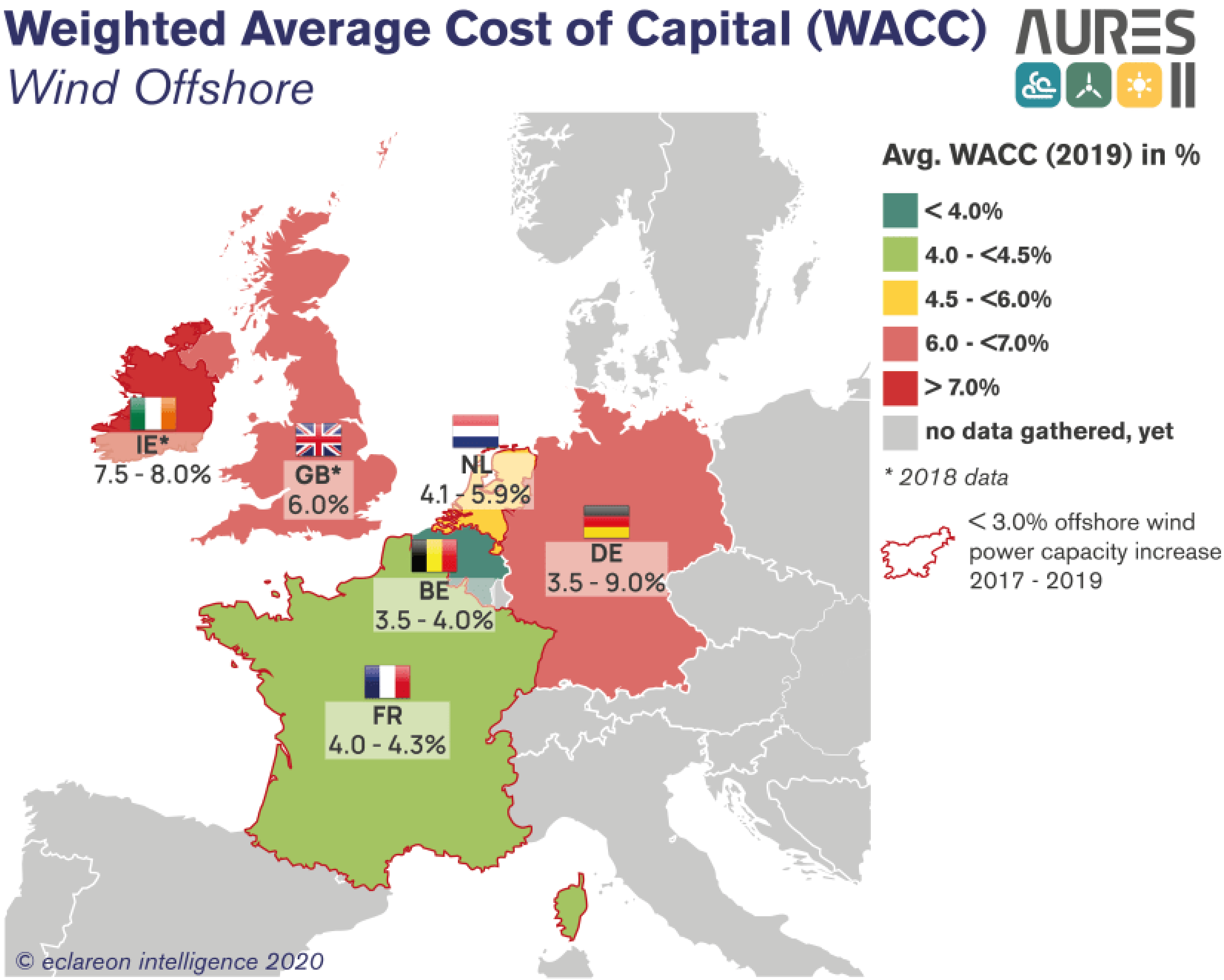


Figure 6. Overview on WACC for wind offshore (2019).

The risk profile of wind offshore projects is generally higher than wind onshore projects, which is confirmed by the WACC values in Figure 6. If offshore WACC values are compared with the onshore ones, it can be observed that the six selected countries present a higher WACC for offshore technology. The most notorious case is Germany, which has a maximum *offshore* WACC value of 9.0%, whereas its maximum *onshore* value is 2.5%.

2.2.1.3 PV (2018-2019)

Figure 7 includes the WACC values for solar photovoltaics technology (PV). The research collected data for twelve EU Member States. Due to resource availability, solar PV constitutes a very important technology for south-eastern European countries, as well as for the Iberian Peninsula.

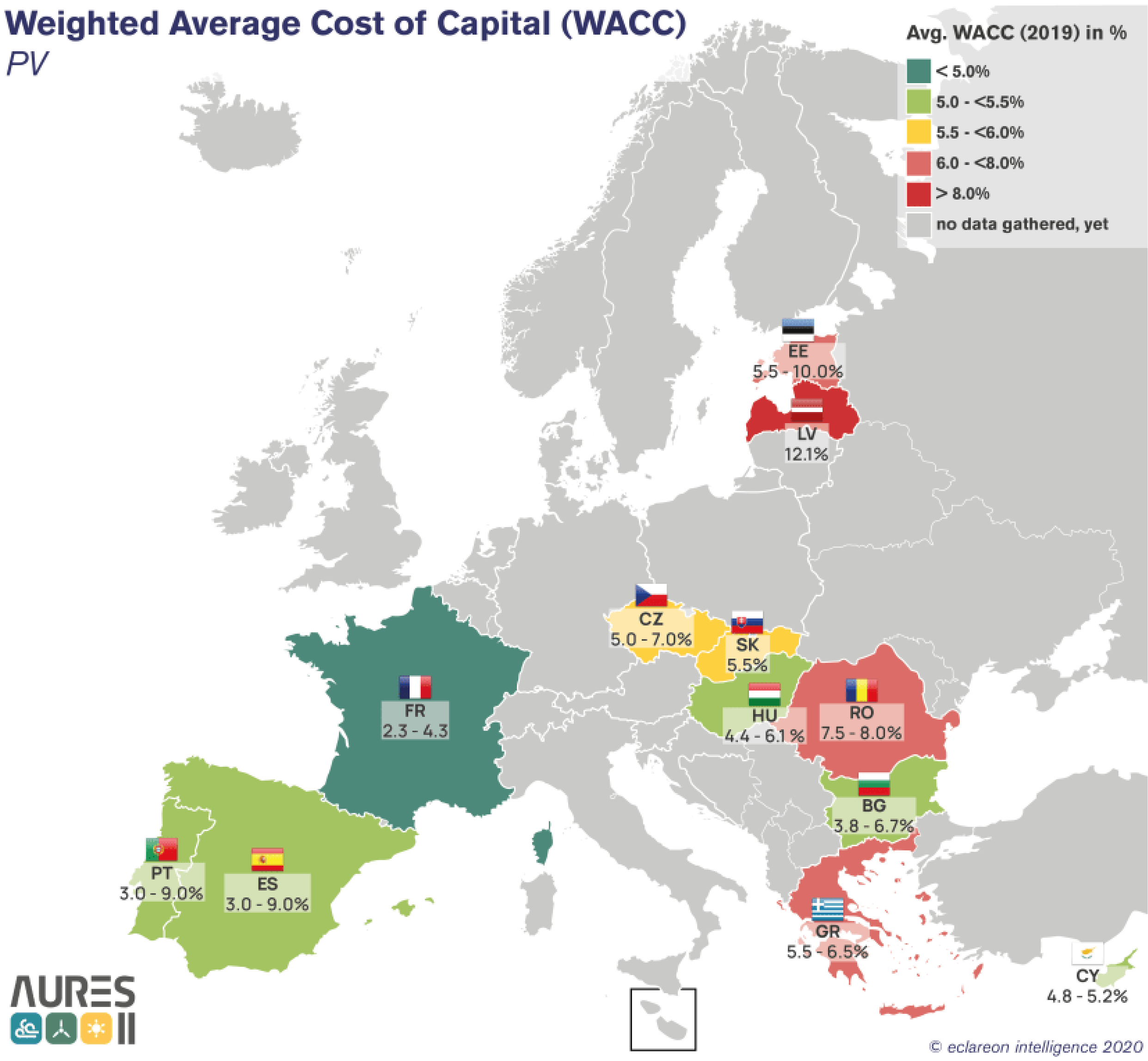


Figure 7. Overview on WACC for solar PV (2019).

It is notorious how the PV WACC values closely resemble the wind onshore WACC figures. There are interesting insights from the interviews that could explain the similarity. Some market players, such as big utilities, reported to rely on balance sheet financing, which allows them to have a more global and general approach and do not differentiate much between projects and technologies, as Banks would do. Besides, certain market players diversify their investments in a large portfolio and can thus benefit from applying a more general WACC and financial values to different technologies.

2.2.1.4 Historic trends and evolution (2014-2019)

The WACC for renewable energy projects is far from being a stable financial variable. On the contrary, it is dependent on different endogenous and exogenous drivers and also on risks perceptions and assessments. Dynamics elements such as the interest rate, country specific risks, energy and climate public policies, regulations, technology maturity, competition between market actors as investors and banks, all play a key role defining and shaping the WACC over time.

To explore the evolution of the WACC variable, the results obtained in the previous projects DiaCore 2014 (Fraunhofer ISI et al., 2014) and RE-Frame 2016 (eclareon GmbH & Fraunhofer ISI, 2016) are taken as a reference. WACC figures are after tax and nominal. In those projects, all EU Member States (except for Luxemburg and Malta) and the UK were covered and through qualitative interviews it was possible to provide for the first time a structured and comprehensive overview of the cost of capital for RES at EU level (Noothout et al., 2016). The focus was put on wind onshore technology and in the WACC, CoD, CoE, and debt to equity ratio for 2014 and 2016.

Although there is still a gap between the countries with highest and lowest WACC, the results of Figure 8 show an impressive and general trend downwards. As the WACC values of some countries were reduced faster, there is a slight convergence in 2019 compared to 2014 level. Spain and Greece were among the countries that reduced their WACC the most.

Out of a total of 26 countries, 25 experienced a WACC reduction and 21 present a reduction of at least two percentage points over the period 2014-2019. Lithuania is the only exception. The EU 28 average shows a 3.1 pp decrease in the considered period. In Annex I, Figure 34 indicates on a European map the percentage points difference between 2014 and 2019 WACC values.

Compared to 2014 WACC values, European markets have experienced a dramatic decrease. However, as it was already pointed out in a previous AURES report (Đukan et al., 2019), the decrease in WACC did not necessarily lead to an ambitious deployment of wind power capacities in all countries, particularly in some markets in Central and Eastern Europe, such as Slovenia and Hungary that present less than 3% wind power capacity increase in 2017-2019 (see Table 1).

Besides, the only country that experienced an increase is Lithuania, with 1 pp. compared to 2014 levels. Although multiple reasons could explain this trend, the CoD and interest rates could be the major drivers behind it. Between 2016 and 2019, both CoD and interest rates suffered an increase in Lithuania. Given the importance of them in the CoC composition, an increased WACC is an expectable consequence.

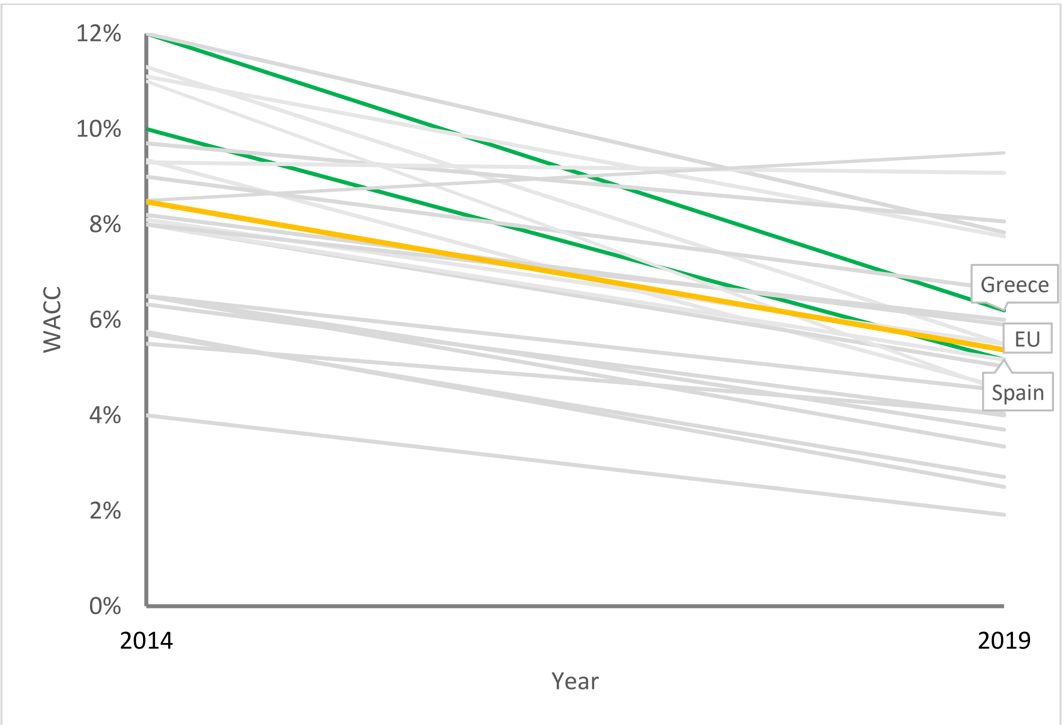


Figure 8. WACC historic trend for onshore wind (2014-2019).

During the interview process, especially during the in-depth interviews conducted in the focus countries (Spain, Portugal, Germany, Greece and Denmark), certain reasons for the general downwards trend were repeatedly mentioned by the experts:

- Excess liquidity and general interest rates (ECB)
- Reduced country risks
- Technological advancements
- Experience in the RE financing sector
- Increased competition
- International flow of capital
- New market players

Some of them, as the monetary policy of the European Central Bank (ECB), the reduced country risks, or technological advancements, do not come as a surprise, since they were already reported in previous studies (Angelopoulos et al., 2017; International Renewable Energy Agency (IRENA), 2015; Egli et al., 2019; Noothout et al., 2016; Steffen, 2019). However, two other interesting reasons were brought into the discussion: increased competition within certain sectors and the emergence of new market players in the renewable energy industry.

Given that the WACC is determined by the Costs of Debt and Equity of a project, some of the listed reasons affect more closely the Debt side, whereas others relate more strongly to the Equity side of the capital structure. Therefore, the monetary policy of the ECB, increased competition, and international flow of capital, are explained under section 2.2.2. The emergence of new market players is discussed in section 2.2.3.

The WACC at large is affected by the notion of risk. RE projects can face multiple risks such as policy risk, currency risk, inflation risk, or in general, **country risk**, that put pressure on the WACC because the higher the risk, the higher the expected return (from both debt and equity sides). Country risk is understood as a series of factors that "can adversely affect the profits of all investments in a country", including "political stability, level of corruption, economic development, legal system and exchange rate fluctuations" (Noothout et al., 2016, p. 19). For example, in the past, countries such as Greece, Belgium, Spain, Italy, Bulgaria, and Czech Republic implemented retroactive changes of policies, which undermined the investment trust in the energy sector (Angelopoulos et al., 2017). However, numerous interviewees experts pointed out that the general trust in energy policies was restored to a large extent, specially in Greece, Spain, and Portugal.

In Greece, where a WACC decrease of 5.8 pp took place, one of the most important factors pointed out by experts was the improvement of the business and macroeconomic environment, which in turn allowed for more MW to be installed.

Furthermore, the general WACC trend can also be understood both through **technological advancements and increased experience** in the financing sector. The former reason is especially relevant for the wind sector, where wind turbine technology has improved, for example reducing forecast errors, which increases certainty on the amount of electricity that can be sold and, in turn, project revenue. For the latter, a well-established market and professionalism of projects also lead to lower risks and cost of capital, as it was reported in Germany, where certain financing structures are already very mature. In general, lower costs of capital have been a result of an ongoing increase of renewable energy finance capabilities within the banking community across Europe.

Besides, it is remarkable that the vast majority of experts consider that the introduction of auctions was not a major driver for the observed downward trend in the WACC. However, experts do pay close attention to auction design elements, because some of them can have relevant impacts on their investment structures and strategies, such as remuneration schemes, pre-qualification criteria, grid connection, penalties, permitting, auction frequency, site development, and auction volumes.

2.2.2 Cost of Debt Results

2.2.2.1 Wind onshore (2018-2019)

The Cost of Debt (CoD) is one of the two main components of the WACC. It basically reflects the cost of borrowing and raising capital to finance a RE project. For this reason, the CoD values are, in many cases, strongly correlated to the general interest rates, as it is discussed in below. Besides, the numerous risks perceived by lenders play a fundamental role in shaping the CoD. The riskier the project and the profile of the borrower, the higher the CoD will be. The map of Figure 9 presents a broad picture of the CoD across Europe. Certain interesting cases are detailed below.

In the following subsections, the main results of CoD are presented and three interesting topics are discussed: the interactions between interest rates and CoD, the competition dynamics between actors, and international flow of capital.

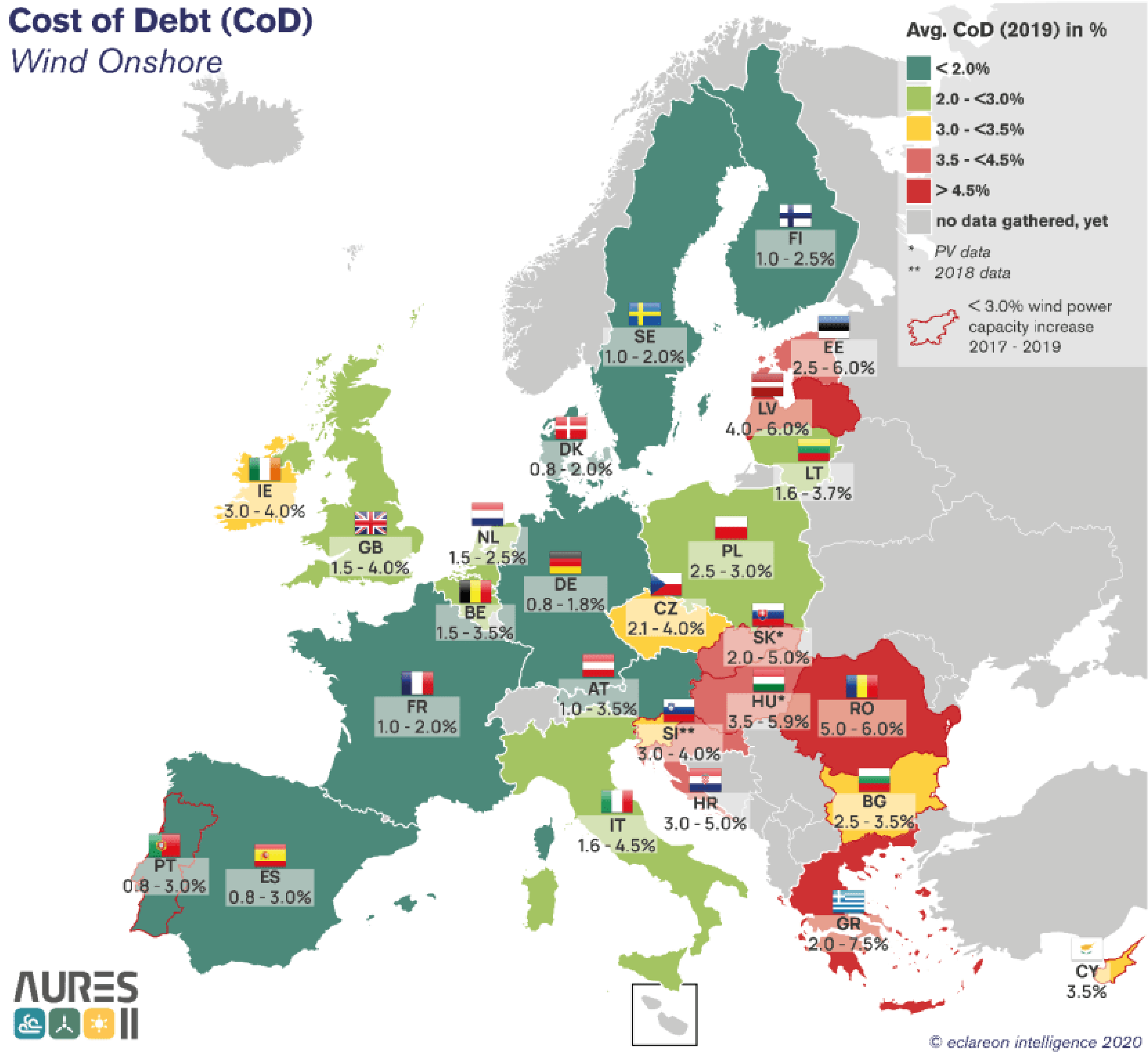


Figure 9. Cost of Debt for onshore wind projects (Average 2019).

Countries in darker green present the lowest CoD across Member States, a *green path* which can be appreciated starting in Portugal and going up to Finland (most of countries using auctions). The CoD average value lower than 2% of certain countries is noteworthy:

- In the Iberian Peninsula, a market expert interviewee explained that the CoD is to a large extent determined by the type of actor and the way they finance the project, and not only by contextual factors as country risk. Therefore, investors using project financing would generally face a higher CoD, whereas corporate finance investors would face a lower CoD.
- The low CoD values observed in the Swedish case (1.0% - 2.0%) were related to the widespread use of PPAs in project financing. If a producer secures a long-term, solid PPA with stable revenues, the bankability of her project will be enhanced (Brunnberg & Johnsen, 2019). In turn, other financial

variables as the CoD and the DSCR will also improve, making the borrowing of capital cheaper. Nonetheless, experts pointed out that the vast amount of PPAs sank the price (revenues), which explains why other market players base their financing structures in different options, as the already introduced green certificate support scheme.

- Finland presents a low CoD (1.0% - 2.5%), explained in part by the fact that several projects are owned by public entities, such as municipalities, that access to loans with low interest rates.
- The lowest CoD was identified in Germany (0.8 - 1.8%). In addition to the remarkable macroeconomic stability, there is a strong competition between banks, which adds more pressure on the loan interest rates to go down (see Competition between actors).
- Likewise, Denmark presents a very low CoD (0.8% - 2.0%). In this case, there is an interesting link between the low CoD and the secure Danish bond market. Certain assets, such as RE constructions and real estate, are financed through special companies and banks that issue bonds linked to the loans they grant, which are sold on the market. As the demand for these bonds has been on the rise, banks and companies are encouraged to grant more loans, which they can then use to create and sell more covered bonds (European Central Bank, 2019). As the supply of loans increases, the loan interest rates decrease, benefiting RE project developers with better financing conditions.

On the other hand, certain cases present a large spread between the minimum and maximum CoD values:

- Various international project developers have been investing in Greece, bringing capital from Banks abroad, which could explain the lower end of its CoD range (2%). Although Greece´s country risk has improved recently, the large CoD values (7.5%) could still reflect a lack of confidence in the business environment by some lenders (see International flow of capital).
- The large spread observed in Estonia (2.5% - 6.0%) was connected by experts to the different nature of market players and business models, similar to the situation in the Iberian Peninsula and Sweden. Thus, bigger project developers could be associated with 2.5-3% CoD, while smaller businesses would be located in the other end, around 4.5-6% CoD.

2.2.2.2 Offshore wind and solar PV (2018-2019)

In Figure 10 the bar plots present the average CoD of 2019 for offshore wind (blue bars) and solar PV (orange bars).

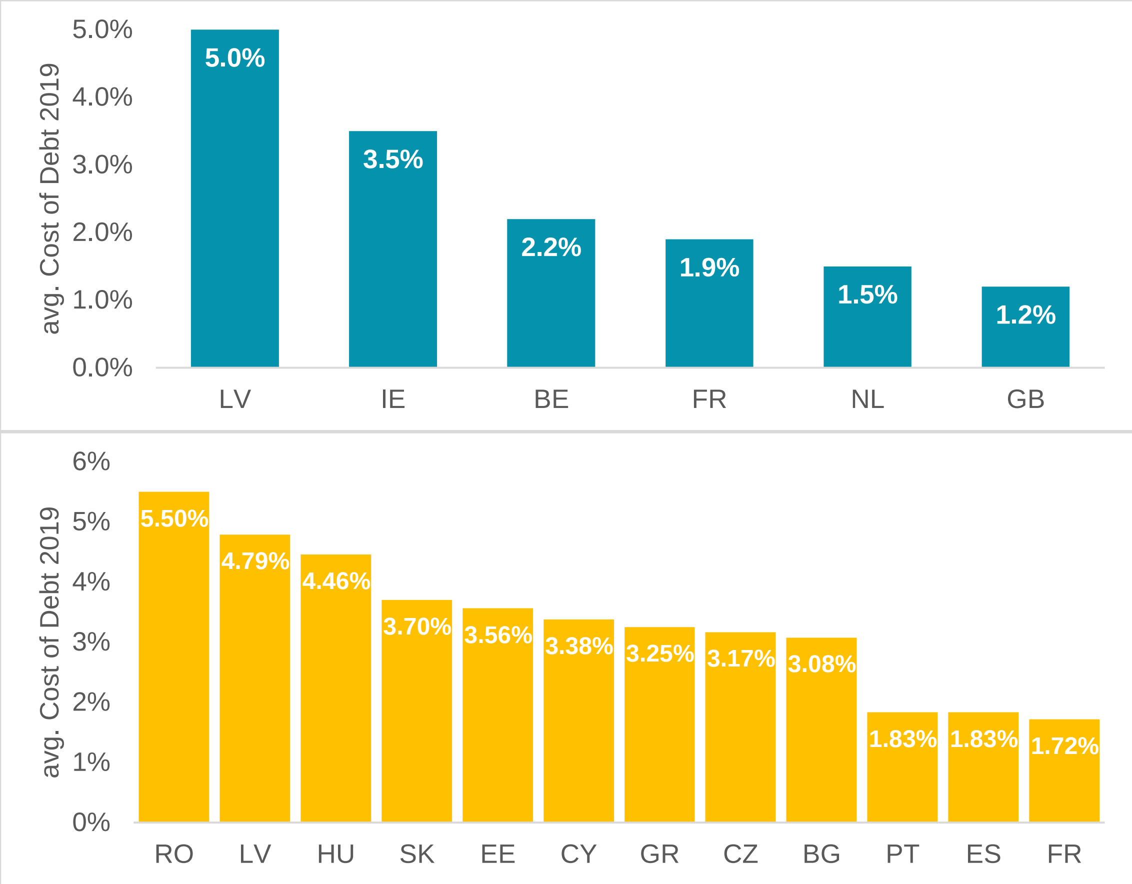


Figure 10. Average Cost of Debt for wind offshore (blue) and solar PV (orange), in 2019.

2.2.2.3 Historic trends and evolution (2014-2019)

Figure 11 presents the historic trend of the CoD for wind onshore between 2014 and 2019. Data from the previous projects DIA Core (Fraunhofer ISI et al., 2014) and RE-Frame (eclareon GmbH & Fraunhofer ISI, 2016) was used. All countries experienced a reduction in the CoD during the period covered. Several countries present a dramatic drop in their CoD, as Spain, Italy, Greece, and Slovenia. Even in Germany, where the CoD was already low in 2014 (1.8% - 3.2%), a downward trend was found (-1.2 pp). The EU average, consequently, also presents a reduction of 3.6 pp between 2014-2019.

Based on the data and insights gathered through the multiple interviews, three main drivers of the CoD downward trend were identified: general interest rates, competition between actors, and international flow of capital. The main conclusions are presented in the following subsections.

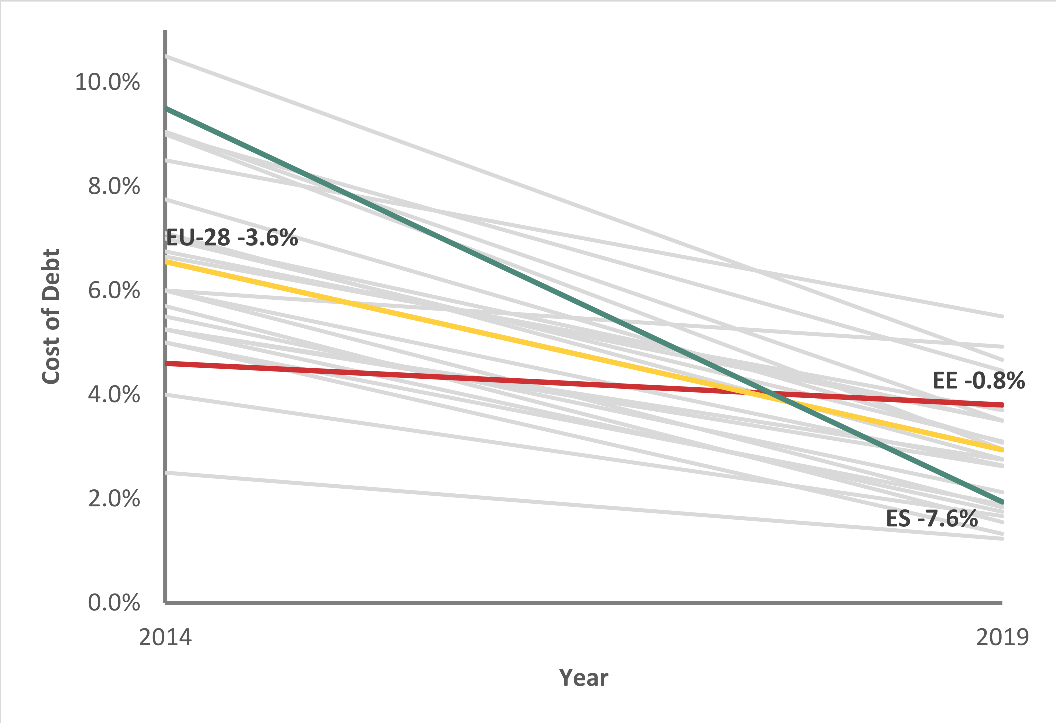


Figure 11. Costs of Debt historic trend (2014-2019) for onshore wind.

2.2.2.4 Interest rates vs. CoD over time. Converging?

Financing a project with borrowed money implies costs, which are strongly and positively corelated to the general interest rates. When the interest rate is on the rise, the cost of borrowing money (CoD) will also increase because the interests owed to lenders is also higher. The contrary case is also the case: when general interest rates decrease, debt financing is also more accessible and cheaper.

The results of the AURES II project confirm the described logic. Figure 12 shows a positive correlation between the average interest rate of 2019 (per country) and the average onshore wind CoD of 2019 (per country). The general trend indicates that the larger the interest rate, the larger the CoD. The interest rate data was retrieved from the Statistical Data Warehouse of the European Central Bank (European Central Bank - Statistical Data Warehouse, 2020). Only countries from the Euro (€) area are included.

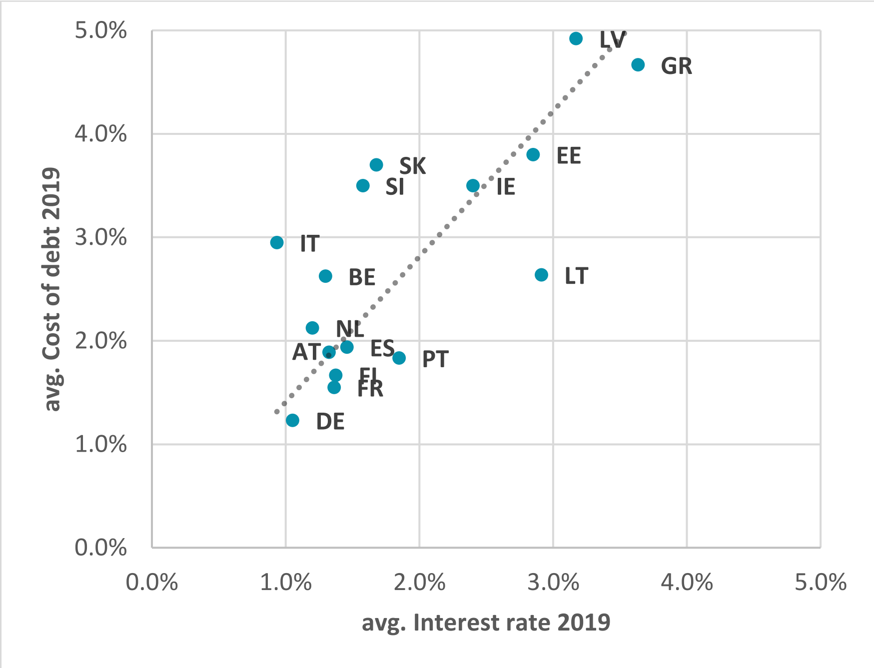


Figure 12. Average interest rates 2019 vs. average onshore wind CoD 2019, per country.

The data collected not only shows correlation between the two variables, but also a tendency to convergence between CoD and interest rates can be observed in Figure 13 below. The CoD has been approaching bank interest rates -i.e., the difference is narrowing-, which could be explained by a more-mature, less-risky RE market, and stronger competition introduced both by auctions and excess liquidity.

In the aftermath of the financial crisis of 2008, the ECB and national central banks in the euro area started to lend unlimited amounts of money to banks, also known as excess liquidity (European Central Bank, 2017). One of the consequences of excess liquidity is that market interest rates have stayed low since 2008. Therefore, market players in the RE industry have benefited from cheaper loans.

As an additional response to the financial crisis and a long-lasting low inflation, the ECB implemented the Asset Purchase Programme (APP), a non-standard measure that aims to bring inflation back to levels below, but close to, 2% over the medium term (European Central Bank, 2019). Through the APP, the ECB have bought different assets, such as corporate and government bonds, which in turn increased the demand for private assets even more. As a result, the effective market interest rate is reduced, encouraging banks to lend more money to companies. Hence, investors in RE projects have also benefited from lower costs when borrowing money (European Central Bank, 2019).

In some cases, as Spain, Greece, and Slovenia, the gap narrowed dramatically. In Figure 13, it can be appreciated that in these three cases, the CoD dropped 6 pp on average, approaching the interest rate value. In Germany, although the gap in 2014 was not considerably large, it has nonetheless closed even more, which confirms the convergence tendency.

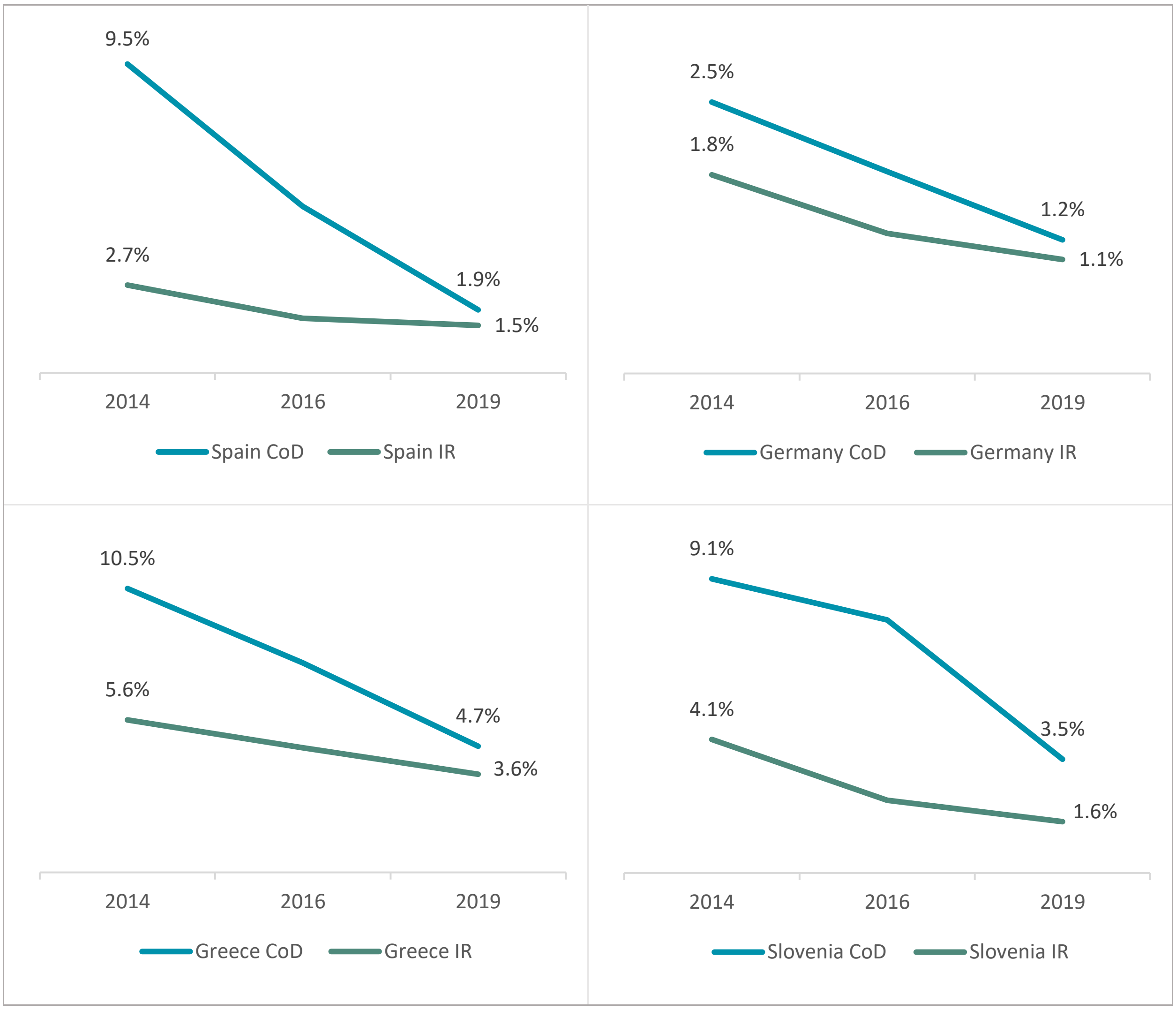


Figure 13. Cost of Debt for onshore wind and Interest Rates evolution in Spain, Germany, Greece, and Slovenia.

2.2.2.5 Competition between actors

Market competition in the RE sector is complex and goes beyond the interesting dynamics of bidders in auction rounds. It is characterized by the interactions between an interesting variety of actors: project developers, manufacturers, power purchasers, operators, subcontractors, land owners, investors, banks, utilities, among others.

Abundance of liquidity was reported in many EU countries, reflecting the non-standard monetary policies that the ECB has been applying since the 2008 financial crisis. Loan fees decreased as a consequence of the pressure of large supply of capital (Egli et al., 2018).

Germany represents an interesting case, where a fierce competition between banks that lend money to RE projects has taken place. In addition to the general excess liquidity, German experts highlighted a lack of RE projects competing in auctions. Thus, as these two causes occur at the same time, the real competition moves from the project developers' sector (participating in auctions for example) to the banking sector, where banks are pressured to reduce loan interest rates to be able to lend money in an already low-demand sector.

Market competition is intertwined with the concept of market concentration, which is understood as "the distribution of a given market among the participating companies" and "reflects both the number of firms within the market/sector (and/or participating in the auction) and the diversity of those firms (i.e. the degree of heterogeneity with respect to the size of those firms)" (del Rio et al., 2020, p. 14). In general terms, low market concentration can foster greater competition, i.e. an unidirectional and negative relationship (del Rio et al., 2020).

However, the relationship between concentration and competition can be understood as bidirectional and dynamic (del Rio et al., 2020). It could happen that after a period under strong competition (e.g. auctions) the market gets more concentrated than before. For example, experts interviewed indicated that the described bidirectional process took place among components manufacturers in Germany. Auctions allowed the participation of diverse manufacturers (low market concentration), however, the low prices of some bidders pushed other manufacturers out of the market. The few prevailing manufacturers (higher market concentration) could then increase prices because competition is lower.

A similar development occurred with wind onshore development sites in Germany, which are considered to be increasingly scarce. Therefore, the market between land owners is getting concentrated and prices, in consequence, have been increasing. In the long term, competition could lead to a higher market concentration and to certain actors increasing prices, which can also hold true for financing and banking institutions.

2.2.2.6 International flow of capital for RE projects

Numerous interviews conducted evidenced that many RE projects received capital from international sources, not only European (as the European Investment Bank), but also from other world regions such as North America and Asia. It could be considered that certain low CoD values reported in EU countries are connected to capital coming from international investors that face lower costs when raising debt to finance their projects. In the map of Figure 14 the arrows indicate the international movements of capital towards national RE projects. As it can be appreciated, the European Investment Bank (EIB) has played an important role in the European flow of capital.

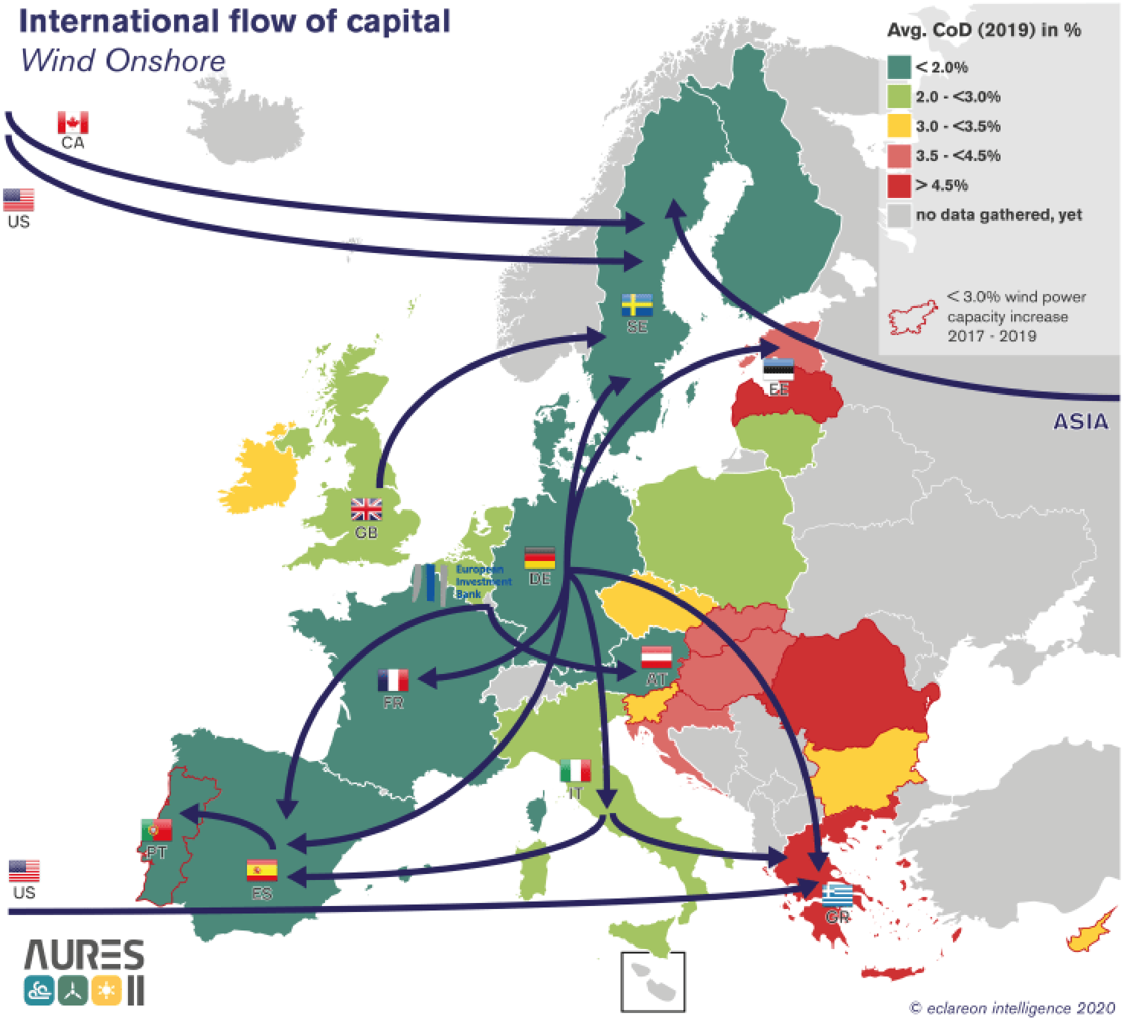


Figure 14. International flow of capital for onshore wind projects.

2.2.3 Cost of Equity Results

2.2.3.1 Wind onshore (2018-2019)

The second component of the WACC is the Cost of Equity (CoE), which reflects the expected return of investors on a specific RE project. The CoE is affected by numerous factors, such as opportunity costs and the risk profile of the project and of the country, among others. Equity's opportunity cost is the hypothetical return the investor would have earned, if she had invested in a different project. The riskier the project, the higher the return investors would ask.

The type of market player also influences the CoE composition. A prominent group of equity investors is constituted by institutional investors, such as pension funds and insurance companies, who can play a key role in long-term renewable energy investments (see Box 1).

Box 1: The role of institutional investors
Why are institutional investors relevant?
The European Union aims to become the first climate-neutral bloc in the world by 2050, which would

require significant investment from both the EU and national public budgets, as well as the private sector. Institutional investors represent one of the largest capital pools worldwide, managing $87 trillion (€73.5 trillion[4]) globally in securities, real property assets, insurance, pension funds and sovereign wealth funds, and are therefore an essential market player in the transition to a decarbonized energy sector. However, about 20% institutional investors have invested in renewables indirectly through funds, while only 1% have invested directly[5].

Who are institutional investors?

Institutional investors comprise insurance companies, private and corporate pension funds, sovereign wealth funds, and charitable foundations. Institutional investors make investments over the long term to meet their defined liabilities, which are realised when, for example, investors need to claim their pension or insurance. To match the maturity of their liabilities and requirements by financial authorities and regulatory bodies, institutional investors need investments that generate a stable, long-term yield. They represent an enormous global capital pool that has yet to be harnessed for the energy transition. Large-scale institutional investments would effectively inject long-term and relatively "patient" capital into renewables, lowering the overall financing costs for any given project. Renewable energy assets, in turn, can give institutional investors stable, long-term, "bond-like" returns.[6]

Institutional investors can be divided into two groups regarding their participation in RE finance: those already aware and with exposure to RE investments and those discovering RE investments and the 'energy transition' as an asset class[7]. Institutional investors with exposure to the sector often regard RE projects as an attractive inflation hedge and are willing to accept lower returns. For example, to finance the construction of the Hornsea One offshore wind project in the U.K.[8], Danish utility Ørsted sold in 2017 a 50% stake in the project to Global Infrastructure Partners[9], and arranged a £400 million (€443 million[10]) package of fixed-rate and inflation-linked bonds from Aviva Investors[11]. This package included investment grade-rated project bonds issued to institutional debt investors, commercial bank loans, and mezzanine debt provided by the Danish pension fund PFA Pension Forsikrings[12].

Institutional investors only discovering the 'energy transition' as an asset class, on the other hand, often focus on investments with a more guaranteed income such as investing in transmission and distribution companies. Some institutional investors invest nonetheless in RE projects. As emissions become more restricted, renewable energy can help to reduce investor exposure to stranded assets. Institutional participation can create a positive feedback loop and help to attract other sources of capital for renewables.

In Figure 15, the map presents the main CoE values that were collected through the interviews. It should be reminded that accessing to WACC values is challenging in general (Steffen, 2019), but more challenging is to access to CoE values. Many interviewees were reluctant to share these values because of confidentiality.

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[4] 1 US Dollar equals 0.84505 Euros as of October 23, 2020. Source: https://www1.oanda.com/lang/de/currency/converter/

[5] IRENA, 2020, "Mobilising institutional capital for renewable energy", https://irena.org/publications/2020/Nov/Mobilising-institutional-capital-for-renewable-energy

[6] IRENA, 2020, "Mobilising institutional capital for renewable energy", https://irena.org/publications/2020/Nov/Mobilising-institutional-capital-for-renewable-energy

[7] Personal communication with RE Finance Expert 1, August 18, 2020.

[8] The Hornsea One project has an installed capacity of 1.2 GW and became fully operation in January 2020. Source: Renewables Now, February 20, 2020, "Ofgem selects preferred bidder for Hornsea One's transmission assets", https://renewablesnow.com/news/ofgem-selects-preferred-bidder-for-hornsea-ones-transmission-assets-688353/

[9] Global Infrastructure Partners (GIP) is an infrastructure fund manager with s $69 billion (€58.3 billion) in assets on behalf of its global investor base

[10] 1 British Pound equals 1.10748 Euros as of October 23, 2020. Source: https://www1.oanda.com/lang/de/currency/converter/

[11] Aviva Investors, 2018, "Aviva Investors finances construction of world's largest offshore wind farm, Hornsea 1", https://www.avivainvestors.com/en-nl/about/company-news/2018/11/aviva-investors-finances-construction-of-hornsea-1/

[12] S&P Global, 2018, "Aviva invests £400M in UK offshore wind farm", https://www.spglobal.com/marketintelligence/en/news-insights/trending/umxo9lyou8wr2oqaa_r1sg2

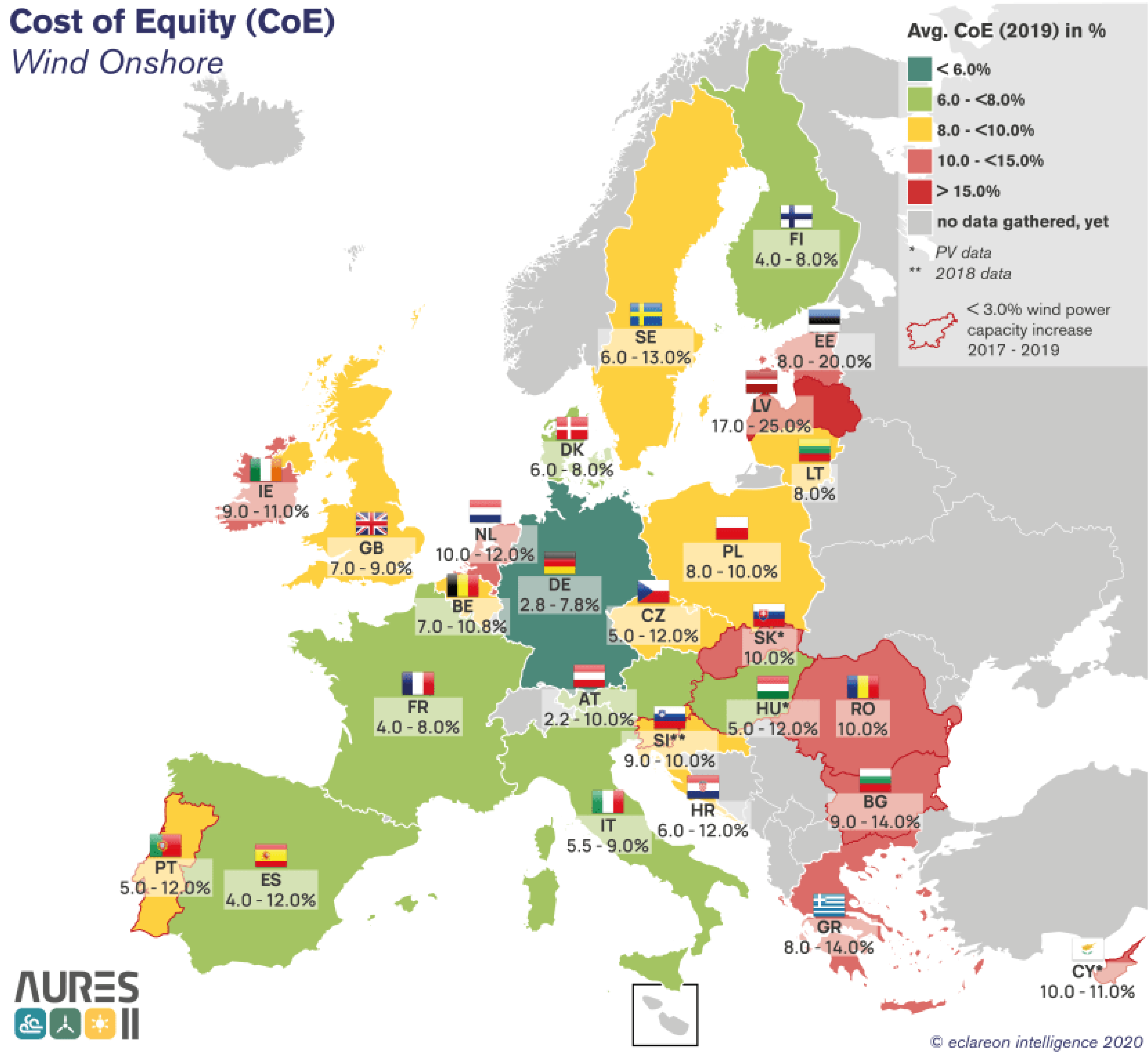


Figure 15. Cost of Equity for onshore wind projects (2019).

Out of the 26 analysed countries, 17 have an average CoE below 10%. The exceptions of high CoE values are regionally grouped: in southeast Europe and especially in the Baltic countries. A rationale behind these high values could be the scarce development of wind onshore projects between 2017-2019, as it is indicated on the map with red border lines, which could be a sign of less RE experience and higher risks. Another explanation is that these countries also present relative higher country risks than western Europe. Higher risk perceptions can lead investors to ask for higher returns, hence, a higher CoE.

The **emergence of new market players** in the renewable energy sector was also mentioned in the discussions with interviewees. Some of these new stakeholders are investors from other industries, such as energy utilities, but also non-energy industries such as IT or heavy industry, which are interested in having a greener profile and portfolio, and are therefore motivated not (only) by traditional businesses reasons. During the interviews, an expert even commented “If it is green, we buy it.”

The shift towards greener investments has multiple reasons, but there are three regulatory rationales that are worth mentioning. First, it was reported that the use of ESG factors (Environmental, Social, Governance) by Credit Rating Agencies adds more pressure on investors, since business positions could be damaged if Rating Agencies consider that the exposure to climate change risks are high for example.

Second, and in a similar direction, the Financial Stability Board established the Task Force on Climate-related

Financial Disclosures (TCFD) with the main goal of providing transparent information to stakeholders and investors on how the companies are managing climate related risks. This will promote not only better-informed investment, but also financial decisions consistent with the at least two-degree Paris Agreement objective (Financial Stability Board, 2020).

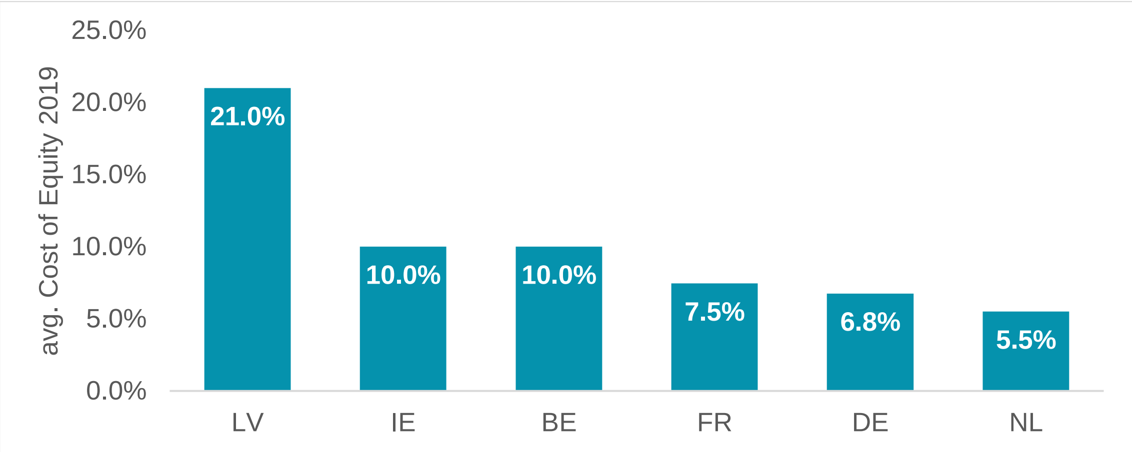
Third, clean investments are gaining momentum among numerous companies as a result of international political forces. On the one side, the Paris Agreement has experienced a *renaissance* since US President-elect Joe Biden re-joined the global deal in early 2021. Besides, there is a particular provision of the climate accord that deserves special attention if the energy transition is to take place. The provision Article 2.1c aims to redirect finance flows into a consistent pathway towards a low-carbon development to fight climate change (*Paris Agreement*, 2015, Article 2.1c). On the other side, the European Union decided that 30% of the COVID 19 recovery plan will be allocated to climate measures (European Council, 2020). The recovery package must be understood in the broader framework of the announced EU climate neutrality by 2050 which will undoubtedly require massive RE deployment. Although the EU did the first move towards climate neutrality, other international competitors have already pledged to reach climate neutrality within this century: Japan by 2050, China by 2060 and President-elect Joe Biden promised it by 2050 as well.

Overall, capital markets are considering climate risks as never before, which creates a higher interest -and competition- in low carbon strategies.

Besides, and also on a global scale, large corporations as Facebook, Google, or Ikea, have entered the RE sector pursuing goals beyond securing energy supply through a stable PPA, for instance, to comply with sustainability and green goals (Murley, 2019). Although these large corporations would participate as off-takers rather than as bidders in tender schemes, their integration in the competition structures of RE sector can have huge impacts that are still to be analysed.

2.2.3.2 Offshore wind and solar PV (2018-2019)

In Figure 16 the bar plots present the average CoE of 2019 for offshore wind (blue bars) and solar PV (orange bars).



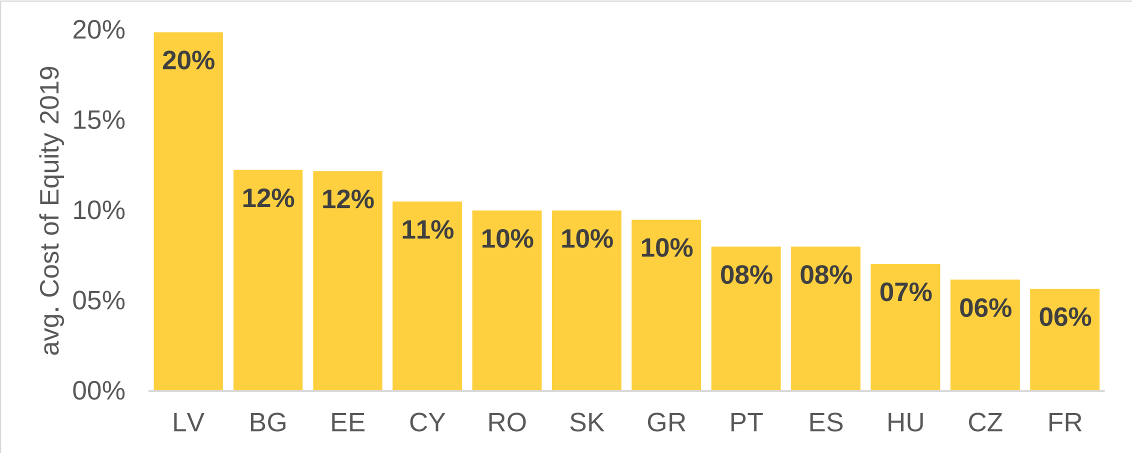


Figure 16. Average Cost of Equity values for wind offshore (blue bars) and solar PV (orange bars) for 2019.

2.2.3.3 Historic trends and evolution (2014-2019)

The evolution of the Cost of Equity between 2014-2019 can be observed in Figure 17 (data based on the previous projects DIA Core [Fraunhofer ISI et al., 2014] and RE-Frame [eclareon GmbH & Fraunhofer ISI, 2016]). Remarkably, all countries except Latvia present a reduction on their CoE during the period considered.

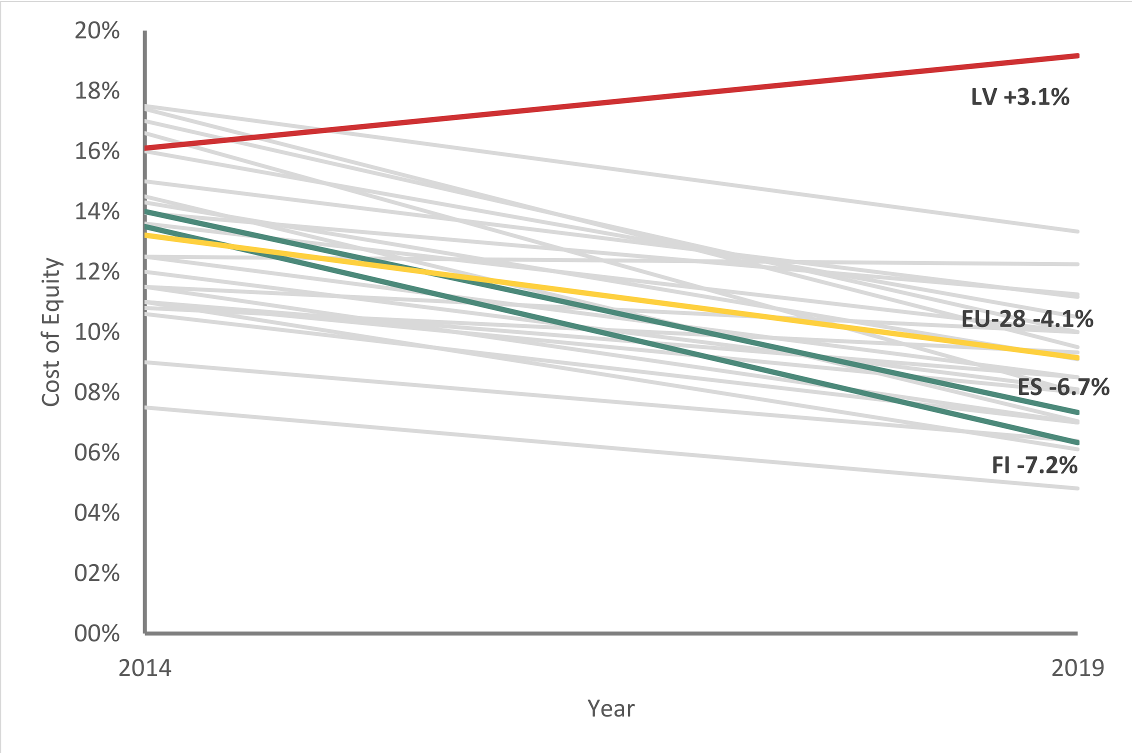


Figure 17. Costs of Equity historic trend (2014-2019).

Interviewees pointed out that public subsidies for RE projects in Latvia have been exposed to certain changes and interferences, which have raised doubts and concerns about their reliability and consistency. In the RES LEGAL EUROPE project (eclareon GmbH et al., 2019) it was indicated that the Feed-in-Tariff support scheme was surrounded by "concerns about corruption and a lack of transparency in the way it was carried out since 2007". This lack of trust, in addition to the scarce wind onshore development in the period 2017-2019, could explain the increase in the return that investors expect in Latvia.

Among the countries where the CoE decreased, Spain and Finland are interesting examples. In the first case, several interviewees agreed that the new Spanish Government has been adopting solid energy and climate policies that have recovered the trust in the RE sector, which had previously been lost due to legal retroactive changes in support levels. A combination of enhanced trust and more competition (auctions) allowed for lower return among equity investors.

In Finland, it was reported that many RE projects are owned by public entities (e.g., Municipalities), which leads not only to low loan interest rates, but also to lower return expectation levels on the equity side. In addition, numerous projects in Finland received no public support, i.e., are conducted though PPA or even merchant, which makes investors accept lower profit margins.

2.2.4 Debt to Equity Ratio Results

2.2.4.1 Wind onshore (2018-2019)

The debt to equity ratio is an indicator of the capital structure that indicates from which source an in which shares the money for investment has been obtained from (Dukan et al., 2019). It is assumed that a higher debt proportion in the capital structure can lead to a lower cost of capital. The reason is that debt is less costly than equity, and there are, for instance, tax exemptions for interests paid to banks.

The map in Figure 18 shows the debt to equity ratios of 2019 in the studied countries for onshore wind.

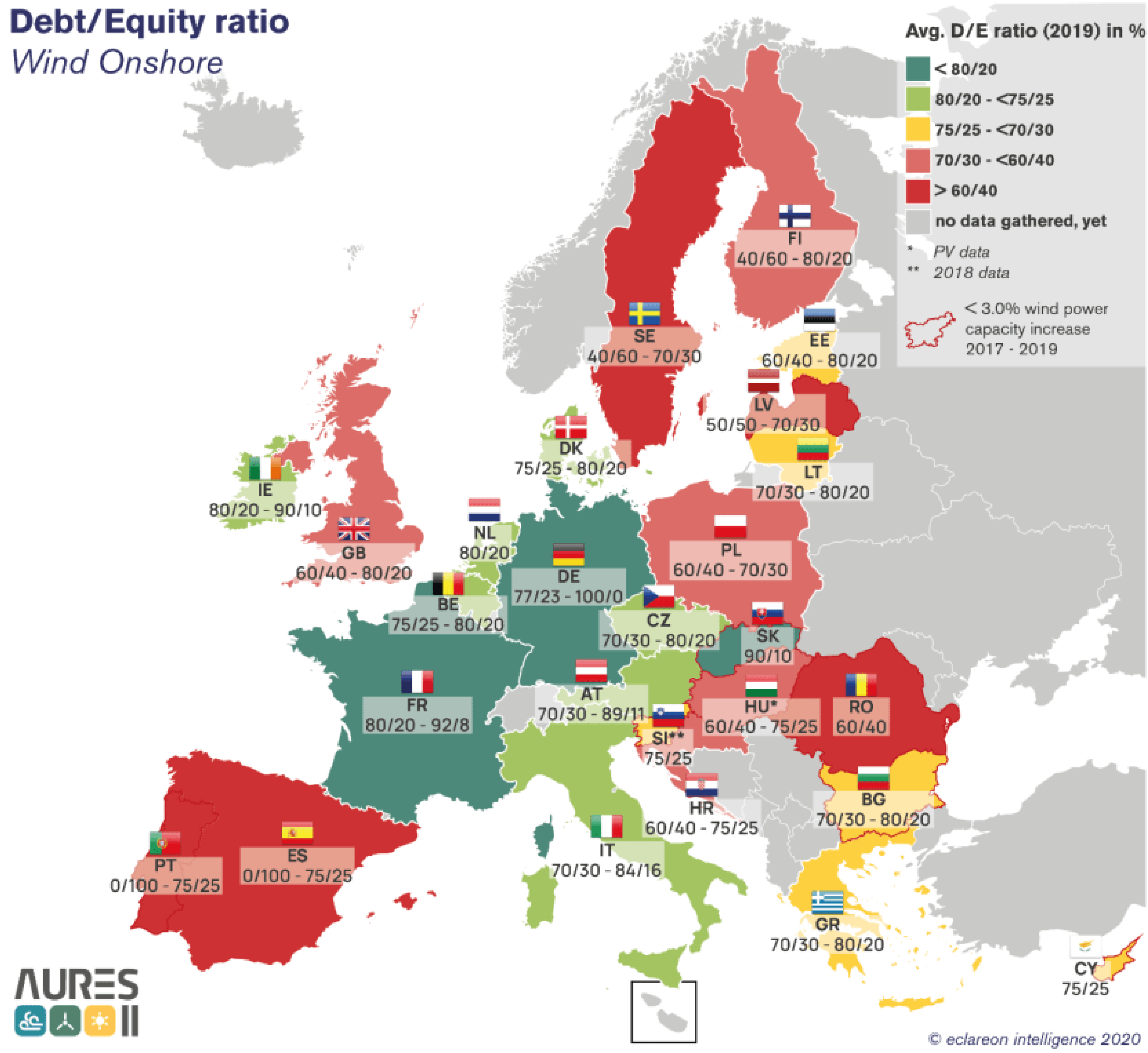


Figure 18. Debt to equity ratio 2019 for onshore wind projects.

A wide gap between European markets can be observed in the map. On the one side, countries as Germany or France have high shares of debt above 80%, whereas on the other side, countries as Latvia and Romania have a lower debt composition of about 50-60%.

The capacity to leverage debt depends on multiple factors, such as the type of market actor (small player, big utility, pension fund, etc.), the country risk, the interest rate, the duration of support scheme (if any), the duration and level of the PPA (if any), if it is project based or balance sheet financing, among others.

Hence, not only between countries, but even within the same country, the results can show very different capital structure compositions. For instance, in Latvia the debt to equity split will depend on performance risk of the general contractor (in case of green-field projects), or on the strength of the off-take arrangements (off-taker, type of off-take – fixed/floating price, its tenor, among others). As a result, in riskier projects equity is expected to represent around 50% of the capital structure, whereas in less risky projects around 30% of it.

In Spain and Portugal, although projects are structured around 75/25, it was also reported that some projects are financed with 100% equity. These fully equity projects were linked to corporate finance structures. During the interviews, it was reported that some market players have abundant capital to invest, and lacking better investment options, they decide to go fully equity in RE projects.

The stability and solidity of support schemes as well as the duration and legal security of PPAs, are key to secure a higher debt to equity ratio and lower overall costs of capital. As stated by May & Neuhoff (2017, p.11) "with such long-term contracts and low variability of project revenues, lenders' revenue requirements lie lower, i.e. the project's financing costs".

If RE projects are exposed to market prices, and these prices are low, the capacity to leverage debt is reduced. Sweden represents an example of this logic, where the debt to equity ratio can reach a low 40/60, and its electricity market price and green certificate price have been low. The higher 70/30 ratio is associated to projects that secured a PPA with more stable prices, and hence, were able to leverage more debt.

In Annex I, the figures of Debt to Equity Ratio for wind offshore and solar PV can be found (Figures 34 & 35).

2.2.4.2 Historic trends and evolution (2014-2019)

In the map of Figure 19, the development of the debt to equity ratio for the period 2014-2019 is presented, based on the previous results of DIA Core and RE-Frame projects (eclareon GmbH & Fraunhofer ISI, 2016; Fraunhofer ISI et al., 2014). A general trend cannot be identified: while in some countries the debt share increased, in some others it was the equity share that did so.

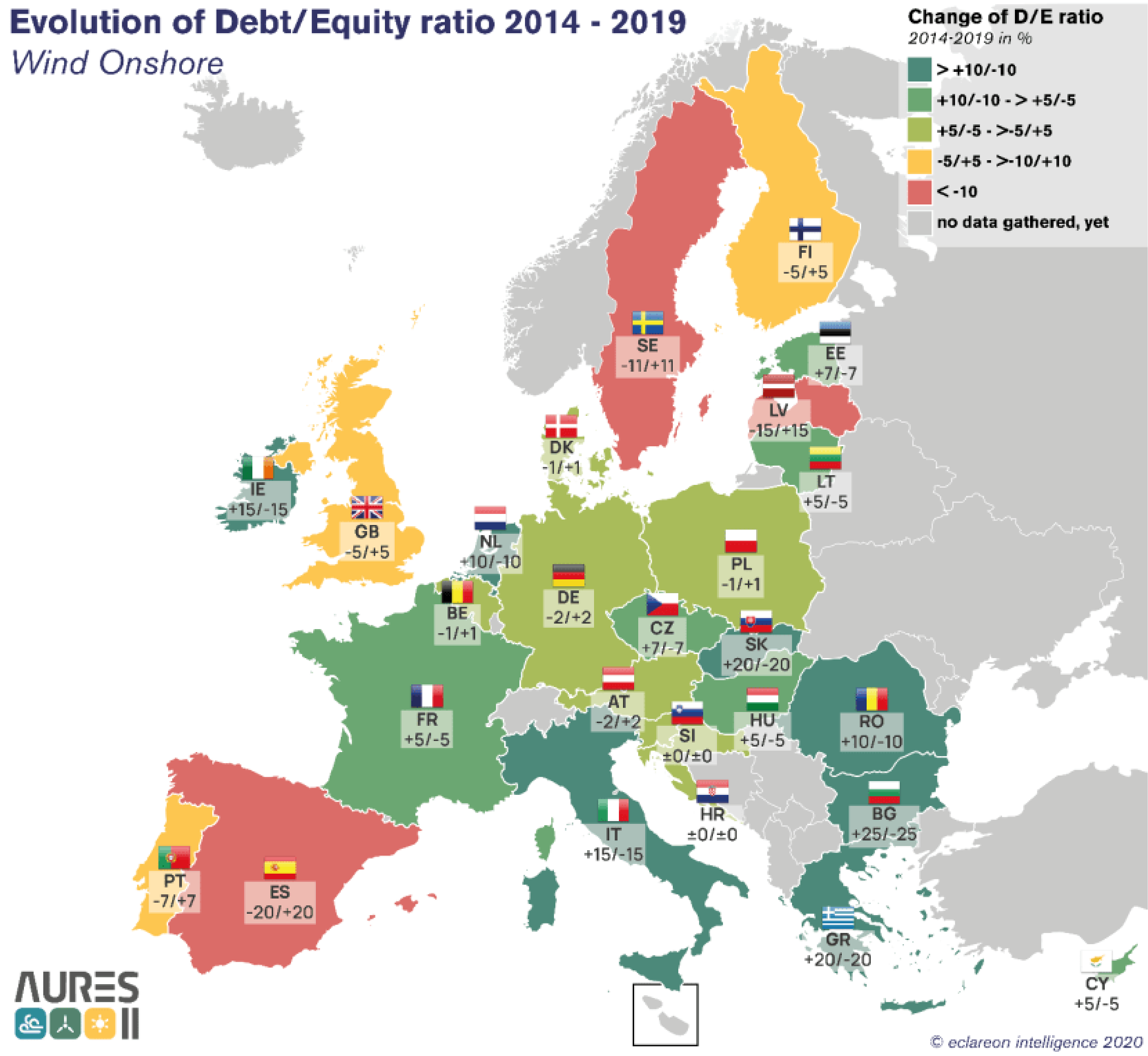


Figure 19. Overview on debt to equity ratio evolution for onshore wind power 2014-2019.

Certain markets are more stable when it comes to capital structures for project financing, such as Germany, France, United Kingdom, Belgium, Denmark, and Finland, whose debt to equity ratio has hardly changed. Some other markets, as Hungary, Slovenia, Lithuania, and Cyprus, also present little change in the debt to equity ratio variable, however, they present at the same time a low deployment of wind power, fact that can explain the *status quo*.

On a different path, countries like Italy, Greece, Ireland, Czech Republic, Estonia, and the Netherlands, experienced a more pronounced shift to larger debt shares. Most in this group present also a significant wind power development, which in addition to the better finance conditions such as lower interest rates, may explain the increased capacity to leverage debt.

2.2.5 Loan Tenor Results

2.2.5.1 Wind onshore (2018-2019)

Loan tenor or loan maturity period, is the duration of time in which the loan is expected to reach maturity or become fully repaid (Dukan et al., 2019). When granting a loan, banks will decide the loan tenor mainly based on their risk perception of the particular RE project. The riskier the project, the shorter the loan tenor, because banks will try to be exposed to risks for a shorter period of time.

Besides, the existence and features of support schemes is a key element for the risk perception of banks. When a RE project will benefit from a long support scheme, the bank can gain more confidence on the repayment capacity (through a more stable cashflow) and will eventually extend the loan maturity. Longer and stable PPAs can lead to a similar situation with longer loan tenors. On the contrary, in countries where RE projects are being gradually exposed to market prices, shorter loan tenors are observed (Egli et al., 2018).

Moreover, Germany has the longest loan tenor, up to 22 years, which is a reflection of stable business cases and low country risks. The expectation that wind power projects can create profits to pay back its debt after the end of the support scheme together with the intense competition between banks to provide loans also contribute to the long loan maturity in the German market.

In Figure 20 the different loan tenor values for the EU MS can be observed.

In Annex I, the Loan Tenor figures for wind offshore and solar PV can be found (Figures 37 & 38).

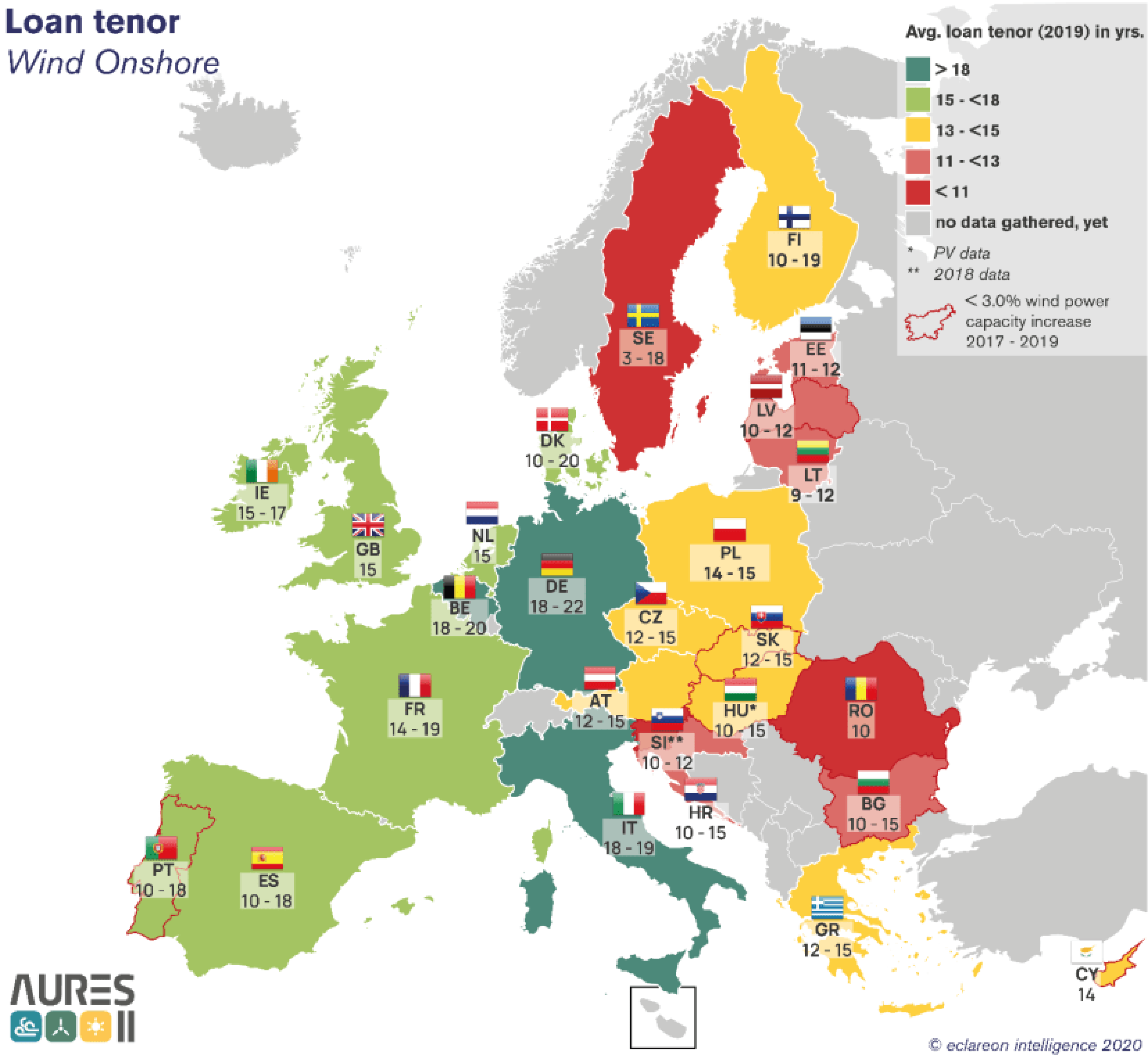


Figure 20. Loan tenor for wind onshore projects (2019).

2.2.6 DSCR Results

2.2.6.1 Wind onshore

The Debt Service Coverage Ratio (DSCR) is a requirement applied by banks to assess and measure the ability of a project to repay its debt obligation, which includes the principal repayment and the interests (Dukan et al., 2019). The applied formula equals to the cash flow available for debt service, over the instalment (principal + interest).

To be bankable, the DSCR of a project needs to be at least 1 (DSCR ≥ 1), meaning that the project will have, in every repayment period, more or just enough cash than what it needs to pay in instalments for its loan (Dukan et al., 2019). For example, if the DSCR that the Bank applies is 1.2, the Bank will only finance the RE project if its expected cash flows available for debt service are at least 20% higher than the project´s debt service obligation (during the loan tenor period) (Dukan et al., 2019).

Similar to the loan tenor, the DSCR is related to the project risk, hence, a low DSCR can be read as a lower project risk (Egli et al., 2018). The DSCR is also dependent on the production scenario estimations. Banks will generally follow a more cautious and conservative production estimate, for example P-50, whereas project developers will consider a P-90 scenario. All other conditions equal, in a P-90 scenario the DSCR is significantly lower than in P-50 scenarios.

Figure 21 presents a map with the DSCR values for 2019. Overall, markets with low country risks and low costs of capital, as Germany, France, Sweden, Denmark, United Kingdom, Belgium, and the Netherlands present the lowest DSCR values.

In countries as Denmark, Spain, and Portugal, a certain spread can be observed between minimum and maximum DSCR value, which could be driven by a gradually exposure to market prices (and risks) of different business models. In general, more exposure to market dynamics is then reflected in higher DSCR values and, at the same time, in shorter loan tenors (Egli et al., 2018).

In Annex I, the DSCR figures for wind offshore and PV can be found (Figures 39 & 40).

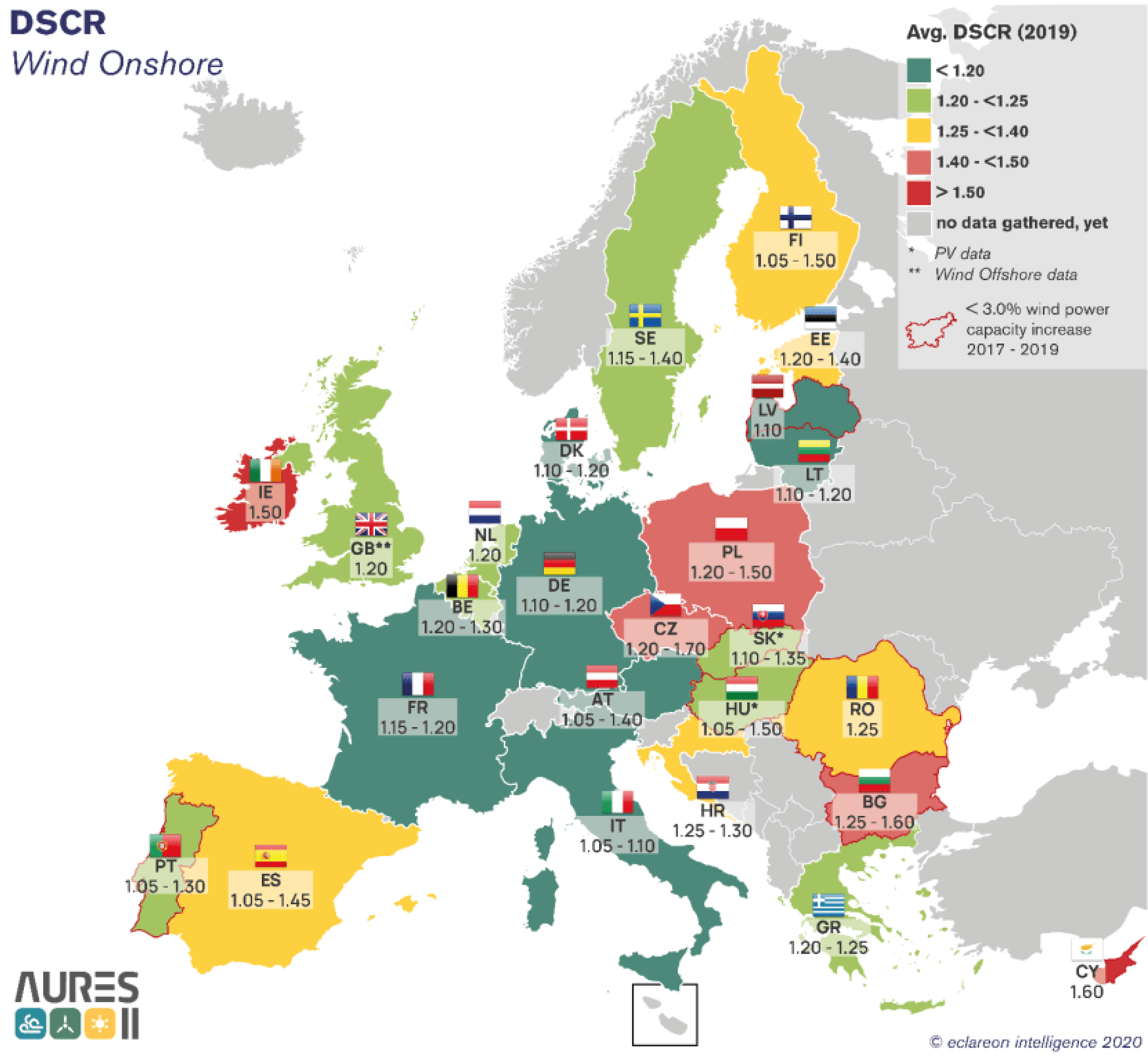


Figure 21. DSCR for wind onshore projects (2019).

2.3 RE project financing in the Time of Corona

The world has confronted different financial crises and cycles before the Covid-19 pandemic. The financial crisis of 2008 constitutes a clear example. After that crisis, along with the non-standard monetary policies adopted by the ECB, interest rates have remained very low. As a consequence, a "new cycle" started, where the cost of debt for RE financing and WACC have been lowering down in Europe, as the results presented show.

Before the pandemic started European markets exhibited a positive and beneficial environment for RE project financing, characterized by low loan interest rates, decreasing WACC, sustained economic growth in some countries, and more ambitious climate policy goals. Banks were more prone to take higher risks, for example, financing RE projects exposed to market prices (without support schemes or "fully merchant") and extending loan maturity. Some institutional investors were also taking part in RE projects facing merchant risk through corporate PPAs that make the investments more viable.

However, as Schiller (2019) pointed out, taking those risks can be very problematic for banks because "if interest rates suddenly increased, they might have to pay more to keep depositors than they earn from the longer-maturity investments, which could cause the banks serious trouble". Even before the pandemic, some negative effects of RE bank policy were already reported in the literature, as Egli et al. claimed that "extensive bank lending tended to lead to overconfident credit issuance, thereby increasing default rates." (2018, p. 3). Nevertheless, there is a lack of clarity regarding the future development of interest rates, therefore, no solid conclusions can be drawn yet.

While the world is focused on fighting back the novel coronavirus, organizing the vaccines distribution, and rebuilding the post-pandemic economy, many questions remain yet unsolved.

On the one hand, some interviewees reported uncertainty regarding the future of existent support schemes and policies. In the past, amid economic crisis, certain EU governments adopted retroactive changes that damaged market trust (Wigand et al., 2020). At the same time the pandemic puts pressure on public budgets, those same fears can be rekindled.

On the other hand, wholesale electricity market prices have fallen as a consequence of lower demand (strict lockdowns across the globe). Whether and when prices will return to pre-pandemic levels is still an open question. In the meanwhile, an interviewed expert pointed out that some RE projects could suffer because their LCOE would now be higher than their market value (due to lower market prices), meaning that their profitability could be compromised. The interviewed expert pointed out that these projects could be later acquired by other market players requiring lower returns, such as big utilities or even by institutional investors, that usually prefer to invest in operating assets, where risks are less pronounced (see Box 2).

Besides, it is expected that banks will reinforce their risk averse attitudes in the near future and tighten the lending criteria. This could impact the debt to equity ratio since -as an interviewed expert explained- some projects will not be able to leverage as much debt as they did before the Covid-19 pandemic. In particular, some institutional investors have paused their investments in the short term, whereas others with more flexibility are investing more aggressively (see Box 2).

Even though governments are currently concentrating most of their efforts into overcoming the pandemic, the EU community is also calling for an increased investment in clean energy for a resilient future. The Green New Deal is set to play a decisive role in the so-needed recovery, after the Covid-19 pandemic starts to fade away.

Box 2: Investment behaviour of institutional investors
Investment behaviour in recent years (before the COVID-19 pandemic)
<u>A growing number of institutional investors is looking to scale up their support for RE projects</u>, either by investing directly in such projects or indirectly by committing financing to funds that take stakes in or buy collaterised bonds (green bonds) from those projects at the capital market. Increased efforts to allocate capital to sustainable strategies and competition among investors across the wider real estate and

infrastructure asset class continue to attract investment in the RE sector[13]*. In 2019, Norway's parliament instructed its $1 trillion (€845 billion) sovereign wealth fund, the Government Pension Fund, to invest up to $20 billion (€16.9 billion) of its assets in RE projects and companies. Similarly, Denmark's Pensionskassernes Administration (PKA) announced in 2018 it will increase its investments in renewable energy to 10% of its total assets by 2020*[14]*.*

<u>Institutional investors maintain a preference for operating assets, which help them avoid risks associated with the structuring and construction stages</u>[15]*. According to interviewed industry experts, institutional investors typically buy RE assets at the lowest point of risk, that is after projects are commissioned. New asset financing accounted for 41% of the €65 billion spent across Europe's wind industry in 2017. The remainder went toward project acquisitions, project refinancing, company acquisitions and capital markets activity*[16]*.*

<u>With competition to invest in operational assets, equity investors, including institutional investors, have an incentive to broaden the focus to construction and development assets</u>. In Germany, for example, the increased competition for new onshore projects among banks (since developers face difficulties obtaining a building permit for the auctions) and equity investors (as oil and gas companies such as BP or Total), further reduce the pipeline of RE projects.

<u>Partnerships with utilities in the power and oil & gas sectors help lower 'construction risk' for institutional investors</u>. While there are not many institutional investors involved in the relatively higher-risk development stage of RE assets[17]*, partnering with utilities has been motivated by a desire to secure access to a RE project pipeline*[18]*. Danish pension fund PKA invests only once a project has been awarded in an auction, and ensure the construction risk is under the utility since they have the expertise. PKA has roughly $2 billion to $3 billion (€1.7 to €2.5 billion) in various direct RE investments, and intends to grow this part of its portfolio alongside local and European utilities and other institutional investors*[19]*.*

- *UK: in 2017, Danish pension funds PKA and PFA bought a 50% stake in the 659-MW Walney Extension offshore wind project in the UK from Danish utility Ørsted. The project was commissioned in 2018.*
- *Germany: in 2014, Danish pension funds PKA and PFA bought a 50% stake in the 252-MW Gode Wind 2 offshore wind project in Germany from Danish utility Ørsted for €600 million. The project was commissioned in 2016*[20]*. Ørsted was to provide operation and maintenance services and ensure a route to market for the power production of the project*[21]*.*

<u>Corporate PPAs can help with merchant risk, but the effectiveness for institutional investors depends on the corporate counterparty (off-taker)</u>. Corporate PPAs can increase the financial viability of awarded projects, especially zero-subsidy projects, as they provide an alternative source of revenue to the project. Institutional investors often rate corporate counterparties lower than a country. However, whether a new project can attract institutional investors depends to a large extent on the off-taker or corporate

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13 JLL, 2019, "Why major institutional capital is moving into renewable energy", https://www.theinvestor.jll/news/emea/alternatives/why-major-institutional-capital-is-moving-into-renewable-energy/

14 Clean TechIQ, 2019, "Institutional Investors Boost their Holdings in Renewable Energy Investments", http://cleantechiq.com/2019/08/institutional-investors-boost-their-holdings-in-renewable-energy-investments/

15 IRENA, 2020, "Renewable energy finance: Institutional Capital", https://www.irena.org/newsroom/articles/2020/Aug/Institutional-Capital-Closing-the-Energy-Transformation-Investment-Gap

16 Greentech Media, 2019, "Institutional Investors Fuel M&A Frenzy in Europe's Wind Market", https://www.greentechmedia.com/articles/read/institutional-investors-fuel-ma-frenzy-in-europes-wind-market

17 IPE Real Assets, 2019, "Energy transition: Transition management", https://realassets.ipe.com/sustainability/energy-transition-transition-management/10029193.article

18 Personal communication with RE finance expert 1, August 18, 2020. Personal communication with RE finance expert 2, August 12, 2020.

19 Top 1000 Funds, 2018, "Denmark's PKA goes for wind farms", https://www.top1000funds.com/2018/04/denmarks-pka-goes-for-wind-farms/

20 Renewables Now, 2016, "Dong's Gode Wind 2 offshore wind farm in Germany generates 1st power", https://renewablesnow.com/news/dongs-gode-wind-2-offshore-wind-farm-in-germany-generates-1st-power-513672/

21 Globe Newswire, 2014 "DONG Energy divests 50 per cent of the German offshore wind farm project Gode Wind 2 to a consortium of Danish pension funds", https://www.globenewswire.com/news-release/2014/07/17/651459/0/en/DONG-Energy-divests-50-per-cent-of-the-German-offshore-wind-farm-project-Gode-Wind-2-to-a-consortium-of-Danish-pension-funds.html

counterparty. For example, if the off-taker is the German railway company Deutsche Bahn, a semi-public entity, a deal is still likely to go through with an institutional investor. Other companies might not offer the same level of comfort since there is no guarantee for the off-taker if it goes bankrupt (i.e., parent companies do no guarantee the off-take obligation of their subsidiaries).

Investment behaviour after the COVID-19 pandemic

The full scale and duration of the impact from the COVID-19 pandemic remains unclear and will depend on both its future spread, as well as the global policy response. In the short term, there is uncertainty about the correct valuation of RE assets. Uncertainties on power prices, challenges in construction and due diligence, and debt markets[22] *are key factors making a correct valuation more challenging in the short term. Lower power prices put downward pressure on asset prices, while disruptions in the supply chain might lead to some construction interruptions. Due diligence is made harder since visits to some sites are not possible or with important limitations due to the lockdown restrictions.*

According to an interviewed industry expert, this uncertainty in asset valuation has resulted in some investors hitting 'pause' on deals in the short term, while others investing more aggressively[23]*. The debt market has cooled down, which opens opportunities for investors with the flexibility to buy now and add in financing later. Other investors have instead paused deals. For example, an institutional investor considered investing in a new 1.2-GW solar PV portfolio to be built in phases in Spain through a £1.2 (€1.3) billion fund. Initially, a corporate off-taker agreed to purchase electricity at £40/MWh (€44.3/MWh), but after COVID-19 lowered its offer to maximum £12/MWh (€13.3/MWh). This prompted the bank and the institutional investor to pull out of the investment. Similarly, finance facilities in Italy and France worth £100 - £150 million each (€111 - €166 million) have fallen through after banks and institutional investors have paused their planned investments on them.*

The response of many funds has been to emphasise their long-term stance. Polhem Infra, the joint venture owned by three of Sweden's main national pension buffer funds, is targeting SEK9bn (€870m) of investments in sustainable infrastructure in the next four years[24].

2.4 Conclusions

The WACC data collected through the interviews presents multiple interesting results. Some of them were to be expected, some were somewhat surprising.

Not very surprisingly, the trends between EU Member States have not changed a lot during the past years. As of 2019, the WACC for renewable energy projects varies within the EU, which represents a gap between the Member States. Germany, for instance, still has the lowest onshore wind WACC in the EU (1.3 - 2.5%), whereas other countries have much higher WACC, such as Latvia (9.1%) or Greece (5.0 - 7.6%) (Figure 2). Compared to values of 2014, the vast majority of Member States reduced their WACC quite dramatically. Even more, the gap observed in 2019 is narrower than the gap of 2014.

Multiple reasons explain the downward trend observed in the EU. As expected, the reduction of risks that investors face (as country risk or policy risks) is a key element shaping the WACC of RE investors. Less-risky projects allow to raise cheaper debt and also to lower return requirements. Besides, the development of interest rates in the Euro zone plays a huge role in the WACC values. As presented in Figures 12 & 13, the interest rates are positively correlated with the Cost of Debt, and examples as Spain and Greece show how the CoD is approaching the interest rate level, which confirms findings from earlier studies.

More surprising however, were other reasons pointed out as being probable triggers of Cost of Debt and Cost

[22] Octopus Group, 2020, How will COVID-19 impact the renewable energy industry?, https://institutional.octopusgroup.com/resources/how-will-covid-19-impact-the-renewable-energy-industry/

[23] Personal communication with RE finance expert 1, August 18, 2020.

[24] IPE Real Assets, 2020, "Swedish pension fund JV to invest €870m in green infrastructure in four years", https://realassets.ipe.com/news/swedish-pension-fund-jv-to-invest-870m-in-green-infrastructure-in-four-years/10047370.article

of Equity reductions, specially international flow of capital, increased competition and the emergence of new market players.

As presented in the map of Figure 14, many RE projects in the EU are receiving financing from international (and also European) sources, for example capital from North America and Asia. The investment of relatively cheaper international Capital in countries with high CoD, could generate spill over effects lowering the WACC of RE projects.

Competition between certain actors could also push CoD down. As a result of the monetary policies that the ECB has been applying, there is abundance of liquidity in many EU countries, leading to a competition in the search of bankable projects. The ramifications of and the interdependencies between different market actors, which drive this change could be only partially covered in this study and will be further assessed in later studies.

Regarding the decrease observed in the CoE, it was reported that new market players (such as energy utilities, but also non-energy industries such as IT or heavy industry) are shifting towards RE projects to green their portfolios. Regulatory pressures (as the Task Force on Climate-Related Financial Disclosures) and the international climate agenda (Paris Agreement and Green Deal) could be one of the motivations of these new market players in the RE sector. This newly observed development can have a lasting impact on declining cost of capital.

The strong and positive renewable energy momentum that was consolidated is being tested by the impacts of the – very surprising – covid-19 pandemic. Before the pandemic, all EU Member States had already drafted their National Energy and Climate Plans with ambitious RE targets by 2030, however, with the pandemic still ongoing, the RES-E sector faces more risks and important variables such as market prices are still an uncertainty.

The EU Covid-19 Recovery Package represents though a huge opportunity to reshape the economy and keep the RE momentum going.

3 Econometric Data Analysis

Mitigating climate change entails a transformation of the energy system towards a low or zero carbon system. The deployment of renewable energies is one major pillar of this energy transition that should occur at least cost. A common measure for costs is the levelized cost of energy or electricity (LCOE) which is composed of investment and operational expenditures and the expected yield. Besides the natural conditions and the initial investments, the weighted average cost of capital and debt (WACC) as a proxy for the discount rate can have a tremendous impact on the LCOE (Donovan and Corbishley, 2016). Recent studies show the impact of the WACC on the LCOE is more pronounced than for the natural conditions (Ondraczek et al., 2015; Weaver, 2012). In literature, many papers have discussed risks as main drivers of the WACC. In the context of energy policies, several authors (Angelopoulos et al., 2016; Boie et al., 2016; Egli, 2020; Giebel and Breitschopf, 2011; Polzin et al., 2015) have identified risks related to policies, markets, resources and technologies. Beyond energy policy, financing costs are theoretically assessed on the basis of a few components (return, asset value in comparison to portfolio value) such as the components of the capital asset pricing model. In contrast to this model, the multi-factor risk model holds that financing costs are driven by multiple factors at different levels (Donovan and Corbishley, 2016), i.e. generic macro-economic factors often summarised by the term country risks (Damodaran, 2016; Pap and Homolya, 2017) as well as asset-or project specific factors such as liquidity reflected in management risk and operation risks (Criscuolo and Menon, 2015), and counterpart risk. Even so many studies have been conducted that analyses the relationship between the WACC and energy and climate policies and projects risks, none is known that includes factors at the macro-economic level as well.

This approach investigates the impact of auctions and other renewable energy policies on the WACC by taking into account diverse country-related risks such as economic, sovereign and political risks.

3.1 Research question and approach

The main motivation of this research is the question whether, and if yes, how the introduction of auctions has affected the WACC of large photovoltaic, wind onshore and offshore projects. As the WACC is a composition of different components, i.e. mainly cost of debt (CoD) and equity (CoE), several factors could drive the WACC. Based on literature review (Angelopoulos et al., 2016; Bouchet et al., 2003; Criscuolo and Menon, 2015; Gatzert and Kosub, 2017, 2016) a first set of variables explaining the WACC, the CoE and CoD has been identified. It comprised risks of different sources and levels:

- at the macro level - economic, political, financial, social risks-,
- at the project level - technology, resource, price and revenue risks -, and
- at the sector or meso level aspects such as experiences with renewable projects, auctions and their design, reliability and credibility of renewable energy policies, capital market structure.

In a second round when running the model, the number of explaining variables was reduced to increase the power of the model.

Macro-level

Political risk emphasizes in this study the regulatory and governance aspects at the political level and stands for the risk exposure due to the political system and government quality in place. It is often concluded under the term country risk, which is decomposed in this study in political and economic risks (Damodaran, 2016). In order to control for the quality of governance, a *Governance Quality* index was built using the following Worldwide Governance Indicators for 2018 from the World Bank (The World Bank 2019[25]).

Economic risk is considered as part of the country risk (Damodaran, 2016) and can be differentiated into a macro and micro perspective. The macro-perspective includes risks associated with the variability of the

[25] https://info.worldbank.org/governance/wgi/Home/Reports

economic environment depicted in prices, GDP, inflation or interest rates and terms of trade (Bouchet et al., 2003). In this study, Gross Domestic Product *(GDP) Growth per capit*a was used to approximate economic risk. The data for GDP growth was retrieved from the World Bank and corresponds to the annual growth. In order to account for the impact of a different GDP growth in different years, the average yearly GDP growth was used, for the years that the organisation (per country) provided project data. For example, if an organisation only provided data for financial closure in 2018, then 2018 GDP growth was used. If the organisation provided data for both years, an average of the 2 years was used. A recalculation of the model using the GDP growth mean per country reports the same estimates, although the fit has a slightly better when calculated with the method outlined here.

Sovereign risk: In line with (Pap and Homolya, 2017) sovereign risk is applied to refer to the risk that a state could default on its debt or other obligations. It is a direct measure of default risk when lending to a government of a country (Damodaran, 2016). Thus, the 10-year yield *Government Bond Interest rates* were collected from Eurostat for each year and country. Since Estonia released its first 10-year yield government bonds in mid-2020, the average between Latvian and Lithuanian interest rates were used. This is justified since the three countries possess a similar economic structure and the Estonian monthly 2020 10-year government bond yields were situated between those of Latvia and Lithuania for the same period.

Sociopolitical risk refers to damaging actions or factors for businesses of firms that arise from social groups' resistance to certain developments or investments e.g. in renewable energy projects in their vicinity (Bouchet et al., 2003). The public support of renewable electricity is measured using data provided by the Eurobarometer 2018. Respondents were asked in all EU countries the following question: To what extent do you agree or disagree with the following statements? The EU must ensure access to clean energy, e.g. encourage a move away from fossil fuels towards energy sources with low greenhouse gas emissions. The responses ("totally disagree", "tend to disagree", "tend to agree", "totally agree") were recoded from 1 to 4 respectively. The variable *Public Support* was coded as the average score per country.

Meso-level

Auctions: Since the introduction of auctions, their impact on financing costs has been discussed, for example by Botta (2019) who investigated the auction design and its impact on equity costs using a stated preference approach. To catch the impact of auctions in this econometric analysis, the variable *Auction Presence* was built using three variables.

- Number of Auctions consists of the total number of wind and solar auctions split into 5 categories implemented in the country during the 5 years prior to financial closure, including cross-national auctions.
- Average Auction Size refers to the average size of auctions that took place in the three years prior to financial closure. The auction size is measured as the volume of electricity up for auction. It is either in kW if the auctioned product is capacity, euros for budget or kWh/a for electricity. A 5-point scale was created for each auctioned product type using the quartiles as a frame of reference in order to enable the comparison of auction size.
- Number of Years since the first auction, was also split into 5 categories.

How long auctions have been implemented is considered to bear a less strong impact on the presence of auctions than the size or number of auctions that were carried out in the few years prior to financial closure. Therefore, the resulting index of auction is a mean composed of these three variables, where the Number of Years was weighted as half compared to Average Auction Size and Number of Auctions.

Long-term Policy Security and Retroactive change: Several studies highlight the importance of political stability and credibility of support as essential features to attract sufficient capital (Lüthi and Wüstenhagen 2013) (Criscuolo and Menon, 2015). Contrary to other forms of investment, renewable energy investments have relied at least on their early phase of market introduction on subsidies to be financially viable. RE Investors are therefore dependent on policy and changes in policy pose one of the most important threats to RE investors (Gatzert and Kosub, 2016). Policy risk encompasses all risks associated with an unfavourable developments in policy, especially retroactive but also a general unfavorable environment. *Policy Security* and retrospective or *Retroactive Change* was gathered from the Technical Assistance Reports on the progress of renewable energy in the EU produced by the European Commission. The reports assess the status and future development potential of the renewable energy for each member state. They qualitatively evaluate the long-term security of support for renewable electricity by determining if the member state provides information on the availability of future support and the presence of retroactive changes. The *Long-term Policy Security* for each country is graded high, moderate or low in each report. *Retroactive Change* is a dummy variable coded as 1 when a retroactive change was mentioned in the reports and 0 otherwise.

Capital market conditions: In an efficiently functioning market the cost of capital is the result of demand and supply. A growing demand could increase the WACC while an increasing supply of capital might have the opposite effect. Further, the structure in the capital market, the number of players and their market power also impact prices. Therefore two indices, the concentration ratio or Lerner index as well as a spread on the rates are selected reflecting to a certain degree the extent of competition and efficiency in the capital market (variables: *Bank Concentration, Bank Interest Margin*). They are sourced by the global financial development database of the World Bank[26].

Market risk corresponds to the level of market exposure. Renewable remuneration schemes affect the exposure of generators to market risks (Gatzert and Kosub, 2016). While a guaranteed price for electricity entails a low market risk, no support scheme, or a quota or fixed premium bear high risks for generator. The data for remuneration types was gathered from the Technical Assistance Reports, the AURES Auction data base and also the EU funded website res-legal.eu. *High Market Risk* is a dummy variable coded as 1 for support schemes that offer little protection from market price volatility, in this instance, quotas and fixed premiums, and 0 otherwise. A second dummy variable, *Low Market Risk*, is coded as 1 for support schemes that offer a high level of protection from market price volatility, i.e. feed-in-tariffs and sliding premiums (both one-sided and two-sided). The dummy *No Remuneration Scheme* was coded 1 for projects where no support scheme affecting market risk was in place[27]. Alternatively, some models were also calculated using market risk as a categorical variable (three categories covering ranging from low market risk schemes such as sliding premiums and tariffs, to fixed premiums, quota and market prices to suspension of schemes).

Revenue risk is considered in this approach as the cumulative experience of the renewable electricity sector. As shown by (Egli et al., 2018) experiences of actors in renewable projects can reduce the WACC. This variable assumes a causal relation and positive correlation between the renewable energy generation, renewable projects and experienced actors in the respective country. It is operationalized as the percentage of renewable electricity generated out of the total electricity generation per year. The data for this variable *Sector Experience* is sourced from Eurostat.

Project-level

Resource risk: natural conditions represent the resource risk and have a significant impact on the LCOE (Ondraczek et al., 2015; Weaver, 2012), which in turn could be reflected in the WACC. The data is sourced from the EU-funded project ENSPRESO and consists of the *Potential Electricity Capacity per technology* per country (Ruiz et al 2019). As this variable might correlate with the size of the country, it also accounts for country size.

Technology risk arises form missing experiences (Gatzert and Kosub, 2016) and less mature technologies (CEPA and Imperial College, 2015; Polzin et al., 2015) in early phases of the technology deployment. A dummy for the three technologies, *photovoltaic, wind onshore and offshore* is introduced.

[26] https://www.worldbank.org/en/publication/gfdr/gfdr-2016/data/global-financial-development-database

[27] In some instances, countries may have provided loans which could affect the cost of capital but do not impact market risk.

3.2 Model

3.2.1 Data

The WACC data was collected within the AURES II (see Section 1) project and contains data from about 220 interviews conducted in 26 European countries and 90 different organisations. Interviewees provided various estimations regarding financing costs and capital structure for large utility scale onshore and offshore wind and solar projects. These technologies were chosen as they are the main renewable electricity technologies used for generation of electricity. For each project, financial estimates such as the WACC, Cost of Debt (CoD), Cost of Equity (CoE), and debt to equity ratio were provided and also year of financial closure, country of the project and technology type, as well as an organisation code for each organisation were given. A descriptive analysis revealed numerous inconsistencies between the provided WACC and its components (i.e. CoE, CoD and debt to equity ratio estimates). Therefore, a WACC value was also calculated for each project based on the available information on its components. The lowest of the two values was then selected and included in the subsequent analysis to avoid the influence of taxes or hurdle rates that interviewees might link to the WACC and which bears little resemblance to the WACC (Donovan and Corbishley, 2016). For statistical purposes so as to avoid low variance issues, a WACC value per organisation and per country was calculated. This decision was justified by descriptive analysis. There was no significant differences in the WACC mean between 2018 and 2019. In addition, in countries with wind offshore projects, the WACC means for onshore wind and PV projects were not significantly different and thus comparable, whereas the WACC mean for offshore wind was significantly different. Therefore, only onshore wind and solar projects were included in some of the models. In addition, calculated organisation-level WACC values that exceeded 0.09 formed outliers that could not be included in the analysis.

The Auction Database, which was also created as part of the AURES II project, collects information on design elements regarding each auction carried out in the EU including the size of the auction, remuneration schemes, auction bids and which technologies are eligible from 2014 until mid-2020 (AURES II 2020). The explaining variables are listed in Table 2.

Table 2. Overview of explaining variables

risk type	exog. var.	var. type	var. level	variable name - indicator	source
Sociopolitical risk	Renewable electricity public support	metric	country	To what extent do you agree or disagree with the following statements? The EU must […] encourage a move away from fossil fuels towards energy sources with low greenhouse gas emissions. (4-point scale)	Eurobarometer
Sociopolitical risk	Political risk: quality of governance	metric	country_year	Index: Political Stability; Absence of Violence/Terrorism; Government Effectiveness; Regulatory Quality; Rule of Law; Control of Corruption	World Governance index (World Bank)
Sovereign risk	Sovereign risk	metric	country_year	Government Bond Interest Rates	Eurostat
Economic risk	Economic Growth	metric	country_year	GDP growth	World Bank
Revenue risk*	Renewable electricity sector experience	metric	country_year	% of Renewable Electricity Generation (out of total electricity generation)	Eurostat
Policy risk	Policy stability	dummy	country_year	Presence of retroactive changes	Technical assistance reports

Policy risk	Longterm policy security	ordinal	country_year	Long-term security of support for RES-E	Technical assistance reports
Market risk	Market exposure	categorial	country_year	Remuneration type: Feed-in-Tariff, Feed-in-Premium, Quota...	Aures Auction dataset
Technology risk	Technology type	dummy	project	Offshore wind	Aures Finance dataset
Resource risk**	Natural conditions	metric	project (country and technology)	Potential Electricity Capacity per technology	ENSPRESO
Capital Market risk	Bank Concentration	metric	country	Concentration of 3 largest banks	World Bank
Capital Market Risk	Bank Interest Margin	metric	country	Bank net interest margin	World Bank
Auction risk	Auction presence	metric	Country_year	Index as average of three sub-variables (each at 5-point scales, but as a result does not itself have a 5-point scale): Number of years since first auction; Number of auctions in past 5 years; Average size of auction for that technology over past 3 years	Aures Auction dataset

Note: *the RE share is set as a national target, which achievement is driven by policies and market development. Low cost of capital, hence, have less impact on the RE deployment but affect policy costs. **accounts partly for the size of the country.

3.2.2 Model specification and justification

Model specification

The WACC database is nested data as it incorporates different levels: project level, organisation level (interview partner) and country level. Therefore, a multi-level or hierarchical model is applied, where project level is the first level and organisation and country the second level. This allows for the distinction of fixed effects (group means are fixed at the project level), and random effects (group means are a random sample of the population at the organisation and country level). Thus, the basic model is designed as a 2-level cross classified random effects model with the WACC as endogenous variable. In one set of models the dataset is reduced to one project per organisation per country and it was not possible to distinguish then between technology and years making level 1 variables redundant. In an extended model, the dataset included wind-offshore data, allowing to distinguish between technologies.

Model: WACC = function of level 1 such as natural conditions, auction, technology and level 2 variables such as political risk, capital market, experience, sovereign risk, economic risk, policy risk, market risk

In a next step, it is tested whether a cross-classified model with *Organisation and Country* is justified or whether a simple 2-level random effects models with *Organisation* is sufficient

Justification of the cross-classified 2-level model

There are two frequently used ways to determine if it is justifiable to use a multilevel model. One is a likelihood ratio test that tests whether the use of a second level significantly improves the model fit compared to a null (1-level) model. This revealed that the addition of the cluster Country provides a significantly better fit than the null model ($chi^2_{(2)} = 30.08$, $p<0.01$) as is the addition of the cluster Organisation ($chi^2_{(2)} = 19.74$, $p<0.01$).

An additional possibility is to calculate the Intraclass Correlation Coefficient (ICC) (or Variance Partition Coefficient). It estimates the amount of variance explained by a particular level, calculated from the null multilevel model. In the case of a cross-classified model, Chung et al. (2018) recommend calculating the in Intra-Unit Correlation Coefficient (IUCC) which estimates the variance for that particular cluster. This revealed that a 44% of the variation in the WACC can be attributed to the Country that the project takes place in and 46% can be attributed to the organisation.

In the next section different sets of models are run to identify the relevant clusters and variables.

3.3 Results of the Random Effects Models

A first run of pilot models including all explaining variables were conducted. Due to the high number of variables, the power of the models was low, with many insignificant and only a few significant variables. Further, non-linear relations such as the *Bank Concentration* and *Bank Interest Rate* were identified. These variables were skipped and the number of dummy variables for the different remuneration schemes were reduced to three.

Next, new preliminary models were built. Annex II Table 13 presents the seven models built to assess the impact of Auction Presence and various control variables on the WACC. All models control for intercept random country and random organisation effects. It was not possible to estimate random slopes due to the sample size. The significance level was determined using the Satterthwaite Approximation. For comparability and computational reasons, all metric exogenous variables were standardised. Models 1 to 6 are nested sequential models designed to assess possible interaction effects. Model 6 is the full model, with all the potentially relevant variables considered in this analysis. Model 7 is a reduced model that is composed of the most relevant variables as determined by the effects of the coefficients and significance of the various variables in the previous models.

The random effects variances are very weak, possibly due to the fact that the WACC is coded as a nominal value, but more importantly this could be because the variables were either coded at the country or country-year level, which explains for a large part of the country-level variance. With regards to the organisation-level variance, a large number of organisations only had one project and thus had no variance.

Given the low variance and a visual assessment of the residuals indicating potential heteroscedasticity, subsequent models were calculated in order to evaluate the impact of the second-level clusters.

Table 14 in the Annex II presents the full model (same variables as Model 6) and a reduced model (same variables as Model 7) calculated for each cluster, i.e. organisation and country respectively, and the cross classified model. Both the AIC and BIC indicate that, compared to the other models in the table, Model 9 with just Organisation as a level-2 cluster provides the best fit, as does the reduced model compared to the full model. Additional likelihood ratio tests also revealed that, when comparing the reduced models to the full model, the Reduced Model Organisation Random Effects model produces a significant improvement compared to the null model ($chi^2_{(7)} = 16.83$, $p<0.05$), whereas the Reduced Model Country Random Effects model did not ($chi^2_{(7)} = 7.23$). This is in line with the intra-class correlation coefficient (ICC)[28] showing that a lower proportion of variance is explained by the country (level 2) (ICC=0.25) than by organisation (level 2) (ICC=0.84) with the WACC as endogenous variable.

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[28] 2 Level ICC: VAR(Level 2) / [Var (Level 2) + VAR (Levels 1)]

Table 3. Final set of models with wind onshore and PV, without wind-offshore

	Model 14	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20
(Intercept)	0.043***	0.042***	0.042***	0.042***	0.042***	0.042***	0.042***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Natural Conditions	−0.000	−0.000	−0.000	0.000	0.000	−0.000	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Sector Experience	−0.003**	−0.001	−0.000	−0.000	−0.001	−0.001	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Government Bonds		0.005***	0.004**	0.005**	0.005**	0.004*	0.006***
		(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Economic Growth		0.003**	0.003***	0.003**	0.003**	0.003*	0.003**
		(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Governance Quality			−0.001	−0.001	−0.001	−0.001	
			(0.002)	(0.002)	(0.002)	(0.003)	
Public Support			−0.002	−0.000	0.000	0.000	
			(0.001)	(0.001)	(0.002)	(0.002)	
Auction Presence				−0.003**	−0.003	−0.002	−0.003*
				(0.001)	(0.002)	(0.002)	(0.002)
Low Market Risk					−0.002	−0.001	−0.001
					(0.002)	(0.002)	(0.002)
High Market Risk					0.000	0.000	
					(0.002)	(0.002)	
Retroactive change						0.001	
						(0.002)	
Long Term Security						−0.001	
						(0.002)	
AIC	−484.024	−510.092	−508.351	−507.674	−504.497	−501.782	−513.657
BIC	−471.870	−493.076	−486.474	−483.366	−475.327	−467.751	−496.642
Log Likelihood	247.012	262.046	263.176	263.837	264.249	264.891	263.829
Num. obs.	84	84	84	84	84	84	84
Num. groups: organis	73	73	73	73	73	73	73
Var: organis (Intercept)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Var: Residual	0.000	0.000	0.000	0.000	0.000	0.000	0.000

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Table 33 displays random effects models using only *Organisation* as second level cluster. The results are consistent with the estimations displayed in Annex II Table 13 This indicates that, for this analysis, the use of a 2-level random effects model with the cluster Organisation rather than a 2-level cross-classified model with Organisation and Country as clusters is justified. In addition, the dummies for low and high market risk are replaced by a categorical variable for market risk (see Annex II, Table 15), but market risk remains insignificant.

In contrast to previous calculations, Table 44 displays results of random effects model including all technologies and a dummy for wind-offshore. Further results of models including all technologies with and without a dummy for wind offshore are presented is in Annex II Table 16. The results are rather consistent with other model results, but the presence of auctions becomes more pronounced, while economic growth is insignificant, except when an interaction variable between wind offshore and economic growth is included.

Table 4. Final Models with all technologies and dummy wind-offshore

	Model 30	Model 31	Model 32	Model 33	Model 34	Model 35	Model 36	Model 37
(Intercept)	0.042^{***}	0.042^{***}	0.042^{***}	0.042^{***}	0.042^{***}	0.042^{***}	0.042^{***}	0.042^{***}
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Wind Offshore	0.005	−0.000	−0.000	−0.000	−0.001	−0.000	−0.000	−0.001
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Natural Conditions	0.001	0.000	−0.000	−0.000	0.001	0.001	0.001	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Sector Experience	−0.002	−0.001	−0.000	−0.000	0.001	0.000	0.000	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Government Bonds		0.007^{***}	0.007^{***}	0.008^{***}	0.006^{***}	0.007^{***}	0.007^{***}	0.007^{***}
		(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Economic Growth		0.002	0.003^{**}	0.003^{**}	0.003^{**}	0.003^{**}	0.003^{*}	0.002^{*}
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Wind Offsh.∗Econ. Growth			-0.006^{***}	-0.006^{***}	-0.005^{*}	-0.005^{*}	-0.006^{**}	-0.006^{**}
			(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Governance Quality				0.001	0.000	0.001	0.001	
				(0.002)	(0.002)	(0.002)	(0.002)	
Public Support				−0.000	0.001	0.001	0.001	
				(0.001)	(0.001)	(0.002)	(0.002)	
Auction Presence					-0.005^{***}	-0.004^{**}	-0.004^{*}	-0.003^{*}
					(0.001)	(0.002)	(0.002)	(0.001)
Low Market Risk						−0.002	−0.002	−0.002
						(0.002)	(0.002)	(0.002)
High Market Risk						−0.000	−0.000	
						(0.002)	(0.002)	
Retroactive change							−0.000	
							(0.002)	
Long Term Security							−0.001	
							(0.001)	
AIC	−528.668	−563.836	−567.767	−563.957	−570.498	−567.393	−563.665	−575.793
BIC	−513.408	−543.490	−544.878	−535.981	−539.978	−531.787	−522.972	−552.904
Log Likelihood	270.334	289.918	292.884	292.979	297.249	297.697	297.832	296.897
Num. obs.	94	94	94	94	94	94	94	94
Num. groups: organ	76	76	76	76	76	76	76	76
Var: organ (Intercept)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Var: Residual	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

3.4 Conclusions

The econometric results reveal that

- *Government Bonds* have a significant impact on the WACC in all models. As 10-year government bond interest rates increase, so does the WACC. Moreover, its impact is the largest on the WACC, i.e. an increase of the bond rate by one percentage point increases the WACC between 0.6-0.8 percentage points. This is conforming to theory.

- The *Economic growth* is significant in all models without wind offshore until Long Term Security and Retroactive Changes were added (Policy risk). This may be due to the low power or due to interaction effects. The coefficient is positive, indicating that an increase in the growth by one percentage point entails an increase in the WACC for PV and wind onshore by about 0.2-0.3 percentage points. A possible explanation for this apparently counter-intuitive result may be that countries which are less developed have a higher growth, which does not directly translate into lower financing costs. Calculating a random slope for GDP growth at a country level would have been desirable to verify this effect, but is not possible due to the sample size. Including an interaction term with wind offshore, the interaction as well as economic growth becomes significant, but negative. Possibly only more developed countries deploy offshore wind, thus GDP growth in those countries entails better financing conditions.

- The *Auction presence* is very significant ($p<0.01$) in models with wind offshore (Model 17), but the significance diminishes when controlling for market risks (Models 18- 20). Action presence shows a lower significance in models without wind offshore (Model 17) when controlling for natural conditions, sector experience, sovereign risk, governance quality, public support and economic growth. The significance disappears when controlling for market risk (Models 18-20). The negative coefficient implies that, as auctions become more present (i.e. more auctions and large sizes), the WACC decreases (by about 0.3-0.5 percentage points). This indicates that the implementation of auctions and thus auction risk does not increase the cost of capital in the long term, just the opposite, it implies learning effects in handling auctions that might be associated with a decrease of the WACC.

- The *Market Risk* is neither significant as dummy nor as categorical variable in Models 18, 19, 20 and in Models 27, 31, respectively. But the dummy reduces the significance of Auction Presence, thus indicating a moderator effect on the WACC, i.e. de-risking renewable policies that reduced the exposure to market risks of generators tend to have a dampening effect on the WACC.

- The *Sector Experience* is significant with a negative sign only on Model 14 (without wind offshore). This supports our assumption that with increasing experience in the deployment of renewables, the WACC decreases by about 0.3 percentage points. The WACC itself affects the support costs, while the RE deployment in the EU is driven by national RE targets. This is in line with findings of Egli et al. (2018). The variable becomes insignificant when including Government Bonds and Economic Growth, both potentially having a stronger explanatory power.

Overall, the results are not surprising but in line with other recent findings and theories. The impact of political and sovereign risks is reflected in the different WACCs between countries in the EU or between developing and developed countries where financing costs reflect several country-specific investments risks such as regulatory, financial and administrative barriers (UNDP, 2013).

Interesting is the effect of auctions as this entails two implications. First, the presence of auctions do not have a negative effect, and second, as the number and size of auctions are components of this variable, the negative sign implies that with an increasing number of participants a) learning effects are present and/or b) competition in auctions is passed through to the capital market, and c) with an increasing volume size, scale effects could occur.

Finally, even though the remuneration schemes *(Market Risk)* display no significance, they indirectly reveal an impact through their impact on the significance of *Auction Presence*. Remuneration schemes that reduce the exposure to market risks tend to have a decreasing effect on the WACC.

4 Cash-Flow-Modelling

4.1 Introduction

The work of this chapter connects with the report "Effects of auctions on financing conditions for renewable energy projects" (Dukan et al., 2019). Within this report, we argue that there might be a link between auctions for renewable energy support and changes in financing conditions and costs of capital. We extend this analysis by taking the results of the financing survey and using them for calculating bid levels for onshore wind and solar PV, within EU 27 and UK. Through this we investigate the effects that auction designs and remuneration scheme types have on support costs. Therefore, we derive support costs that would be required under assumed market conditions, to deliver projects that at least break-even, but still guarantee a minimum bid level, to ensure cost efficiency of renewable energy deployment. From an economic point of view this means that they have an NPV that is zero, or an IRR that equals to the projects WACC. At the same time, we conducted the analysis only for the surveyed financing and cost of capital estimates that relate to project financed projects. Therefore, to derive the minimum bid levels, we also consider if under such conditions, the projects would be bankable. We do this through taking into account the surveyed DSCR levels and loan tenors, to derive the projects debt size. Finally, it's important to note that this report does not take into account auction theory. Hence, we do not estimate bid levels under bidder's expectations of competition, under different pricing rules and other auction-theoretic considerations. We simply treat the available auction designs as cash flows that affect a potential bidder's estimation of expected net present value.

Within this section we address the following questions:

1) Under the current market conditions what would be the expected bid prices across EU 27 and UK?
2) How do financing conditions affect bid prices in comparison to other investment variables?
3) What support costs would member states have under their current remuneration scheme designs, surveyed financing conditions and present market conditions?

As we focus on investigating bid levels and support costs for countries with different remuneration scheme designs, we also compare our results across countries that have contracts for difference, sliding premiums and fixed premiums. Research into the link between these three support scheme types indicates that contracts for difference should achieve lower costs of capital, better financing conditions and lower support costs. Therefore, we also focus on this additional question:

4) What role does the design of the remuneration scheme have on bid price levels and support costs?

In the upcoming sections we first describe the cash flow model, then we elaborate on the dataset that we constructed for the purpose of performing the calculations. This includes a description of the use of the financing survey data, auction database and investment data. Finally, we outline the main results of the model, connected to the above questions, and present conclusions and further steps.

4.2 The cash flow model

The AURES I project, developed a discounted cash flow model that "simulates single investment appraisals in the context of auctions for renewable energy support" (Kitzing & Wendring, 2016)The tool enabled users to "simulate the necessary support levels for single renewable energy investment projects under particular market conditions and assuming country and technology specific project characteristics as well as different auction designs" (Kitzing & Wendring, 2016).The main output of this model was a non-strategic bid price, which did not include any game theoretic considerations, but rather only economic feasibility calculations. The model calculated a bid level based on expected Net Present Value (NPV), while considering three scenarios and assigned probabilities (the probabilities can be assigned manually but as default it takes the ones indicated below):

1. Project realised in time, no penalties [90% probability]
2. Project is realised after realisation period, a penalty is paid [5% probability]
3. Project is not realised, a penalty for non-realisation is paid [5% probability]

Each of the three scenarios produces a different NPV and IRR level. The model minimizes the expected bid level, while keeping the expected NPV = 0. It takes this assumption, under the condition that bidders strive to minimise their costs, given a price-only award criterion i.e., bids with smallest required bid levels win the auction round.

Following this rationale, we expanded the AURES I cash flow model and introduced significant upgrades. The AURES II cash flow model follows the same rationale in the sense that it does not produce game theoretic bid levels, but rather purely bid levels that allow the projects to have a NPV = 0. Unlike the first AURES model, the AURES II model calculates expected bid levels for all EU countries for which we have collected financing data, and for both onshore wind and solar PV. Therefore, the new model does not allow for single investment appraisals but its main purpose is to estimate overall differences in bid levels and support costs across the EU, while taking into account the most recent auction designs.

Considering the uncertainty of the final outcome of a winning project (in regards to its actual realisation), we again simulate bid prices based on the above mentioned three basic investment outcomes. Whereas the first AURES I model was based on a Goals Seek function, we integrate into the new model a Solver optimisation function with constraints. The entire model and the Solver optimisation criteria are described in Figure 222.

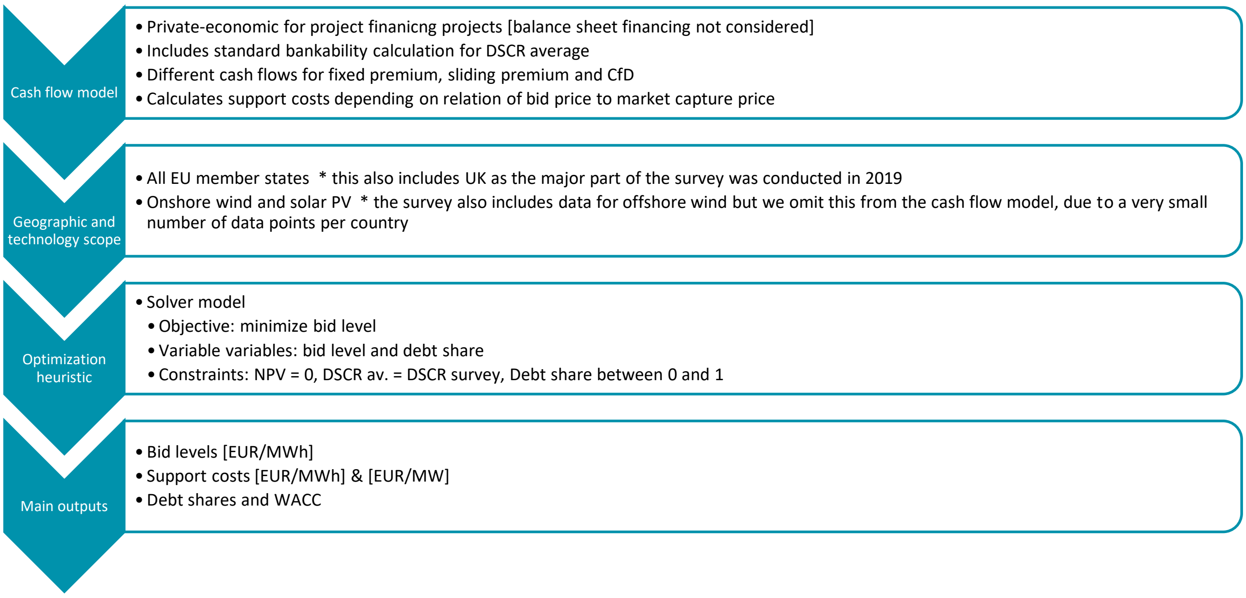


Figure 22: Cash flow model summary

The cash flow model assumes three different revenue streams, depending on the type of the remuneration scheme in place. The revenue flows of each of these and the way in which we assume them in the model is described in more detail in Figure 233. The model calculates the revenues by comparing the bid price with the electricity price in that year (corrected for market values factors – see Section 4.3.2.2 for more details). The revenues are defined as follows:

- Sliding premiums: when the bid price is higher than the electricity price the model covers the difference by allocating the projects with support. When the electricity price is higher than the bid level, the model assumes revenues from the electricity market, hence no support is allocated.

- Contracts for Difference: similarly, as with sliding premiums, when the bid price is higher than the electricity price the model covers the difference by allocating the projects with support. However, when the electricity price is higher than the bid level the model deducts revenues from the project, assuming that the producer returns them to a government authority.

- Fixed premiums: the model assumes that projects receive a top-up on the electricity price. The bid prices and the electricity price do not interact in the same way as with the sliding premiums and contracts for difference

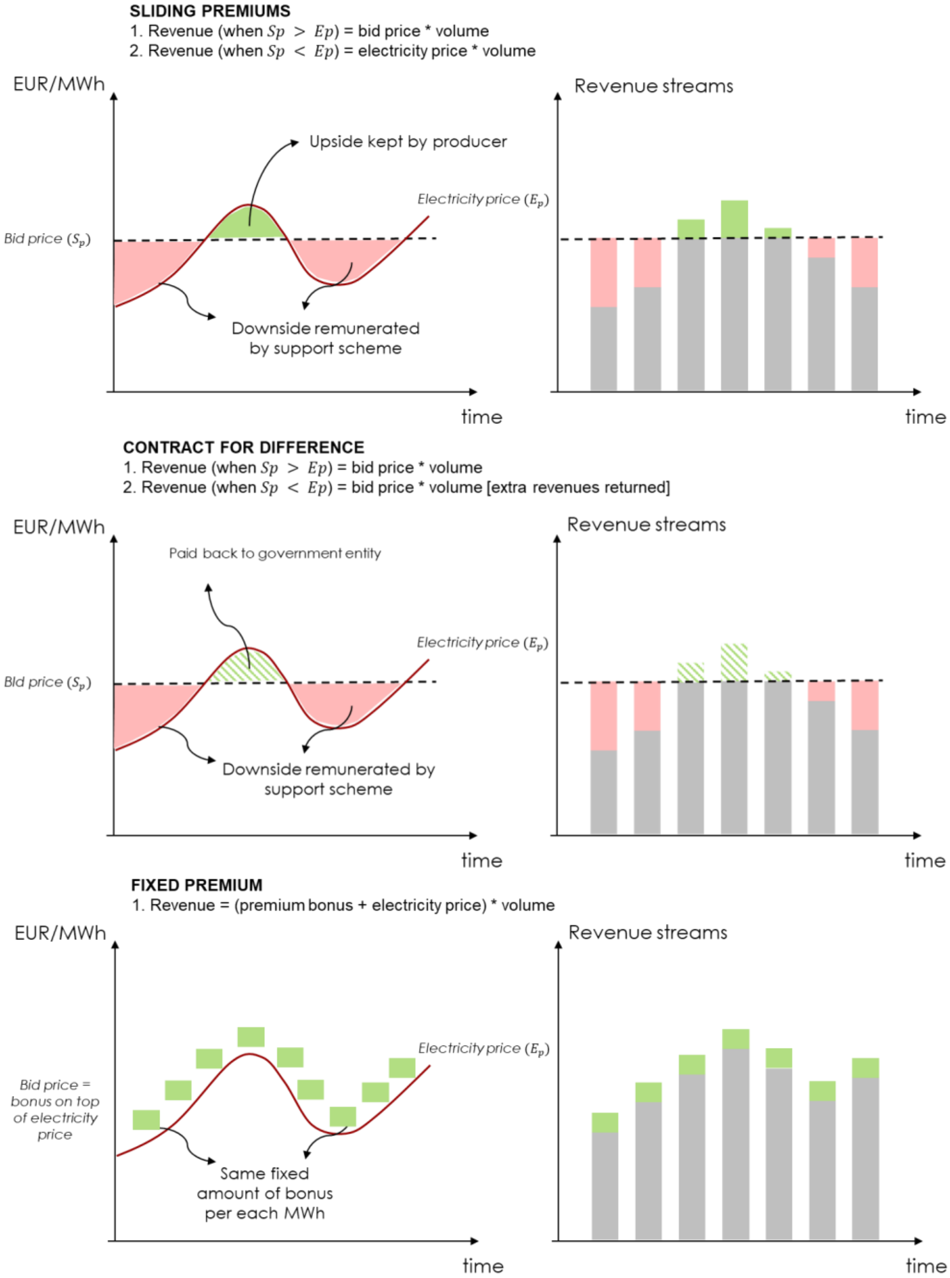


Figure 23. Revenue flows assumed in the cash flow model: sliding premiums, contracts for difference and fixed premiums

4.3 Input values and assumptions

Figure 244 shows the overall scope of analysis and the three main databases that we used as inputs for the cash flow simulation. Within this section we will describe the data that we used, and the main assumptions we made.

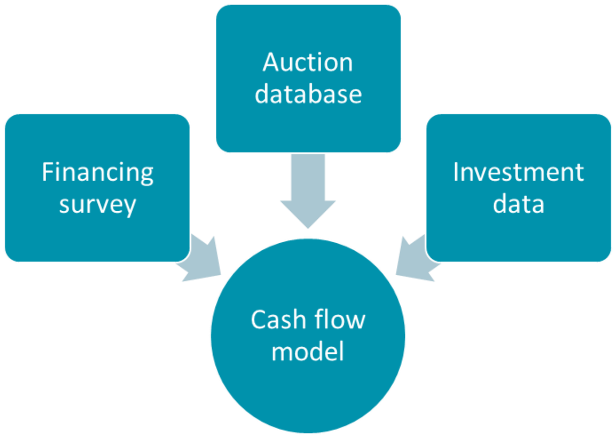


Figure 24. Scope of the cash flow analysis: the main data inputs

4.3.1 Financing survey data

The financing data that we use consists of project specific and country ranges for these financing indicators: costs of equity, costs of debt, DSCR values and loan tenors – although the survey also collected data on debt shares and WACC values, however we omit these in the cash flow model because of the reasons described in Section 4.3.1.1. We conducted the data collection through a survey – that lasted between September 2019 and April 2020 – with project developers and financing professionals in EU 27 and UK. The survey was structured and it was conducted in local language via telephone. To establish a sense of trust between the interviewees and our country researchers, we did not record the structured interviews. The survey consisted of three parts that aimed both at collecting quantitative and qualitative data. First, we asked the interviewees to provide us with project specific estimates for financing indicators. Due to the confidential nature of the data, some interviewees declined to provide us with such data. In such instances, we reverted to asking for country estimates instead. Besides this quantitative data, we also collected qualitative data which makes up the major part of the findings that we presented in Section 2. Within this interview segment, the researchers stepped outside the format of our structured survey and asked the interviewees' semi structured questions, related to the main drivers behind the development of costs of capital and financing in a specific country.

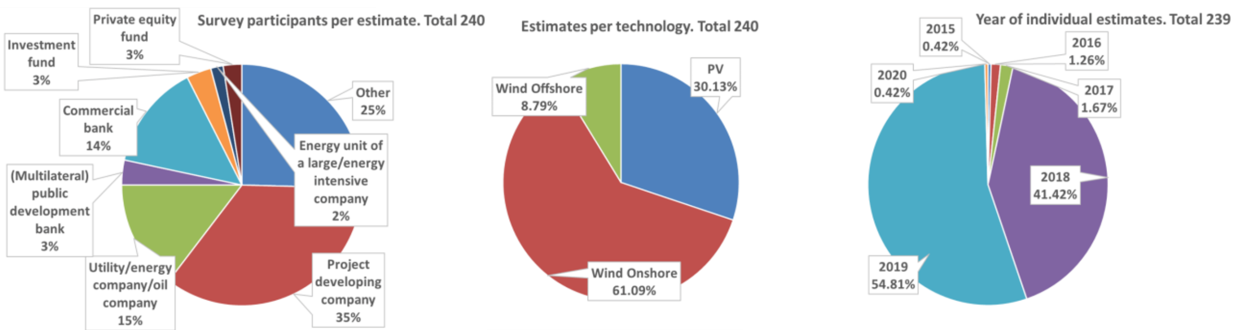


Figure 25. Detailed information regarding the financing survey

Overall, we have conducted 93 interviews with participants from 90 different organisations that are described in more detail in the leftmost graph in Figure 25. The interviewees provided a total of 240 estimates for financing conditions and costs of capital for solar PV, onshore wind and offshore wind projects. As can be seen in Figure 25, most of these were for onshore wind, while offshore wind comprises only 8.79% of the overall estimates. Furthermore, the estimates mostly relate to years 2019 and 2018. Finally, 51.25% of the estimates are project specific while the rest are country estimates.

In 90% of the estimates the interviewees provided ranges for some of the asked data. For instance, an interviewee, might have provided an exact figure for cost of debt, but a range estimate for costs of equity or any of the other two financing indicators considered – DSCR and loan tenors. The interviewees provided one single estimate for all financing indicators in case of only 24 estimates. Considering this we have split the estimates into sub-estimates that consist of combinations of best and worst data inputs for cost of debt, cost of equity, loan tenor and DSCR. We combine this into worst and best case sub-estimates for each original estimate, where the best sub-estimate consists of:

$$COD_{best} = min_{COD}, COE_{best} = min_{COE}, DSCR_{best} = min_{DSCR}\ loan\ tenor_{best} = max_{loan\ tenor}.$$

The opposite combination holds for the worst sub-estimate. Besides this we have also calculated average values for each estimate - for instance in case of costs of debt:

$$COD_{average} = \frac{COD_{best}+COD_{worst}}{2}$$

We repeat this process for all the above mentioned financing indicators for each of the 240 estimates. Overall, through this process we have obtained a total of 651 sub-estimates, with different combinations of financing conditions.

As the original financing survey was not complete – meaning that for some estimates individual financing indicators were missing – we had to supplement the data with our own estimates. We filled the gaps with the average values of the best and worst sub-estimate for each estimate, per each country and technology. Where this was not possible, for instance in cases where the survey recorded no values for a single financing indicator in a country for a specific technology, we have used an average financing indicator of the other technologies for that country (excluding offshore wind). In cases where the financing indicator was not available for any other technology in a country, we use regional values. In that case, we averaged the best and worst financing indicators for all countries that are bordering the country that does not have a value for a specific financing indicator. This last resort approach was only necessary for DSCR in Slovenia. Overall Table 5 presents the extent of data supplements for each financing indicator and for all technologies and countries that we consider.

Table 5. Number of data point gaps that had to be filled by average estimates

	Project vs. balance sheet	Cost of debt	Cost of equity	DSCR	Loan tenor
Supplemented with average estimates	158	14	66	150	104
Share in total	33.19%	3.11%	13.87%	36.95%	25.62%

As can be seen from Table 5 the survey yielded realisable data in case of costs of debt, but was less reliable in case of DSCR and loan tenors, where we needed to supplement 36.95% and 25.62% of the data, respectively. Besides this, the survey did not report the type of financing it relates to for every estimate. We resolved this issue by assuming that each estimate that has a DSCR and loan tenor value, but no information of type of financing, is a project financed project (this occurred in 33.19% of the estimates).

Since the final data mainly relates to project financed projects (86.18% vs only13.82% for balance sheet), we focus only on project financing related estimates. Besides this we also disregard offshore projects, since these comprise only 8.79% of all the estimates, and because most of these are balance sheet financed. Conducting the cash flow simulation for balance sheet financed projects would also require developing a separate Solver model, which we omitted at this point in the research process. After excluding some estimates, for the reasons named above, we derive a total of 562 sub-estimates for which we run the model.

We define each of these sub-estimates as a separate scenario, to which we assign other investment and auction-design related values that we describe in Sections 4.3.2 and 4.3.3.

4.3.1.1 Debt share and WACC model calculation

In project financing debt is usually sized through debt sculpting (Bodmer, 2020), where each period's loan repayment is sized to fit that periods Cash Flow Available for Debt Service (CFADS). In doing so the project maintains s constant DSCR level throughout the loan repayment period. In other words:

$$DSCR = \frac{CFADS}{(Principle + Interest)} \qquad (Principle + Interest) = \frac{CFADS}{DSCR} \tag{3}$$

In the financing survey we have collected data on debt shares and WACC levels. However, the debt share values we collected did not correspond to the collected DSCR values. In other words, these two input variables were not aligned, most likely because the interviewees did not respond based on exact financing term sheets, but more based on project data they drew from memory. Since the WACC equation equals:

$$WACC = \frac{E}{D+E}(r_e) + \frac{D}{D+E}(r_d)\,(1-T) \tag{4}$$

Where:

$$E = market\ value\ of\ equity$$

$$D = market\ value\ of\ debt$$

$$(r_e) = cost\ of\ equity$$

$$(r_d) = cost\ of\ debt$$

$$T = corporate\ tax\ rate$$

and by default includes debt size, we also ignored the surveyed WACC values and instead calculated them ourselves, after deriving the debt share. While as explained above the standard in project financing is to calculate debt shares through sculpting, we did not apply this method until now. Instead, we calculated the debt shares based on an average DSCR level, over the projects loan repayment period. However, sculpting is applied mostly for projects that have variable CFADS, whereas under our price assumption (constant increase by 1%, and adjusted for inflation), CFADS constantly increases. Instead of large variability in DSCR levels, we record constant DSCR increases. From this perspective, taking an average DSCR as the benchmark for calculating the debt shares could be justified. As we calculate the debt levels, simultaneously with bid prices in the same Solver model, the obtained debt share are those where:

$$DSCR_{survey} = Project\ DSCR_{average}$$

$$Debt\ share\ < 0{,}1\ >$$

$$NPV\ \geq 0$$

$$Bid\ price = minimum$$

Based on this we obtain the debt share and WACC values as shown in Figure 266 and Figure 277. As can be seen our values deviate from the surveyed ones, due to the inconsistency of the surveyed DSCR values, debt shares and WACC values. We calculate the bid levels based on the P-50 production scenario, while we calculate the debt shares based on P-75. While P-75 is generally considered as an acceptable production estimate for financial institutions, assuming this level might have under or overestimated debt shares in some cases. Namely, we did not collect DSCR values based on corresponding P value estimates, where a P-90 value would correspond to a higher DSCR value and a P-75 or P-50 to a lower DSCR level.

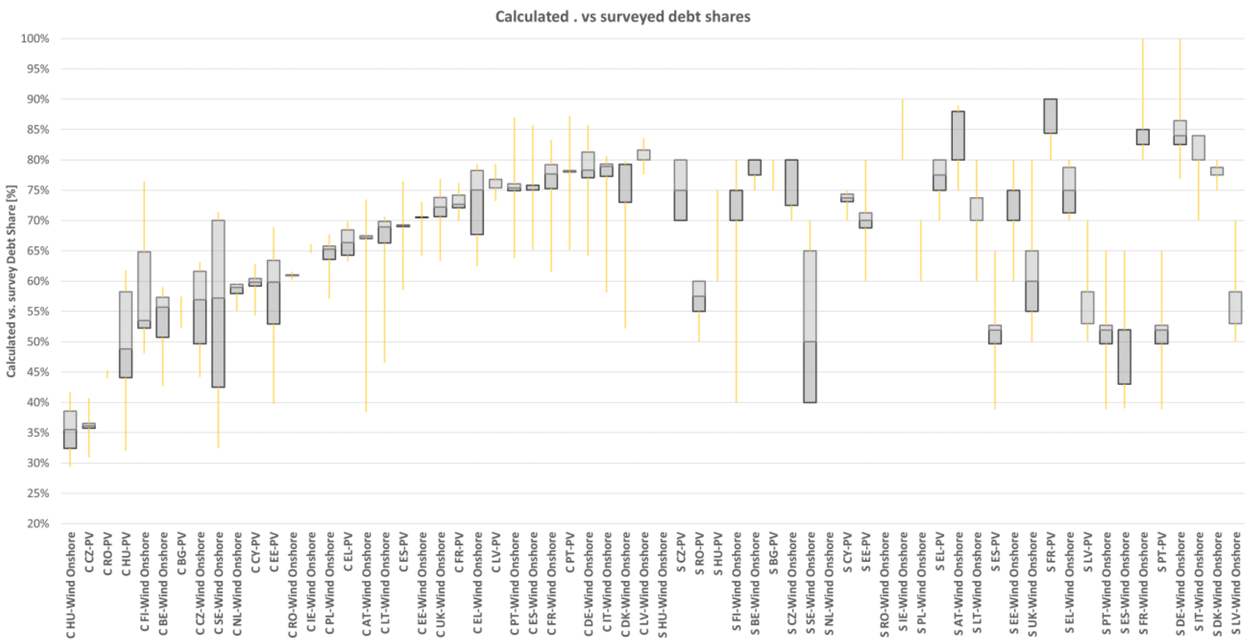


Figure 26. Calculated vs. surveyed debt shares

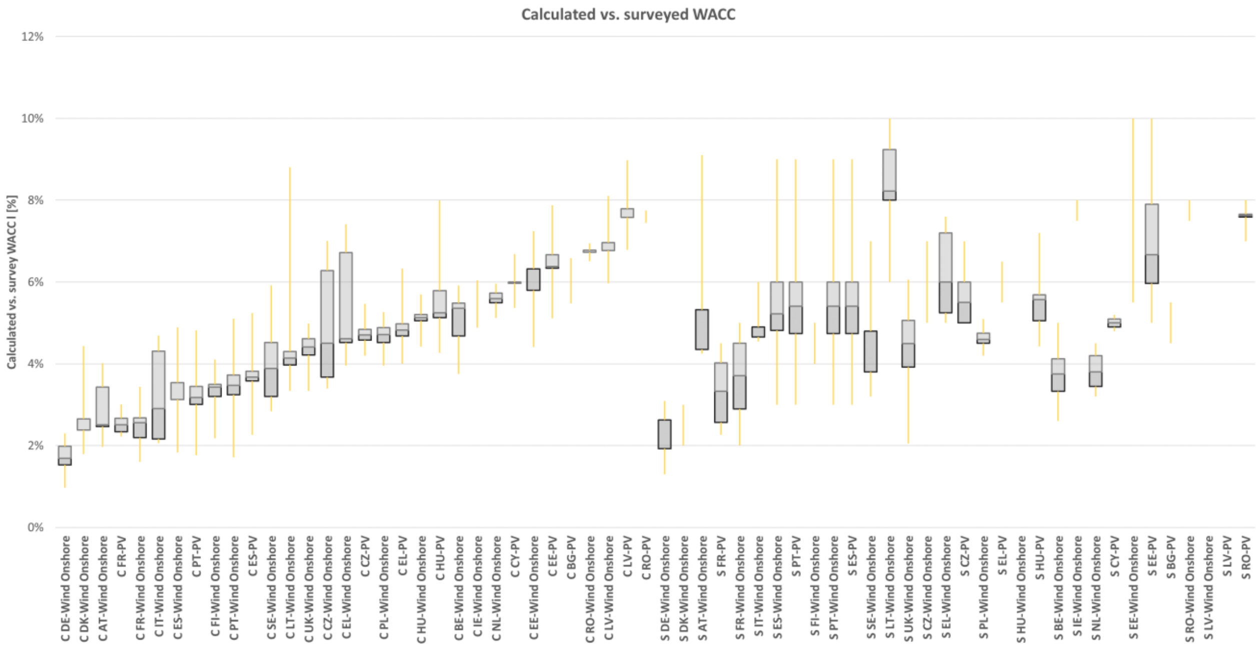


Figure 27. Calculated vs. surveyed WACC

4.3.2 Investment data

For the purpose of this cash flow model, we construct a database with best estimates for onshore wind and solar PV investments in EU 27 + UK. We strive to minimise the amount of different sources per variable type as much as possible, although this was not possible in all cases, without making overly-simplistic assumptions, for example in the case of CAPEX for onshore wind and solar PV. While combining different sources of data risks making mistakes, taking an individual CAPEX value for all EU member states would also impact our analysis. In specific, it could impact final bid prices in countries in which the assumed average investment cost value, over or underestimates the true country value.

4.3.2.1 Main investment inputs (CAPEX, capacity factors and O&M)

The main investment data include the following (in 2019 values where relevant):

Onshore Wind			
Variable name	Unit	Data Source	Comment
CAPEX	[EUR/kW, 2019]	1) IRENA, (2019), 2) Wind Europe internal database	The IRENA database contains 650 GW of project data on onshore wind. In case of Europe, it contains onshore wind weighted average total installed costs for DK, DE, FR, IT, ES, SE and UK for 2019. For these countries we take these values for the CAPEX level. From Wind Europe, we have received a dataset with estimates of CAPEX levels for years 2018, 2019 and 2020. After adjusting these values to the 2019 numbers, we average the CAPEX values for the three years. We average them because the original values do not seem to have any clear trend, in the sense that they decrease/increase over the three years. This way we obtain CAPEX data for AT, BE, HR, FI, EL, HU, IE, LU, NL, PL, and RO. We obtain the remaining data after searching for country specific

			values from other reports
Capacity Factors	[%]	JRC, Wind potentials for EU and neighbouring countries, 2018	The dataset contains capacity factors for onshore wind in all EU Member States. It takes into account land availability - which considers setback distances - and different turbine types, depending on their hub height and specific power. Weather conditions are based on MERRA reanalysis data (from 01.01.1981. to 31.12.2009). The capacity factors that we use assume a wind turbine model with the specific power of 300 W/m2 – we take the average of the areas with capacity factors that are higher than 20% (page 31).
O&M	EUR/kW/year	IRENA, (2019)	We assume the average of the values of O&M in available EU countries, including SE, DK, DE and IE. After adjusting for inflation and currency, we obtain 40 EUR/kW as the default base value for all countries. We would like to note that this is an overestimate in comparison to some other available sources. For instance Steffen et al (2020) estimate onshore wind O&M costs to be 1.32 EUR/kWh for 2017 for Germany. With an average capacity factor of 24% this would amount to 27.75 EUR/kW/year, which is a large underestimation in comparison to the data provided by IRENA for Germany (55.72 EUR/kW/year in 2019).
Solar PV			
CAPEX	[EUR/kW, 2019]	1) IRENA, (2019), 2) Solar Power Europe, 2019, other sources	Solar PV projects vary by size and application, and are therefore generally divided into residential, commercial, industrial and utility scale. We assume that only larger projects that fall under the categories utility scale and commercial, would participate in auctions. IRENA (2019) contains cost estimates for utility and commercial scale projects in FR, DE, IT, NL, ES and UK. For these countries we average the two values for each country to arrive at the final CAPEX estimates. To arrive at the values for other countries we make these two steps: 1) we first average all of the commercial and utility scale CAPEX for the above mentioned countries from the IRENA database 2) we then obtain rough estimate for market shares for solar PV project types from Solar Power Europe (2019) for the other markets in the EU, for which data is available 3) based on these two steps we calculate the weighted averages of the CAPEX, depending on the respective market shares of utility scale and commercial solar PV projects. Through these three steps we obtain CAPEX estimates for AT, BE, BG, CZ, DK, EL, HU, PL, PT, RO, SK and SI. We obtain the CAPEX values for the remaining EU countries - HR, CY, EE, FI, IE, LV, LT, SE, LU and MT – through a combination of reports and local utility project cost estimates
Capacity Factors	[%]	Pfenninger & Staffell (2016)	We base the solar PV capacity factors on Pfenninger & Staffell (2016). With this study the authors aim to validate the use of Renewables.Ninja as a source for solar PV capacity factors, through comparing their model derived estimates with "metered time series from more than 1000 PV systems as well as national aggregate output reported by transmission network operators". We obtain capacity factor values from their Europe-wide annual averages based on MERRA-2.
O&M	EUR/kW/year	IRENA, (2019)	We assume the IRENA O&M estimate for utility scale projects in Europe at USD 9/kW/year. However, this value is only for Germany. Therefore, in our analysis we could be greatly under and

			overestimating solar PV O&M costs in other EU countries. In comparison Steffen et al (2020) estimate the O&M costs of utility scale solar projects in Germany at 7.05 EUR/KW/year in 2017. We did not obtain O&M values for any other country that we study.

Finally, it's important to point out that each of our scenarios calculates the bid levels for project sizes of 1 MW of installed capacity. While this disregards potential economies of scale, running the risk of overestimating bid levels and support costs, we do this to make the analysis comparable.

4.3.2.2 Electricity prices and market values

The cash flow model evaluates project cash flows over an operating lifetime of 25 years in case of onshore wind, and 30 years in case of solar PV. Considering this the assumption regarding future expected electricity prices are crucial. Electricity price forecasting relies of various methods, including multi-agent models, fundamental structural methods, reduced-form models, statistical approaches and computational intelligence techniques (Weron, 2014). In our approach we do not rely on any of these techniques, nor do we rely on any external and publicly available price forecasts. While some EU countries have such forecasts, for example in Denmark the Danish Energy Agency publishes hourly expected wholesale prices for the period from 2020 to 2030 (Danish Energy Agency, 2019)equivalent data sets are not available for all EU countries that we study in this report. Considering this we take a simplistic approach, where we take the 2019 Q4 average wholesale baseload electricity prices, for all EU member states, as the starting price of our model (DG Energy, 2019). As our baseline assumption we assume a yearly price increase of 1%, and adjust this for the 2019 yearly average inflation rate, assuming this value for the entire project lifetime period.

Research has shown that the revenues of wind and solar PV power generation on the spot markets, decreases with increased penetration rates of these technologies (Hirth, 2013, 2015). Variable renewable electricity such as electricity from wind and solar PV power plants, reduces the spot price during windy and sunny hours, especially in cases where the penetration of these technologies in the power system is high. a large penetration of wind energy in the power system, reduces prices during windy days, by shifting the residual load curve to the left, thereby reducing the market clearing electricity price (Hirth, 2013). While this reduces revenues for conventional power generation technologies, or pushes them out of the market, it also "self-cannibalises" wind power, by reducing the electricity prices that wind energy producers receive. This effect is similar for solar PV, except that at lower penetration rates (<2-5%), its market value is higher than the average electricity price, but at higher penetration its value drop is more profound than that of wind power, as solar generation is concentrated in fewer hours of the day (Hirth, 2015).

The effects of these value drops are less pronounced in systems with a large penetration of hydro-capacity (Hirth, 2016). Hydro generators are more flexible, and can adjust their production to generate electricity in periods of highest electricity prices. While the start-up time of conventional power generation technologies that make up most of the current fossil fuel based power systems - such as lignite and hard coal plants – is between 75 min to 10 hours (IRENA, 2019a), hydro power plants are ramped up in a matter of minutes, making them much more responsive to electricity price changes. Therefore, in comparison to thermal systems such as in Germany, hydro systems like in Sweden and Norway, and the power systems of countries like Denmark that are well interconnected to the former two, experience a lesser market value drop of electricity from intermittent variable renewable energy. Based on observed market data, Hirth (2016) demonstrates this effect on the example of Denmark, Germany and Sweden. We base our estimates of the market values factors for onshore wind on the regression equations presented in Hirth (2016),

$$y = -0.3x + 1.0 \quad (1)$$

Hydro systems – onshore wind (based on Sweden and Denmark)

$$y = -1.0x + 1.0 \quad (2)$$

Thermal systems – onshore wind (based on Germany)

where y denotes the market value factor and x the share of onshore wind in the power system. Available studies of market value factors for solar PV, do not differentiate between value drops in hydro and thermal systems. To maintain consistency with the above approach, we use a regression equation based on German market data (Hirth, 2015), while running the risk of underestimating solar PV market values in hydro based power systems :

$$y = -3.6x + 1.3 \qquad (3) \qquad \textit{Solar PV – based on Germany}$$

To identify current market value factors, we first derive the shares of onshore wind and solar PV generation in gross electricity consumption for each of the countries in our study. We apply Eurostat (2019) for onshore wind and solar PV electricity generation in 2018, and for simplicity assume this as the share in 2019 (our starting year). For the shares of solar PV and onshore wind in 2030 we conducted a review of the countries National Energy and Climate Plans. Therefore, we assume that until 2030 the countries market value factors change in line with the shares of solar PV and onshore wind that are aligned with their political climate ambition.

4.3.2.2.1 Onshore wind

In case of onshore wind, applying the derived market shares into equations (1) and (2) would yield different results. For example, at 15% onshore wind penetration, the derived market value factors would be 0.96 and 0.85 in a hydro and thermal system respectively. Therefore, to differentiate between thermal and hydro systems we define a so called Flex Ratio (FLR) – the ratio of the hydro share to shares of variable renewables (VRE), solar PV and onshore wind:

$$Flex\ Ratio = \frac{\%\ hydro}{(\%\ solar\ PV + \%\ onshore\ wind)} \qquad (4)$$

We define different FLR levels for both 2018 and 2030 power systems, based on which we differentiate between using either equation (1) or (2) in each of the years. In addition, we define an intermediary system (in between a hydro and thermal system), for which we apply a regression equation with a slope of – 0.65. The FLR limits and regression equations that we apply for these different systems are:

Table 6. Flex Ratio ranges for a thermal, hydro and in between power system

FLR Range		*Type of system*	*Regression equation*
≥ 4.03		*Hydro systems –based on FLR in Sweden*	$y = -0.3x + 1.0$
≥ 1.50	*< 4.03*	*Intermediary system – at least 50% more hydro than VRE*	$y = -0.65x + 1.0$
≥ 0.00	*< 1.50*	*Thermal systems – less than 50% more hydro than VRE*	$y = -1.0x + 1.0$

As the shares of solar PV and onshore wind change over time, in relation to the overall share of hydroelectricity that in most countries remains fairly constant until 2030, the systems with a high FLR lose the flexibility benefits. Hirth (2016) notes that the benefits of hydro power seem to level of at around 20% wind energy penetration. Therefore in our simplified setting, countries change in between 2018 and 2030 from systems with FLR above 4.03 to those below this threshold level. Doing this simulates the fact that larger shares of VRE will have a greater impact on market value factors, despite the initial hydroelectricity market shares. We maintain this methodology for all countries, except for Denmark, which we regard throughout as a hydro system due to its large interconnection to Norway and Sweden.

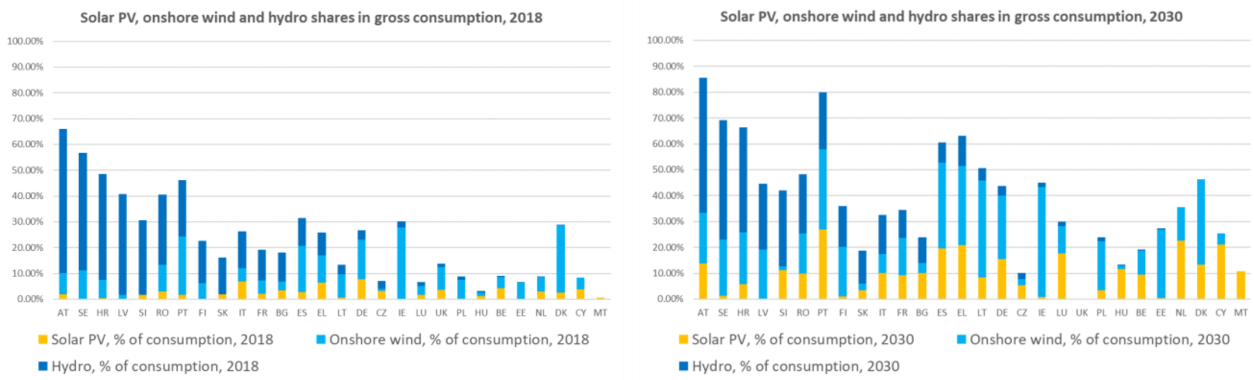


Figure 28. Current variable RES in Member States (based on Eurostat 2018) and expected shares of variable RES (based on NECP review)

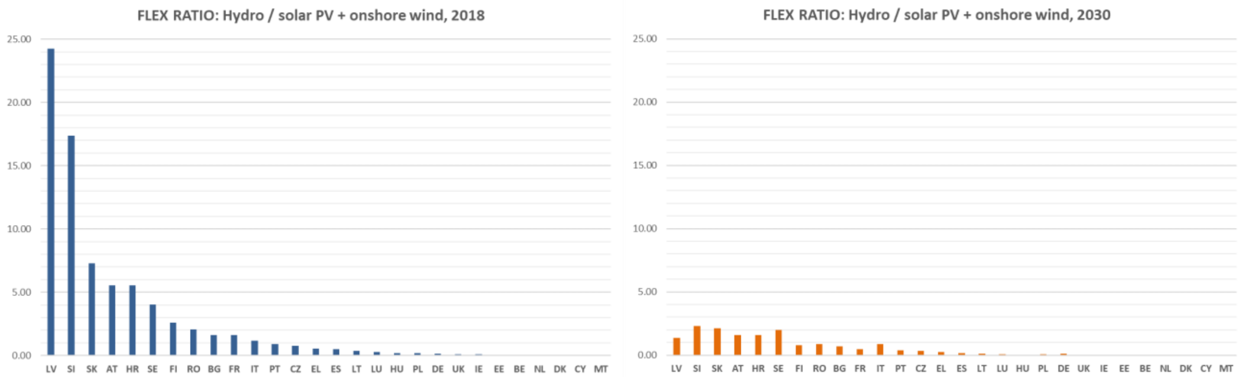


Figure 29. Flex ratio for 2018 and 2030 (based on expected NECP shares of RES in 2030)

In this simplistic setting, we however fail to account for the future development of the power system, where more interconnection capacity will be constructed and where the electrification of the heating and transport sectors may play a major role in providing the needed system flexibility (Gea-Bermúdez et al., 2020). In addition, this setting fails to account for the impact of low-wind-speed wind turbine technology on the market value factors of onshore wind. It’s expected that future wind turbines will have specific power ratings in the range of 175W/mw - 250 W/m2 and hub heights of 125 – 150m, in comparison to current level that are around 325 W/m2 and 100 m hub heights (Riva et al., 2017). Turbines with lower specific power have lower rated speeds (the wind speed at which the turbine reaches its rated power, after which the produced power is constant), and produce more power at lower wind speeds. Consequently, they achieve higher revenues from wholesale markets. At 30% penetration level, research estimates that such advanced wind turbines achieve 15% higher revenues for each MWh sold on the market, than their classical counterparts with higher wind speed ratings (Hirth & Müller, 2016).

Table 7. Calculated market value factors for onshore wind and comparison with published data

Country ID	Market value factor, 2018 [onshore wind]	Market value factor - 2019 [IEA Task 26]	Market value factor, 2030 [onshore wind]	Market value factor - 2030 (IEA Task 26)
AT	0.98	0.98	0.87	
BE	0.96	0.89	0.91	
BG	0.98	0.9	0.96	
HR	0.98		0.87	
CY	0.96		0.96	
CZ	0.99		0.98	
DK	0.92	0.89	0.90	0.87

EE	0.94		0.73	
FI	0.96		0.81	
FR	0.97	0.95	0.86	1.02
DE	0.85	0.84	0.75	0.85
EL	0.89	0.96	0.70	
HU	0.99		0.99	
IE	0.72	0.86	0.58	
IT	0.95	0.98	0.93	
LV	1.00		0.81	
LT	0.91		0.63	
LU	0.96		0.89	
MT	1.00		1.00	
NL	0.94	1.025	0.87	
PL	0.93	0.92	0.81	
PT	0.77	0.95	0.69	
RO	0.93	0.94	0.84	
SK	1.00		0.98	
SI	1.00		0.99	
ES	0.82	0.97	0.67	
SE	0.97	0.96	0.86	0.96
UK	0.91	0.98	0.84**	0.92

** in case of UK we apply an average of the market value factors for other countries, since the UK does not have an NECP from which we could derive the market shares of onshore wind in 2030

The market value factors that we derive and presented in in Table 7 where we present them in comparison with the value factors derived by a comparable study from IEA Task 26 (Riva et al., 2017), which models the expected value factors using Balmorel. For the 2030, it also takes into account more advanced wind turbine designs, compatible for low wind speeds, which then increases the value factors upwards. As expected, our market values differ from the ones derived by IEA Task 26, however the margins of error are small and differ on a country-by-country basis. For instance, in Germany for 2018/2019 the market values factor that we derive is quite similar to IEA Task 26 values, whereas our values for 2030 are 10% smaller because our method fails to assume the development of advanced wind turbines. In case of Denmark, our value factors remain high throughout the analysis, despite Denmark's low share of own hydro production.

4.3.2.2.2 Solar PV

In case of solar PV, our approach is simpler than in case for onshore wind. First, we do not differentiate between hydro and thermal systems. This is because we lack publicly available data on the effects of hydroelectricity on market value of solar PV. Second, we apply equation (3) to all countries for solar market shares in 2018/2019 and 2030. However, the regression equation (3) takes into account all existing literature on the market value of solar PV (up until 2015) and includes studies on California, Germany, Ontario, Australia and Arizona. Although the power systems in EU are different, by taking equation (3) we at least apply findings from multiple countries and not one single market. We present the derived market value factors for solar PV in Table 8

Table 8. Calculated market value factors for solar PV

Country ID	Market value factor, 2018 [solar PV]	Market value factor, 2030 [solar PV]
AT	1.23	0.81
BE	1.15	0.96
BG	1.18	0.94
HR	1.29	1.09
CY	1.16	0.54
CZ	1.18	1.11
DK	1.20	0.82
EE	1.29	1.28
FI	1.30	1.26
FR	1.23	0.96
DE	1.02	0.74
EL	1.07	0.55
HU	1.25	0.88
IE	1.30	1.27
IT	1.05	0.93
LV	1.30	1.30
LT	1.28	1.00
LU	1.24	0.67
MT	1.28	0.91
NL	1.19	0.49
PL	1.29	1.18
PT	1.24	0.33
RO	1.20	0.95
SK	1.23	1.18
SI	1.24	0.89
ES	1.20	0.60
SE	1.29	1.25
UK	1.17	0.92**

** in case of UK we apply an average of the market value factors for other countries, since the UK does not have an NECP from which we could derive the market shares of solar PV in 2030

This method leads to extreme value drops in some countries, for instance in case of solar PV in Portugal, where the market value factor decreases from 1.24 in 2018/2019 to 0.33 in 2030. However, in the same period Portugal plans on increasing its share of solar PV from the current level of 1.8% to 27% in 2030, or a factor 15 increase.

4.3.3 Auction database

The auction database consists of auction designs for individual auction rounds that have been held in EU 27 and UK, and it contains a total of 492 inputs. This includes technology specific and multi-technology auctions, as well as multiple unit and singe unit auction rounds. Each input consists of auction designs within one single auction round for one single technology. For instance, a multi-technology auction round would consist of inputs for onshore wind, solar PV, biomass etc., which in the database all have identical auction designs. For the cash flow simulation, we consider auction designs that have taken place until July 2020. To collect the data, we have reviewed the national legal frameworks that regulate auctions for RE and detail the design elements and rules. After filling in a research template with all the collected information on a national tender scheme, it was reviewed by a national expert on the topic to validate the data.

The auction designs that we consider in the cash flow simulation are those marked in red in Figure 30.

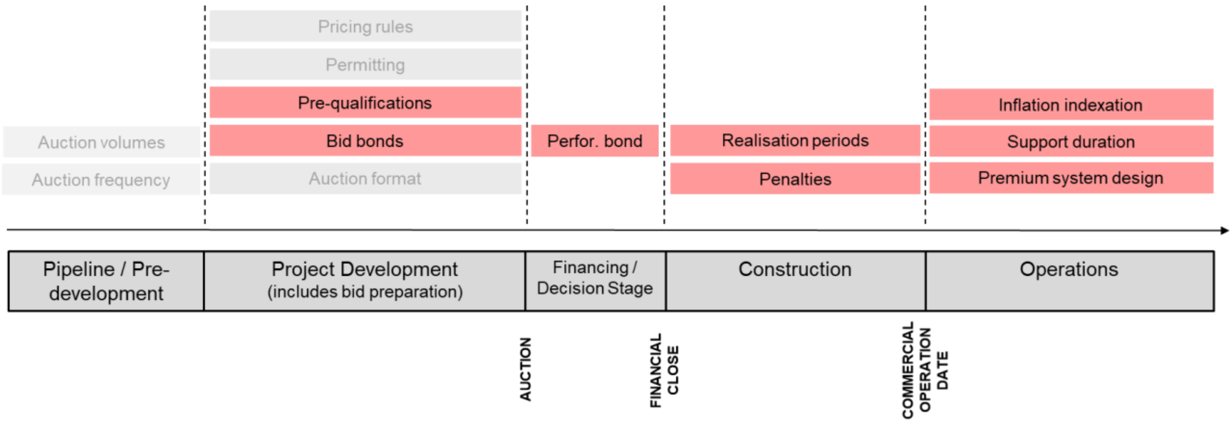


Figure 30. Auction designs considered in the cash flow simulation

From the individual auction rounds in each country where auctions were held, we assume the most recent auction designs that are applicable for solar PV and onshore wind. This includes 29 multi-technology and 7 technology-specific auction designs. Most of these were held in 2019 or 2020 (75%), while the latest auction that we consider took place in the UK in 2015. Instead of modelling each countries individual and specific remuneration scheme rules – for instance different referencing schemes, rules related to maximum possible awarded volume or budget etc. – we take a simplified approach and construct three different revenue models that replicate typical remuneration scheme designs for contracts for difference, sliding premiums and fixed premiums, as described in Section 4.2.

Among the countries that we study, nine of them did not have an auction framework in place until July 2020, and this includes AT, BE, BG, CY, CZ, LV, RO and SE. For these countries, we construct fictive auction designs and remuneration schemes that comply into one of the three, above mentioned categories. While this grossly ignores the current support policies that these countries have, we do this in order to make our results comparable across the EU 27 and UK.

Here we describe some of the basic rules we applied in constructing these fictive designs. In doing so we relied on RES Legal (2020), to determine the current support designs and apply those that are most similar:

a) Remuneration scheme types: we assign to the countries remuneration schemes that correspond to current merchant risk exposure. For instance, Sweden has a quota certificate system so we assigned it a fixed premium. Austria on the other hand has a feed in tariff so we assigned it contracts for difference. Those countries that have a combination between FIT and premium system – such as in the case of Bulgaria – we assign a sliding premium. Where information regarding the countries current support scheme is not available, we assume the remuneration scheme that is applied in most other countries - we do this only for Cyprus

b) Support duration: where available we apply the support duration that applies to the current non-auction-based support scheme. In situations where the support duration is not known from reading the current national legislation, we assume a duration that is an average of the other contract for difference, fixed premium or sliding premium schemes. Within this we assume that onshore wind and solar PV have the same support duration

c) Support level indexation: we assume the countries do not adjust their support levels to inflation, unless specified otherwise in the current country legislation

d) Bid bond levels: we take an average level of bid bonds and performance bonds for onshore wind and solar PV in the countries with an active auction framework

e) Penalties: we assume penalties where the bid bond and performance bonds are retained after the realization period has passed. We also assume that in this case the overall support contract is cancelled. The levels of bid bond retention penalties are the same as the bid bond levels, which we defined as described above

f) Realization periods: we take the average realization periods for the countries that have an active auction scheme, and differentiate this between solar PV and onshore wind

Table 9 presents the main auction and remuneration scheme designs that we use in the cash flow model. Since our cash flow model is yearly and not monthly, we convert the project realisation periods from months to years. Furthermore, not all countries have bid bonds and penalties in form of a fixed amount of EUR per kW. Estonia and Finland express their bid bonds in form of EUR/kWh, while Hungary expresses them in form of % of CAPEX. Since we know both the CAPEX levels and capacity factors for all countries and technologies, we convert these bid bond amounts and penalties into EUR/kW. We can do this since our model calculates bid levels on a per MW basis.

Finally, only a few countries express their penalties in forms other than a retention of the submitted bid bond and performance bond. France applies a two-stage support level reduction for its solar PV auction (0.00025 EUR/kWh in the first stage and 0.005 EUR/kWh in the second stage), while in case of solar PV Germany, Luxembourg and Malta apply a one stage reduction (0.003 EUR/kWh, 0.003 EUR/kWh and 0.005 EUR/kWh respectively). Ireland is the only country that applies a support duration penalty, equalling to a one-year reduction. While most countries apply their bid bond retention penalties after the final realisation period deadline and in one single blow, Germany applies a three-stage bond retention penalty in case of onshore wind, while Hungary and Slovakia apply this penalty type in two stages, both for onshore wind and solar PV. As we incorporate these designs into the cash flow model in yearly time steps, we are unable to differentiate between these multi-stage penalties. Instead, we assume that all bid bond retention penalties occur after the final realisation period deadline. However, this would most likely not make a large difference for the bid levels, since as default we assume only 5% probabilities for project outcomes where either a penalty is paid and the project is realised, or the project is not realised and the full penalty is paid.

Table 9. Auction and remuneration scheme designs used in the model

	Active auction framework	Year of auction round	Remuneration scheme	Support duration	Project realisation period	Inflation indexation	Amount of bid bond	Amount of performance bond
				[years]	[months]	[1 = yes, 0 = no]	[EUR/kW]	[EUR/kW]
AT-Wind Onshore	no		CfD	13	33	0	29.98	52.46
BE-Wind Onshore	no		Fix P	13	33	0	29.98	52.46
BG-Wind Onshore	no		Slid P	15	33	0	29.98	52.46
BG-PV	no		Slid P	15	28	0	25.85	42.34
CY-Wind Onshore	no		Slid P	15	33	0	29.98	52.46
CY-PV	no		Slid P	15	28	0	25.85	42.34
HR-PV	yes	2020	Slid P	12	36	1	6.63	39.77
HR-Wind Onshore	yes	2020	Slid P	12	48	1	6.63	39.77
CZ-Wind Onshore	no		Fix P	20	33	0	29.98	52.46
CZ-PV	no		Fix P	20	28	0	25.85	42.34
DK-PV	yes	2019	Fix P	20	24	0		26.31
DK-Wind Onshore	yes	2019	Fix P	20	24	0		77.45
EE-PV	yes	2020	Fix P	12	12	0	0.93	

EE-Wind Onshore	yes	2020	Fix P	12	12	0	2.37	
FI-PV	yes	2018	Slid P	12	36	0	1.65	13.18
FI-Wind Onshore	yes	2018	Slid P	12	36	0	5.08	40.65
FR-PV	yes	2019	CfD	20	20	1		30.00
FR-Wind Onshore	yes	2020	Slid P	20	36	1	30.00	
DE-Wind Onshore	yes	2020	Slid P	20	24	0	30.00	
DE-PV	yes	2020	Slid P	20	18	0	5.00	45.00
EL-PV	yes	2020	CfD	20	36	0	10.00	30.00
EL-Wind Onshore	yes	2020	CfD	20	36	0	12.50	37.50
HU-PV	yes	2019	CfD	15	36	1	16.39	38.23
HU-Wind Onshore	yes	2019	CfD	15	36	1	21.41	49.96
IE-PV	yes	2020	CfD	15	23	0	2.00	
IE-Wind Onshore	yes	2020	CfD	15	23	0	2.00	
IT-PV	yes	2020	CfD	20	24	0	50.00	50.00
IT-Wind Onshore	yes	2020	CfD	20	31	0	55.13	55.13
LV-PV	no		CfD	17	28	0	25.85	42.34
LV-Wind Onshore	no		CfD	17	33	0	29.98	52.46
LT-Wind Onshore	yes	2019	Fix P	12	22	0	14.48	
LU-PV	yes	2020	Slid P	15	18	0		50.00
MT-PV	yes	2018	Slid P	20	18	0		50.00
NL-PV	yes	2020	Slid P	15	48	0		
NL-Wind Onshore	yes	2020	Slid P	15	48	0		
PL-Wind Onshore	yes	2018	CfD	15	30	1	14.04	
PL-PV	yes	2018	CfD	15	18	1	14.04	
PT-PV	yes	2019	CfD	15	36	0	10.00	60.00
PT-Wind Onshore	no		CfD	17	33	0	29.98	52.46
RO-Wind Onshore	no		Fix P	15	33	0	29.98	52.46
RO-PV	no		Fix P	15	28	0	25.85	42.34
SK-PV	yes	2019	Slid P	15	21	0	75.00	
SK-Wind Onshore	yes	2019	Slid P	15	39	0	75.00	
SI-PV	yes	2020	Slid P	15	36	0		
SI-Wind Onshore	yes	2020	Slid P	15	36	0		
ES-PV	yes	2017	Slid P	15	36	0	60.00	
ES-Wind Onshore	yes	2017	Slid P	15	36	0	60.00	
SE-Wind Onshore	no		Fix P	15	33	0	29.98	52.46
UK-PV	yes	2015	CfD	15	43	1		
UK-Wind Onshore	yes	2015	CfD	15	43	1		

4.4 Results

4.4.1 Expected bid prices and sensitivity to investment inputs

Within this section we first address the research questions 1) *Under the current market conditions what would be the expected bid prices across the Member States?* and 2) *How do financing conditions affect bid prices in comparison to other investment variables?*

Figure 31 shows the results of the cash flow simulation, or the potential bid price levels in the analyzed countries. We divide the bid levels according to remuneration type, where the black columns indicate fixed premiums, the green ones contracts for difference and the red ones sliding premiums. The graph is a box plot where the central line shows the median value, the upper box the 75% quartile, the lower box the 25% quartile, and the whiskers the maximum and minimum values. In general, the countries that have fixed premiums achieve lower bid levels, but this is because of the nature of the fixed premium support scheme where producers receive a top up on the electricity price, while in sliding premiums and contracts for difference the projects have either a one sided or two-sided floor and ceiling remuneration price. Therefore, the bid levels between fixed premiums and contracts for difference/sliding premiums are not directly comparable. We first focus on the results from the perspective of financing costs and costs of capital, and afterwards we also comment on some other underlying investment assumptions of the cash flow calculations. For now, we comment only onshore wind results.

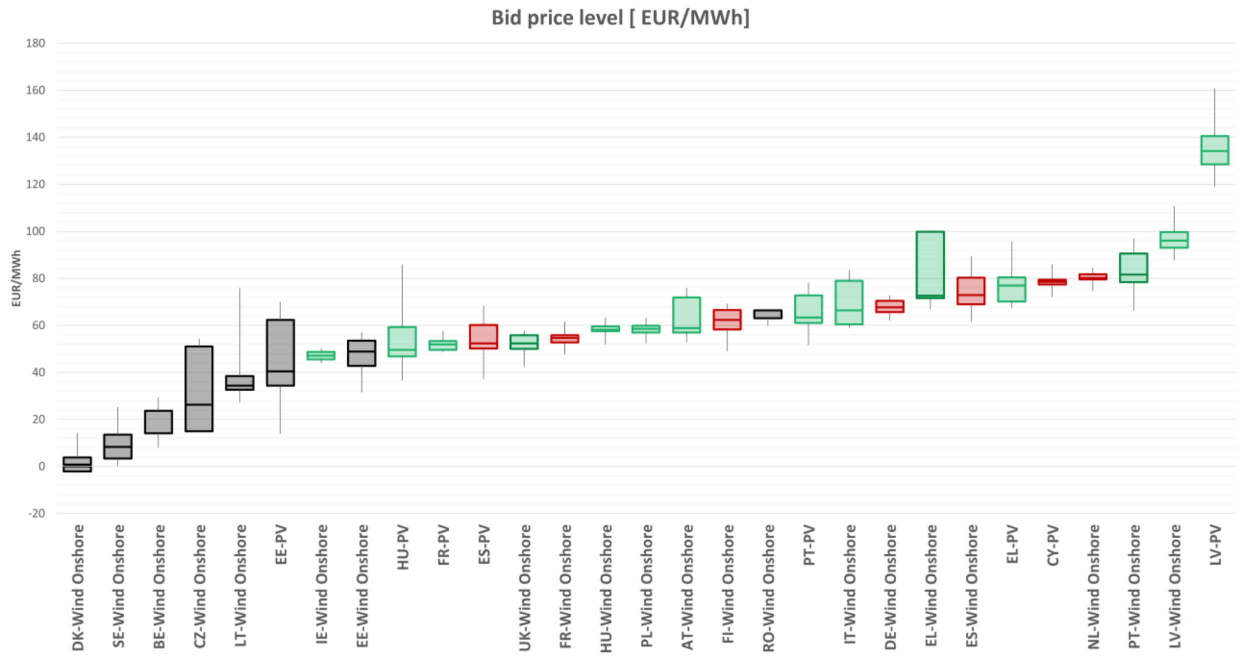


Figure 31. Expected bid levels for fixed premiums (black), contracts for difference (green) and sliding premiums (red)

The results reveal the following main observations in regards to bid levels within different remuneration schemes.

Among the **fixed premium** countries, the lowest bid levels would be achieved in Denmark, while the highest in case of onshore wind in Romania[29]. The difference in the overall WACC level between the two countries is around 4% - in DK the calculated WACC is 2.60%, while in Romania it is 6.78%. We present the other financing conditions and costs of capital values in. Within **sliding premiums,** we also observe a considerable difference among the countries. As the lowest bid level for onshore wind we outline France, and as the highest the Netherlands. It's worth pointing out that within the survey we collected very high DSCR and cost of equity values for the Netherlands. It is possible that these estimates are biased and not representative of the Dutch market. Consequently, the model calculates relatively low debt shares equaling 58.45% on average – levels that according to Section 2 we observe in markets like Sweden, where revenues are more exposed to market risks, due to its quota obligations scheme. According to the model and the survey inputs, onshore wind in France has much better financing conditions than onshore wind in the Netherlands – where the WACC in

[29] For the purpose of this exercise, we assume RO to have fixed premiums, since it currently has a quota system

France amounts to 2.51% and in the Netherlands 5.62%.

Finally, in regards to contracts for difference, we observe a larger difference between the lowest and highest bid levels than in case of the lowest and highest values in countries with sliding premiums. These are onshore wind in Ireland and in Latvia. The table below demonstrates some of the reasons behind this. The survey collected very high costs of equity values for Latvia, equaling to 19.17% on average. In contrast to this, we calculate lower debt shares in Ireland, but this again arises mainly due to differences in surveyed DSCR values (1.5 in IE and 1.1 in LV). As we pointed out earlier, the DSCR values were collected without taking into account P-value estimates, where the low DSCR value in Latvia could be for a P-90 estimate, while the value in Ireland for P-75 or P-50. Furthermore the differences in bid levels between these two countries are also due to much higher assumed capacity factors in Ireland than in Latvia – where the former has a capacity factor of 45% and the latter 28% (Dalla-Longa et al., 2018).

Table 10: Min and max bid levels and financing conditions for each remuneration scheme type

Bids in [EUR/MWh]	Mean bid	Median bid	CoE mean	CoD mean	DSCR	Loan tenor	Debt shares	WACC
Min and max bid levels, and financing costs – **fixed premiums** (onshore wind)								
DK-Wind Onshore	2.31	0.79	7.00%	1.38%	1.15	18.33	74.71%	2.60%
RO-Wind Onshore	63.84	62.98	10.00%	5.63%	1.25	10.00	61.05%	6.78%
Min and max bid levels, and financing costs – **sliding premiums** (onshore wind)								
FR-Wind Onshore	54.28	54.63	6.92%	1.72%	1.17	17.95	76.93%	2.51%
NL-Wind Onshore	80.44	80.13	11.50%	1.94%	2.00	15.00	58.45%	5.62%
Min and max bid levels, and financing costs – **contracts for difference** (onshore wind)								
IE-Wind Onshore	47.11	47.14	10.00%	3.50%	1.50	16.00	65.34%	5.46%
LV-Wind Onshore	97.14	96.05	19.17%	4.92%	1.10	11.00	80.57%	6.87%

The above differences in bid levels between the studied countries arise not only because of the different financing conditions and costs of capital, but also due to other underlying investment assumptions. Figure 32 shows the sensitivity of bid levels to changes in individual financing assumptions and capacity factors, OPEX and CAPEX values. For this calculation we assume the minimum, maximum and average surveyed financing inputs – therefore we deviate from the method of treating each survey input as an individual scenario. We conduct the analysis on just several countries and only for onshore wind – this includes Denmark that has a fixed premium remuneration scheme, Germany with a sliding premium scheme and finally the UK and Greece with contracts for difference. We choose these countries because they represent diverse remuneration schemes, and because our input data for them are reliable, meaning they were subject to minor manipulations. Furthermore, we define several sensitivity scenarios, as indicated in Table 11Table 11. Sensitivity analysis scenarios.

Table 11. Sensitivity analysis scenarios

Scenario	Description
Vary all Var	assume the best and worst inputs values for all parameters
Fin Var Vary	keep all investment variables constant and vary all financing variables together
Vary CoD	vary costs of debt from worst, average and best, keep everything else constant

Vary CoE	vary costs of equity from worst, average and best, keep everything else constant
Vary loan duration	vary loan duration from worst, average and best, keep everything else constant
Vary DSCR	Vary DSCR from worst, average and best, keep everything else constant
Vary capacity factor	Vary capacity factors + - 15%
Vary CAPEX	Vary CAPEX + - 15%
Vary OPEX	Vary OPEX + - 15%

As can be seen in Figure 32, varying all financing conditions and costs of capital together (scenario Fin Var Vary) has a smaller impact on the bid level in Denmark, than varying the capacity factors, while the effect of varying the CAPEX has almost the same magnitude. In Germany varying the capacity factor has almost the same effect as varying the financing conditions, while the effects of varying the CAPEX and OPEX are smaller. In Greece the variation in financing conditions produces a larger overall spread between the minimum and maximum bid levels, and overall, the impact of financing seems to be more relevant than capacity factors, CAPEX and OPEX. Finally, in the UK, the variation in bid levels is slightly smaller for the Fin Var Vary scenario, than for the scenarios where capacity factors are varied and almost the same as the variation in CAPEX. Subsequently, changes in individual elements of costs of capital and financing conditions have a smaller effect than varying individually the capacity factors, OPEX and CAPEX and this holds in all of the four observed countries.

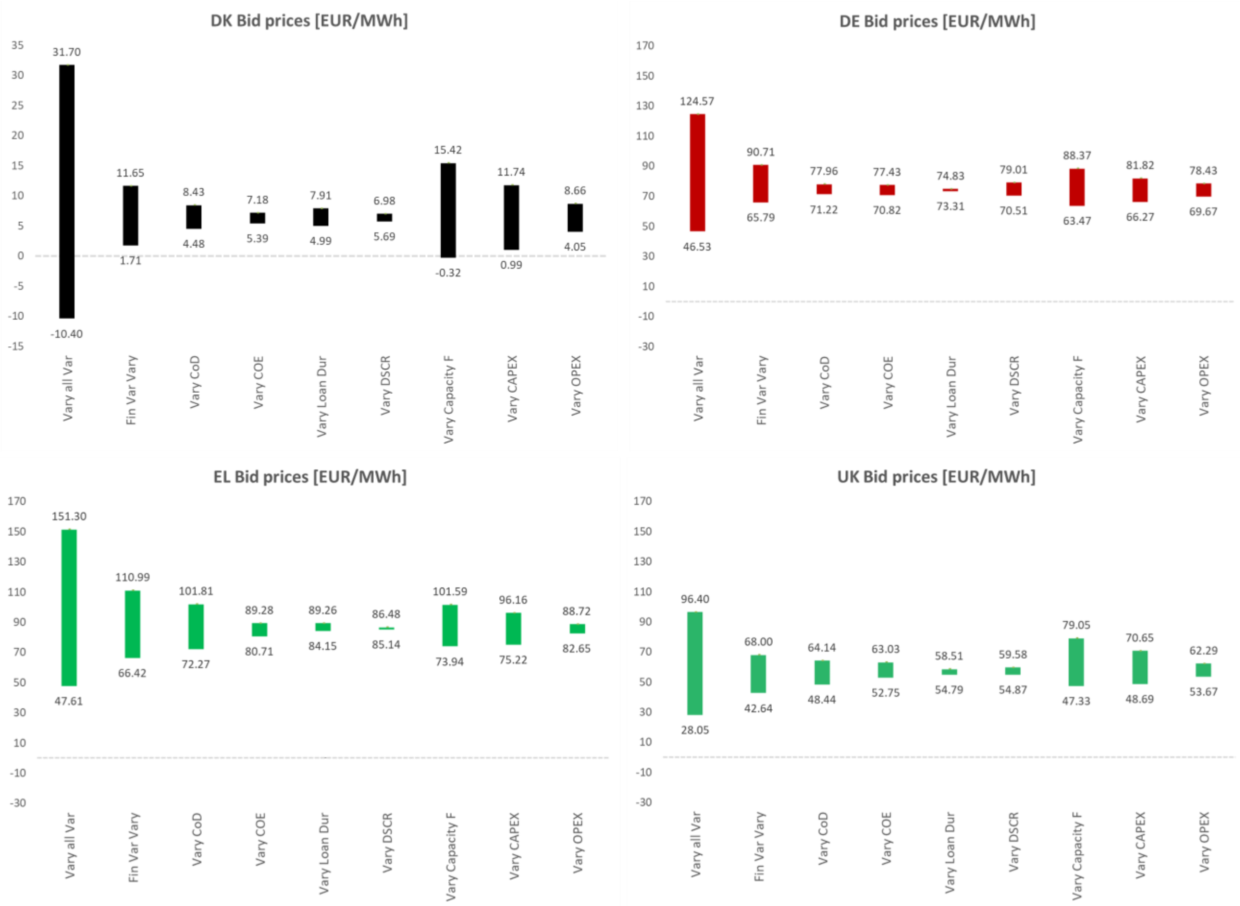


Figure 32. Sensitivity of bid levels to changes in individual financing assumptions and capacity factors,

OPEX and CAPEX values

In conclusion, bid levels differ across the EU not only because of financing conditions but because of many other underlying investment factors. While financing conditions contribute to this variation, we observe that their effect is almost the same as the effect of capacity factors and CAPEX values, in some of the observed cases. Furthermore, we observe that costs of equity have a relatively small impact on bid levels, indicating that policies that target lowering costs of equity would not create large additional benefits in terms of reducing bid levels. This implies that policies targeting de-risking of auction designs that effect bidders prior to submitting their bids – which in the context of this analysis mainly includes pre-qualification requirements – would nor derive substantial benefits. On the contrary, relaxing these requirements could create unwanted effects, such as potentially lower realisation rates of projects. Therefore, policies that target de-risking of these auction designs should mainly be intended for achieving other goals besides cost-efficiency, for instance increasing actor diversity.

4.4.2 Expected support cost levels under current market conditions

We now turn to addressing the third research question *3) What support costs would member states have under their current remuneration scheme designs, surveyed financing conditions and present market conditions?*

Cost-efficiency does not depend only on bid levels, instead it depends on the support costs that the government has to pay winners of the auctions. Figure 333 shows support costs, divided into groups of three different remuneration scheme types, where the green line shows the mean values for each country-technology support costs in case of contracts for difference, the black one in case of fixed premiums and the red one in case of sliding premiums. We represent these results in form of EUR/MW of installed capacity, over a 25-year project lifetime. There are large differences for each of the studied remuneration scheme designs. For instance, in regards to contracts for difference the UK would pay on average 291,846 EUR/MW, whereas in Latvia support costs would amount to 938,959 EUR/MW. In regarding to fixed premiums, the difference between Denmark as the lower and Romania as the highest value amounts to a 10-fold difference in support costs, while in regards to countries with sliding premiums the difference is smaller but still significant. For instance, Germany would have to pay 858,143 EUR/MW on average, whereas France 522,120 EUR/MW. These differences cannot be attributed only to different financing conditions, but also other underlying market conditions.

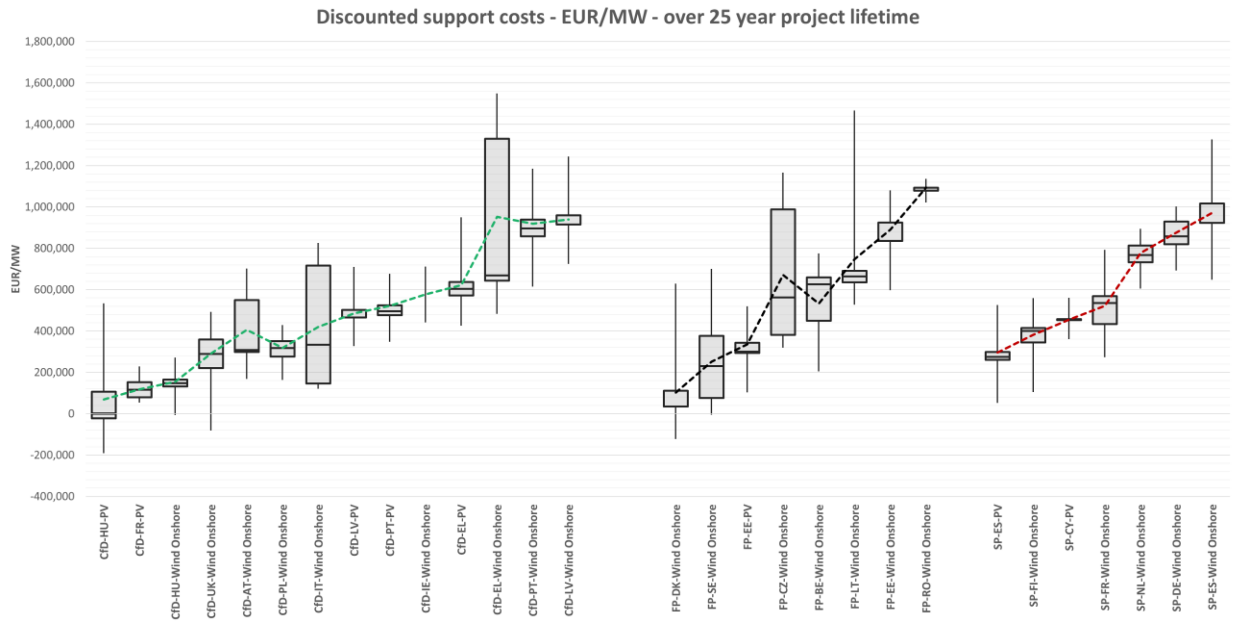


Figure 33. Discounted support costs over the projects lifetimes. Contracts for Difference (green line), fixed premiums (black line) and sliding premiums (red line)

When it comes to support costs the actual bid levels tell only half of the story. Since the remuneration schemes that we analyse allocate support depending on the assumed electricity price, support costs are directly a function of the difference between the calculated bid levels and assumed electricity prices (in case of Denmark they are same as the bid level, since in fixed premiums support is paid as a top-up on the electricity price). If we again investigate this issue by looking into onshore wind in the four countries that we analysed above – Germany, UK, Greece and Denmark – we can observe that spreads between the bid levels and electricity prices could also explain the variations in support costs. Figure 344 presents in the upper part the mean bid levels and the assumed capture prices (we describe the method of obtaining capture prices in Section 4.3.2.2). Unlike the UK where the bid level is adjusted for inflation - according to the reviewed auction designs - this is not the case in Germany, Greece and Denmark. Therefore, unlike in Germany and Greece, where the bid level remains fixed (as can be seen on the two horizontal lines in the upper segment of Figure 344), the adjusted bid level in the UK constantly increases. Furthermore, to demonstrate these differences, in the lower part of Figure 344 we derive the spreads between the mean bid level and capture prices in each country, and multiply this with the yearly electricity production at the P-50 level, and discount this with the social discount rate to arrive at the lifetime support costs per MW.

Figure 34. Mean bid levels, assumed capture prices and discounted support payments for Germany, UK, Greece and Denmark

As can be seen from the figure, over the project's lifetime Denmark would pay the least support costs per MW, while Greece would pay the most, although the difference to Germany is very small. While the better financing conditions in Germany reduce the bid level, the lower prices on the German wholesale electricity market and the lower overall market value factors increase the "bid level-electricity price spread". On a per MWh basis this spread is larger than in Greece, where the average wind capture price over the project's lifetime amounts to 53 EUR/MWh, while the same is 39.63 EUR/MWh in Germany. The differences in support costs per MW also arise because of the different capacity factors. Whereas we assume a capacity factor of 24% for Germany, our capacity factor for Greece is 28%, in part due to greater limitations of available surface areas with higher capacity factors in Germany[30]. Therefore, support costs on a per MWh basis in Greece, would actually be slightly smaller than in Germany.

To understand the relevance of costs of capital and financing conditions for support costs, we conduct a sensitivity analysis assuming the same scenarios as described in Table 11. The results of this are very similar to the sensitivity analysis of bid levels. Changing overall financing conditions (Fin Var Vary) has a lesser effect on support costs in Denmark and UK than varying capacity factors. In contrast the effect of changing financing conditions in Germany and in Greece is greater than changing any other investment input variable, especially in Greece where the effect of financing costs is twice as larger as changing either the capacity factors or the CAPEX values. In addition, varying the surveyed Greek costs of debt alone induces a larger effect than changing the capacity factor. However, this is because the spread of the min and max values for the surveyed costs of debt in Greece amounts to 5.5%, while the average for the other countries and technologies that we analyse is 2%.

These results imply that financing conditions alone cannot explain the variations in support costs and that other investment inputs play a major role, especially capacity factors and CAPEX values. In addition, due to the designs on the remuneration systems, the overall differences in support costs levels are largely influenced by the differences in capture prices and bid levels that make the projects NPV equal to zero.

[30] For further information on the assumed capacity factors please refer to Dalla-Longa et al. (2018)

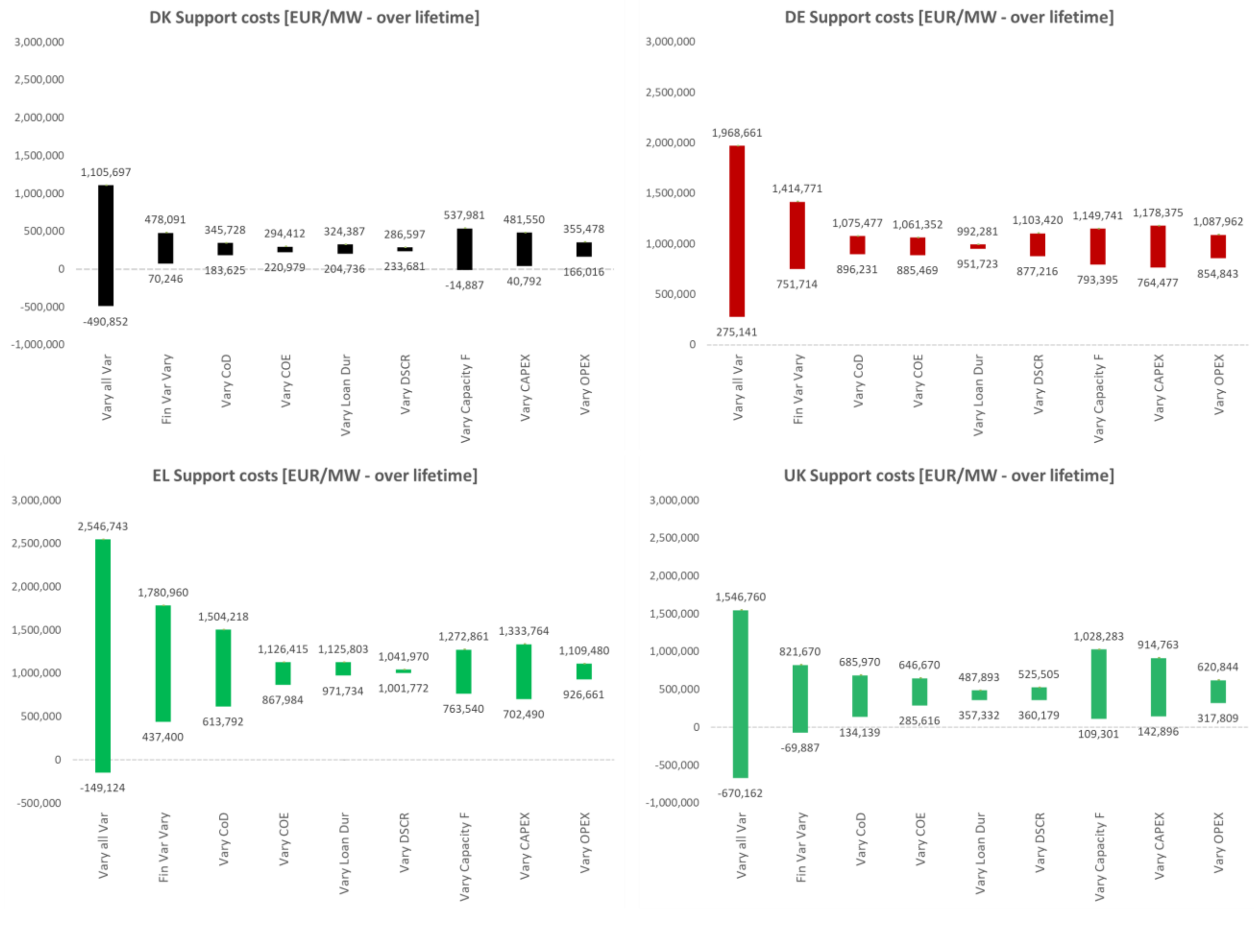


Figure 35. Sensitivity of support costs in EUR/MW to changes in investment inputs variables

As expected, considering the results of the previous section that analysed the effects on bid levels, support costs also depend on many more investment factors than the underlying auction scheme. Primarily this includes the market conditions, meaning the electricity price levels, the capture prices of solar PV and onshore wind and the difference of this to the submitted bid levels. This is mainly due to the design of the remuneration schemes that we studied, that are based on paying renewable electricity generators, a difference to the prevailing electricity price i.e reference price. As we observed in Figure 344, support payments in Germany that has a sliding premium scheme, would be almost the same on a per MW basis as support cost payments in Greece, simply because the assumed capture prices in Germany are is 39.63 EUR/MWh, while they are 53 EUR/MWh in Greece. This is regardless of the higher bid levels that are required to make Greek projects feasible (which are on average 81 EUR/MWh in Greece and 69 EUR/MWh in Germany – assuming market conditions which we described in Section 4.3.

4.4.3 Role of remuneration scheme designs on bid price levels and support costs

Finally, we turn to addressing the last research question *4) What role does the design of the remuneration scheme have on bid price levels and support costs?*

Research into the effects of different support schemes on financing cost and risk, shows that investors prefer schemes with greater revenue predictability (Bürer & Wüstenhagen, 2009). Support systems in which the premium amount is awarded as a top-up to the electricity price, expose investors to greater uncertainty in regards to future revenue flow (Couture & Gagnon, 2010), and might require greater remuneration levels to compensate for the additional risk (Kitzing, 2014; Kitzing, Juul, Drud, & Boomsma, 2017). Remuneration schemes like sliding premiums, might lead to lower levels of secured revenues, especially in combination with tendering, which in case of high competition incentivizes lower strike prices. In case of offshore wind, sliding premium schemes in Germany and the Netherlands have seen zero support bids (Musgens & Riepin, 2018) – a trend that makes investors secure their revenues through corporate Power Purchase Agreement. In contrast the UK Contracts for Difference scheme might be able to attract more debt financing, since it stabilizes revenues at the bid level (May, Neuhoff, & Richstein, 2018).

To summarise, the general status quo of the current research on remuneration schemes, bid levels and financing states that countries with contracts for difference should achieve lower financing costs and support costs, than projects in sliding premium and fixed premium schemes, because they stabilize revenues and can therefore attract better financing conditions. Based on the results of our analysis, we cannot fully confirm the above described state of research.

As indicated in Table 122 below, our analysis implies that countries with contracts for difference on average require lower support costs than sliding and fixed premium schemes. However, on average countries that have contracts for difference have a higher average calculated WACC, than countries with sliding premiums. The same holds for the average surveyed costs of equity and costs of debt values. Regarding other financing conditions, countries with CfD schemes seem to have the lowest DSCR values on average, while the survey records the longest loan tenors in countries with fixed premiums. DSCR values and loan tenors are indicators of financing risk, where lower DSCR values imply better financing conditions, as companies can take on larger debt sizes, while shorter loan tenors imply higher risk levels as banks strive to exit financing deals sooner. This would suggest that these two values should correspond with each other, where according to theory they should be the most favourable for contracts for difference and the least favourable for fixed premiums. However, this is not the case with the data that we surveyed.

Table 12. Average bid levels, support cost and financing conditions per remuneration scheme type

	BID LEVELS [EUR/MWh]		**SUPPORT COSTS [EUR/MW]**	
	Median	Mean	Median	Mean
contract for difference	69.08	71.12	438,307	485,153
sliding premium	57.96	67.33	601,964	611,368
fixed premium	23.66	32.19	552,556	577,997
	WACC (calculated)		**DEBT SHARES (calculated)**	
	Median	Mean	Median	Mean
contract for difference	4.52%	4.71%	69.31%	67.28%
sliding premium	3.72%	3.77%	72.08%	61.46%
fixed premium	4.96%	5.08%	69.50%	67.54%
	COE		**COD**	
	Median	Mean	Median	Mean
contract for difference	9.50%	9.69%	3.20%	3.36%
sliding premium	8.50%	9.48%	2.16%	2.98%
fixed premium	8.79%	7.89%	3.28%	2.13%
	DSCR		**LOAN TENOR**	
	Median	Mean	Median	Mean
contract for difference	1.23	1.23	14.04	13.84
sliding premium	1.37	1.39	14.94	13.21
fixed premium	1.36	1.38	13.15	15.32

Looking at the difference in support costs between Germany and the UK in Figure 355 above, would imply that contracts for difference achieve lower support costs than those with sliding premiums. However, it's not possible to generalise based on comparing two cases, as for instance in Denmark support costs are much lower than in either Germany or UK, whereas according to theory they should be higher because of higher exposure to electricity price fluctuations. This implies that risk depends on many more variables than the designs of remuneration schemes alone, for instance differences in country risks, market electricity prices and capacity factors (where larger capacity factors generate more revenue, and larger difference between Cash Flow Available for Debt Service and loan repayments).

4.5 Conclusions of the cash flow simulations

Within this chapter we investigate potential bid price levels under current market conditions for onshore wind and solar PV within the EU 27 and UK, while taking into account the results of the financing survey, presented in Sections before. In connection to this we also analyze the support costs that would arise from these bids. To assess the relevance of financing conditions and costs of capital on support costs and bid levels, we also conduct a sensitivity analysis of bid levels and support costs, taking into account variations in the surveyed financing inputs and other input variables that we assumed. We conduct the sensitivity analysis based on four countries with different remuneration schemes, and underlying risk levels and this includes Denmark, Germany, Greece and UK. Finally, we also asses the effect of different remuneration scheme designs on bid levels and support costs, whereby we test the current research status quo, where contracts for difference are assumed to deliver better financing conditions and lower support costs than sliding and fixed premiums.

Our findings lead to the following conclusions:

◦ While improving financing conditions - through for instance de-risking auction designs - could decrease bid levels, its effect is for average, mature EU markets not much more significant than the effect of other underlying investment parameters, mostly notably the capacity factor and CAPEX. Furthermore, the effects of changing costs of equity, through for instance investing into schemes that de-risk the pre-auction project development stage - through decreasing bid bond levels, lowering penalties, decreasing the extent of material pre-qualifications etc. - would not create significant additional benefits in terms of decreasing bid levels. From this it stems that policymakers should conduct such de-risking policies mainly to achieve other policy targets besides cost-efficiency, for instance increasing diversity of market actors. On the other hand, for single item auctions like offshore wind sites, de-risking strategies such as the government doing pre-development work on a site can make a country´s auction more attractive, encouraging competition and increasing cost-efficiency.

◦ Cost-efficiency from a societal point of view, does not only depend on improving financing costs and costs of capital, for instance by de-risking auction designs, but also on the underlying market conditions. Considering the design of the remuneration schemes that we studied, where the level of support payments depends on the difference between the bid level and the market electricity prices (seen on the market by onshore wind and solar PV – also known as capture prices), support cost levels are directly related to electricity price trends i.e variables that are exogenous to auction designs. Moreover, our analysis also shows that besides financing and costs of capital, capacity factors have a major effect on support costs. Among the four countries that we focus on in our sensitivity analysis, favorable wind conditions have a larger effect on support costs than financing costs in Denmark and UK. However, it’s worth pointing out that these two countries have among the best financing conditions in Europe, meaning that the variations in financing conditions that we surveyed are relatively smaller, than in other countries with worse financing conditions such as Greece, where varying financing conditions affect support costs more than any other investment variable.

◦ Nevertheless, improving financing conditions and costs of capital could still significantly reduce support costs, especially in higher risk countries such as Greece. Based on the results of our financing survey and our cash flow simulation, the difference in assuming worst case and best case financing costs in Greece would reduce support costs per MW for onshore wind from 1.780.960 EUR/MW to 437.400 EUR/MW. Smaller but still considerable effects would also be achieved in Denmark – a country with the least support costs for onshore wind in the EU, where substituting worst case with best case financing would reduce support costs from 478,091 to 70,246 EUR/MW. In the UK, best case financing costs would induce negative support payments i.e. producers would pay back the government 69.887 EUR per MW. Therefore, besides the relative importance of other underlying investment variables, de-risking financing conditions and reducing costs of capital could substantially reduce the cost of the energy transition. It's important to note that unlike capacity factors that are dependent on the availability of suitable surface areas, or CAPEX levels that depend on external factors such as innovation or economies of scale, financing costs are subject to equity and debt providers risk perception. Therefore, they are variables that could be improved by government intervention, at least to levels of other best in class infrastructure investments in a country (we mention this because even the best in class investments are exposed to the underlying country risk).

- Our cash flow analysis indicates contracts for difference would on average generate lower support costs than sliding and fixed premiums. However, our results also point out that on average countries with contracts for difference have higher calculated WACC values than sliding premiums, and lower WACC values than countries with fixed premiums. This is due to the country diversity underlying our analysis. Although Greece has a contract for difference remuneration scheme, its support costs are much higher than those in Denmark or Germany, simply because the underlying country risk is higher, and overall risk perception of renewable energy investment is worse. However, it would be worth investigating further the effects of replacing a remuneration scheme in one single country, for instance substituting sliding premiums in Germany with a CfD scheme.

5 Final conclusions

The Weighted Average Costs of Capital (WACC) is a key variable in any renewable energy project and countries with lower WACC values represent better opportunities for investors and overall increased chances of meeting the EU climate targets. Within the EU, the results collected through the survey showed that there is still a gap between countries with low WACC (e.g. Germany) and countries with high WACC (e.g. Latvia). Additionally, the vast majority of EU countries experienced a strong decrease of WACC values for RE projects (2014-2020).

As cost of capital is a key issue of further RE deployment, factors, in particular policies driving the WACC are at the centre of the analysis. From the interviews, we learnt that multiple reasons are behind the downward trend at the macro level: reduced country risks, interest rates development, technology improvements, new market actors shifting to RE, increased competition, and abundant and international capital flows.

The collected information of the interviews was further condensed and put into an econometric model that treats the WACC as endogenous variable. In a first step we compared the drivers of cost of capital discussed in literature with those collected in the interviews and set up a primary model. As main explanatory variables we included market structures, diverse risk aspects, experiences and policies. After further analyses we reduced the model and employed public support, market risks, natural conditions, technologies and country risks but also experiences in deployment of renewables and auctions as variables mainly impacting the WACC. To account for different aspects of the term country risks we applied three different variables accounting for economic, political and sovereign risks – economic growth, governance quality and government bonds.

The results for sovereign risk underpin the findings of the interviews and literature: an increase of one percentage point in government bond rates entails a rise of the WACC by around 0.6-0.8 percentage points. This explains the large differences in the WACC between countries. But surprising and interesting are the results for the auction and deployment variables: First, the presence of auctions does not have a negative effect on the WACC. i.e. it does not increase cost of capital, and second, the negative sign implies that a) with an increasing number of auctions, learning effects are present, i.e. project developers, investors and financing institutions become used to and more efficient in dealing with auctions, b) competition in auctions is passed through to the capital market, and c) with an increasing volume size, scale effects in cost of capital could occur. Moreover, increasing experience in deployment of renewables reduces the WACC by about 0.3 percentage points. These findings are in line with the interview results, pointing out that the WACC of RE projects has decreased. Regarding the impact of policies, the effect is indirect: even though the remuneration schemes display no significance, they reveal an effect through their impact on the significance of the variable "auction", meaning that policies or remuneration schemes that reduce the exposure to market risks tend to have a decreasing effect on the WACC.

On a more specific level, based on the cash flow simulation we find that EU markets could achieve the greatest reductions in support costs and bid levels by de-risking costs of debt. This could be achieved through introducing remuneration schemes that decrease revenue volatility – such as Contracts for Difference. This may lead to greater debt size, less expensive debt pricing and longer loan maturity. We can confirm that de-rising debt financing would lead to largest support cost savings based on our sensitivity analysis, which we conducted for the example of onshore wind in Denmark, Germany, Greece and UK. However, it's important to stress that on average the "CfD-countries" that we have analysed display higher WACC levels than countries with a sliding premium, but lower WACC levels than those with fixed premiums. This implies that financing costs and costs of capital do not depend only on support policies, but on many other external factors, for instance the country risk.

As opposed to de-risking debt financing i.e. making project cash flows less volatile during the project's lifetime, we find that measures to reduce costs of equity would have a lesser effect on support costs. These measures would aim at reducing the so-called allocation risk and qualification risk, as well as the risk of non-compliance (Dukan et al., 2019). Measures to tackle these risks include as relaxing pre-qualification requirements, reducing bid bonds, prolonging realisation deadlines etc. Therefore, policymakers should conduct such measures only if their goals are to achieve policy goals other than cost-efficiency, such as increasing actor diversity through reducing the above-mentioned risks of participating in auctions.

Overall, all analyses reveal that renewable policies mitigating market risks have a dampening effect on the WACC and that differences between the countries can be explained by the presence of differing sovereign risks, Finally, learning effects in RE deployment and auctions have taken place and reduce the cost of capital as the empirical analysis reveals.

6 Annex

6.1 Annex I

Research Template used for the interviews in focus countries:

***

Please provide some information about your background (interview partner)

1. **What are your contact details?**

First Name	Please enter text here
Last Name	Please enter text here
Organisation name	Please enter text here
Where is your organisation located?	Please enter text here

2. **What is your background in renewable energy investment?**

☐Project developing company

☐Energy unit of a large/energy intensive company

☐Utility/energy company/oil company

☐Investment fund

☐Private equity fund

☐Commercial bank

☐(Multilateral) public development bank

☐Insurance company

☐Pension fund

☐Energy cooperative

☐Other

3. What are your experiences in RES?

How many RES projects have you worked on (overall)- during the last 5 years?	Please enter text here
Which countries did you invest in in the last 5 years?	Please enter text here
How many employees work in your company (approximately)?	Please enter text here
What kind of financing do you typically use for your projects?	☐ project based ☐ balance sheet ☐ both

Quantitative part

Questions for the interviews:

Interview partner 1	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**Project 5**	**Project 6**	**Project 7**	**Project 8**	**Project 9**	**Project 10**
Wind Onshore / Offshore investments										
Country where the project is located										
WACC										
Debt/Equity ratio										
Cost of equity										
Cost of debt										
DSCR										
Loan Tenor										
Technology (please indicate in this field if the project is wind onshore or offshore)										
Size of project (or at least size categories)										
Time (year/date) either of the financial closure, or of the auction round										
Type of financing (project finance, balance sheet)										

Type of investors (Project developer, energy unit of a large company, utility, investment fund, private equity fund, commercial bank, multilateral development bank, insurance company, pension fund, energy cooperative, etc.)										
Project phase (i.e. planning, construction, operating)										
Additional support, e.g. financing from a development bank such as EIB, EBRD, WB, etc. Or grant?										
Completed construction										
PV 2018- 2019										
Country where the project is located										
WACC										
Debt/Equity ratio										
Cost of equity										
Cost of debt										
DSCR										

Loan Tenor										
Size of project (or at least size categories)										
Time (year/date) either of the financial closure, or of the auction round										
Type of financing (project, balance sheet)										
Type of investors (Project developer, energy unit of a large company, utility, investment fund, private equity fund, commercial bank, multilateral development bank, insurance company, pension fund, energy cooperative, etc.)										
Project phase (i.e. planning, construction, O&M)										
Additional support, e.g. financing from a development bank such as EIB, EBRD, WB, etc. Or grant?										
Completed construction										

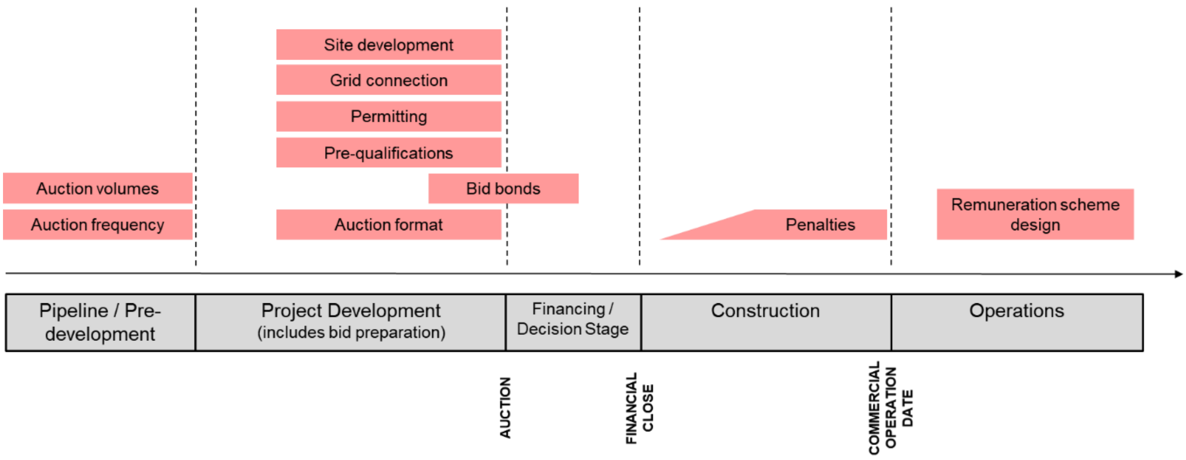
Qualitative part for focus countries

A) Did the financial indicators indicated below change after the introduction of auctions? If yes, can you please indicate how the indicators were before and after the auctions?

(assuming a p90 production scenario)	Before introduction of auctions	After introduction of auctions
Cost of debt (%)		
Cost of equity (%)		
DSCR (1.1, 1.2, 1.5 etc.)		
Loan tenor (years)		
D/E ratio (80/20, 70/30 etc.)		

B) Why have these changes occurred? Please list the according to you top 3 reasons of the changes above (reasons can be risks related to the project development – side of equity provider –, or risks on a project financing perspective – side of banks). Please also rank the reason(s) according to their importance between 1 and 3. *1 slightly important, 2 fairly important and 3 very important.*

C) Which of the below illustrated auction design elements (to what degree) do they affect your financing conditions listed in the table below? Please evaluate each of these design elements according to their effect in the countries you have experience in.



Please introduce the name of design elements of the graph above in the fields of the table below – which are applicable in the country where you have developed your project, i.e think of the specific design elements in your target country.

Country 1

Ranking	Cost of debt	Cost of equity	D/E ratio	DSCR	Loan tenor
Very large					
Fairly large					

Important					
Slightly important					
Not important					

***

Research template used in non-focus countries:

***

Please provide some information about your background (interview partner)

1. **What are your contact details?**

First Name	Please enter text here
Last Name	Please enter text here
Organisation name	Please enter text here
Where is your organisation located?	Please enter text here

2. **What is your background in renewable energy investment?**

☐Project developing company

☐Energy unit of a large/energy intensive company

☐Utility/energy company/oil company

☐Investment fund

☐Private equity fund

☐Commercial bank

☐(Multilateral) public development bank

☐Insurance company

☐Pension fund

☐Energy cooperative

☐Other

3. **What are your experiences in RES?**

How many RES projects have you worked on (overall)- during the last 5 years?	Please enter text here
Which countries did you invest in in the last 5 years?	Please enter text here
How many employees work in your company (approximately)?	Please enter text here
What kind of financing do you typically use for your projects?	☐ project based ☐ balance sheet ☐ both

Quantitative part

Please fill in the following table

Financial parameter	**WACC**	**Debt/Equity ratio**	**Cost of debt**	**Cost of equity**	**DSCR**	**Loan tenor**
Wind Onshore 2018						
Wind Offshore 2018						
PV 2018						
Wind Onshore 2019						
Wind Offshore 2019						
PV 2019						

***

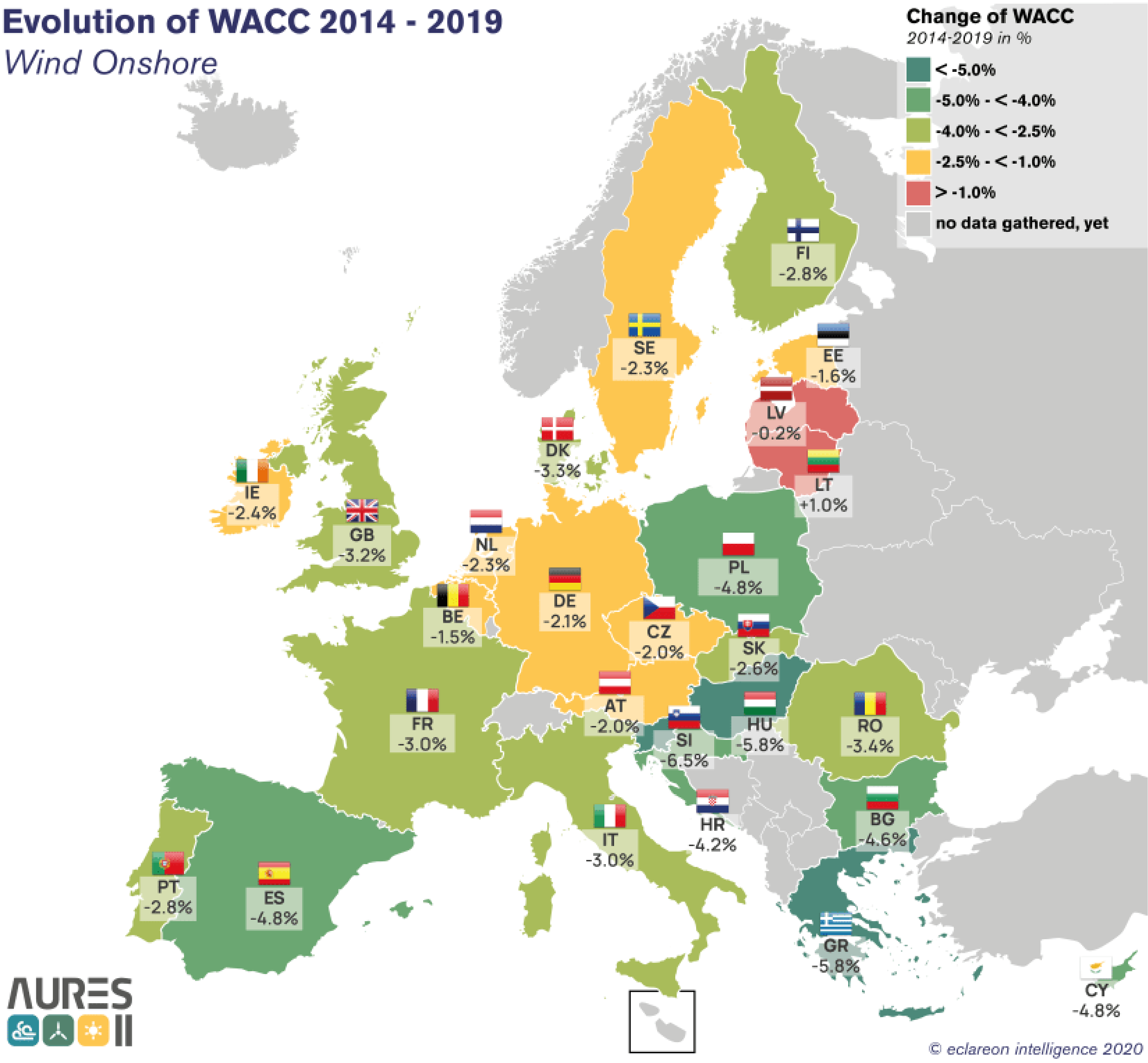


Figure 36. Evolution of WACC for wind onshore (2014-2018), difference in percentual points.

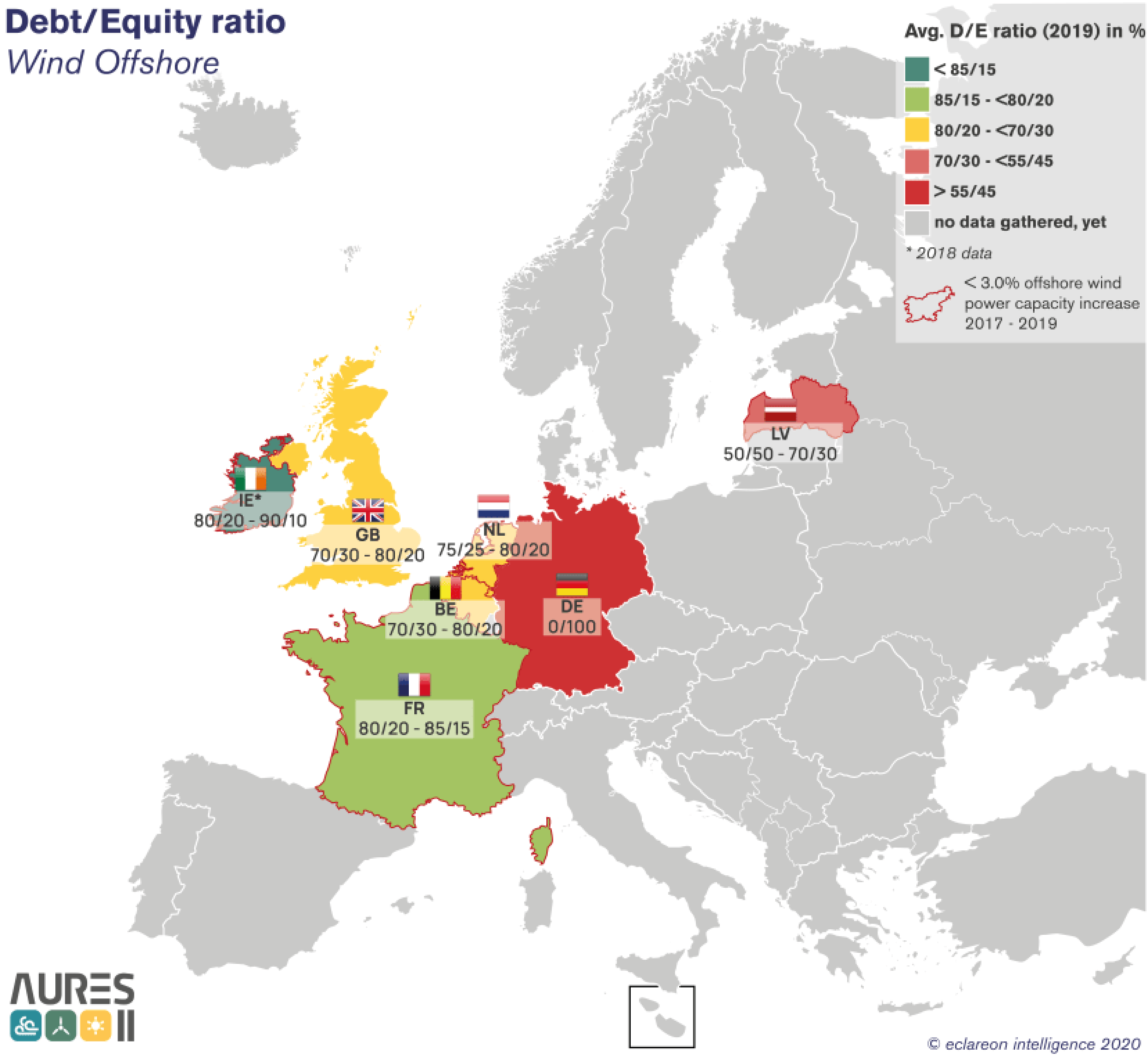


Figure 37. Debt to Equity Ratio for wind offshore (2019).

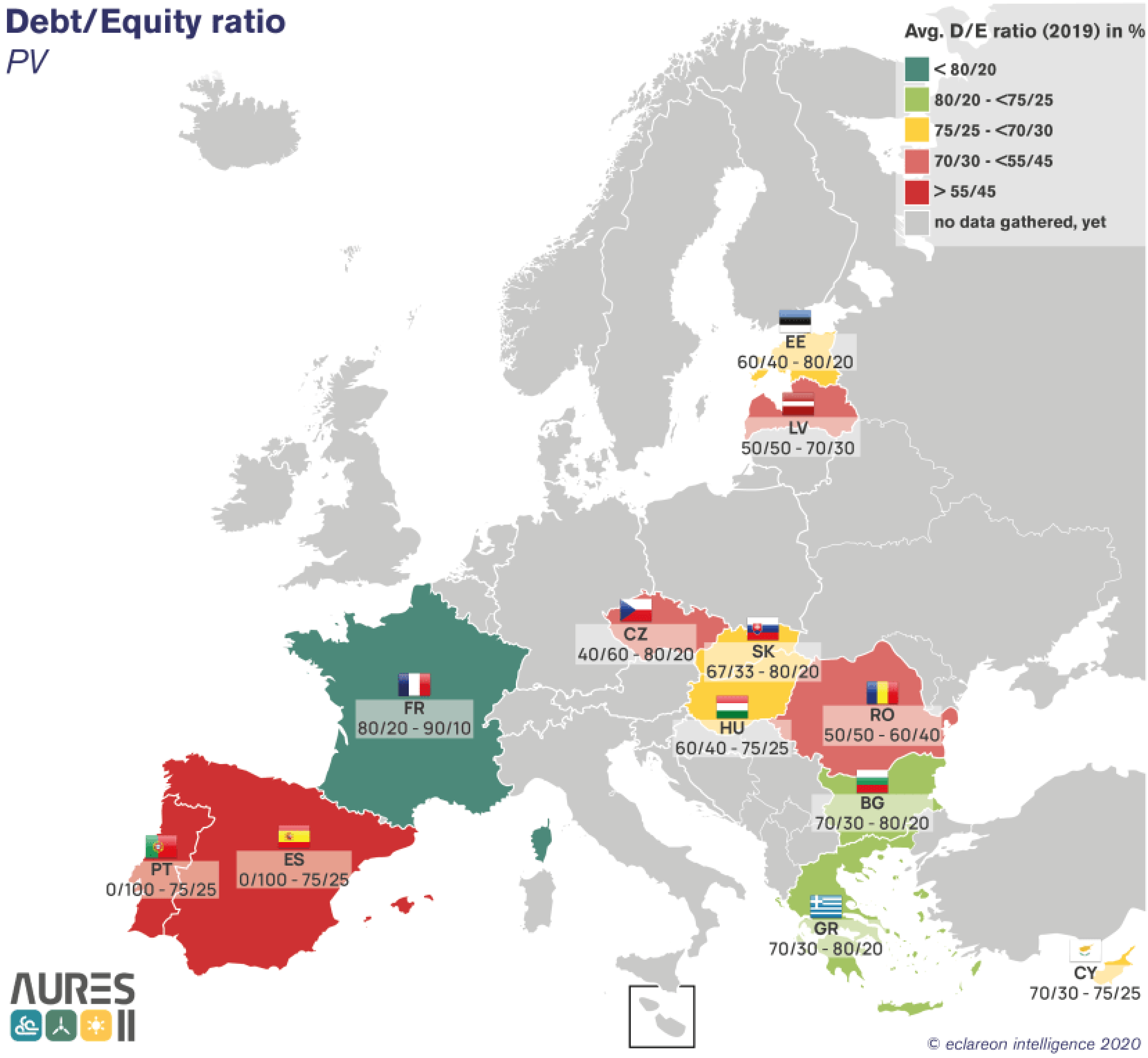


Figure 38. Debt to Equity Ratio for solar PV (2019).

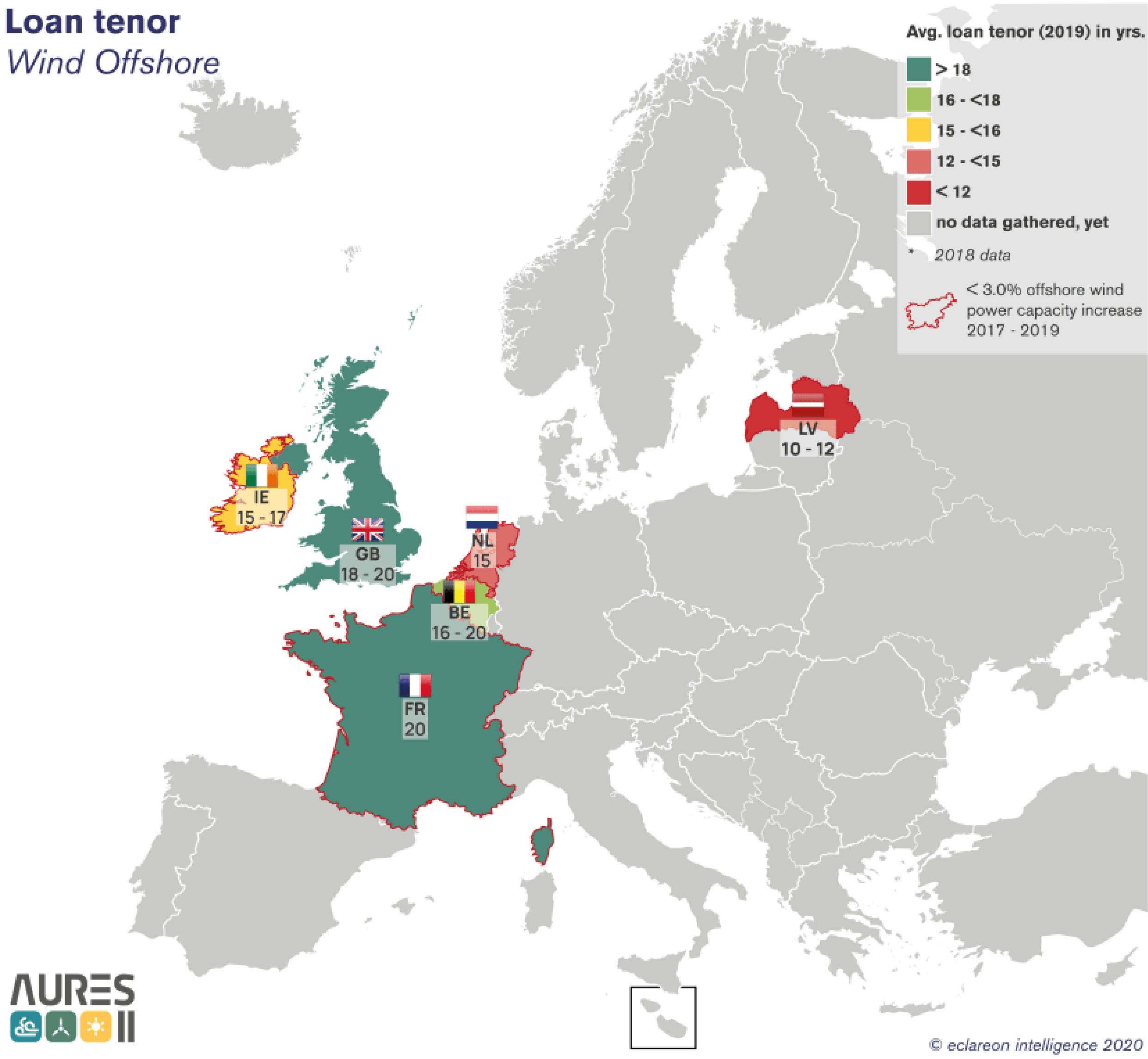


Figure 39. Loan Tenor for wind offshore (2019).

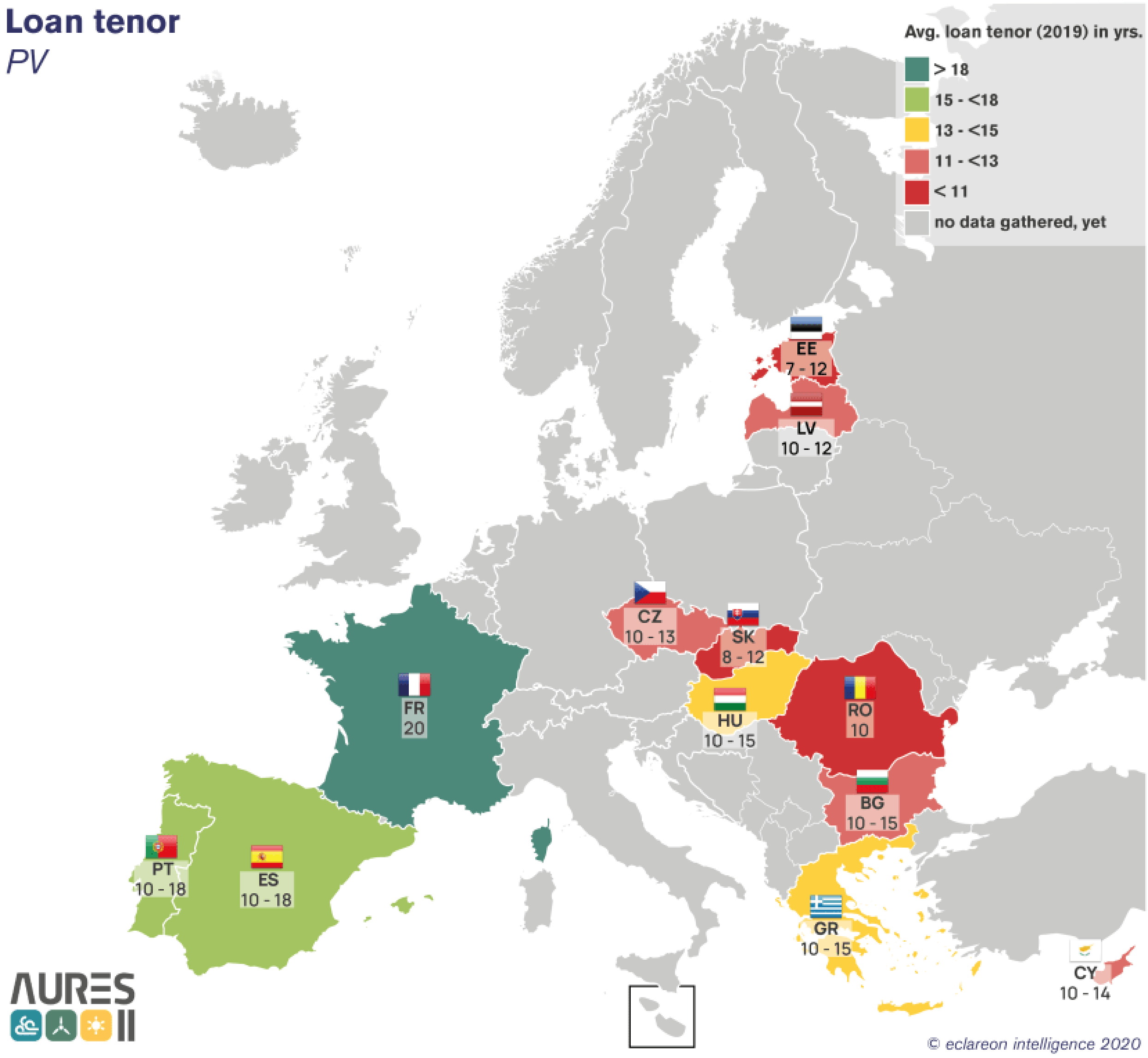


Figure 40. Loan Tenor for solar PV (2019).

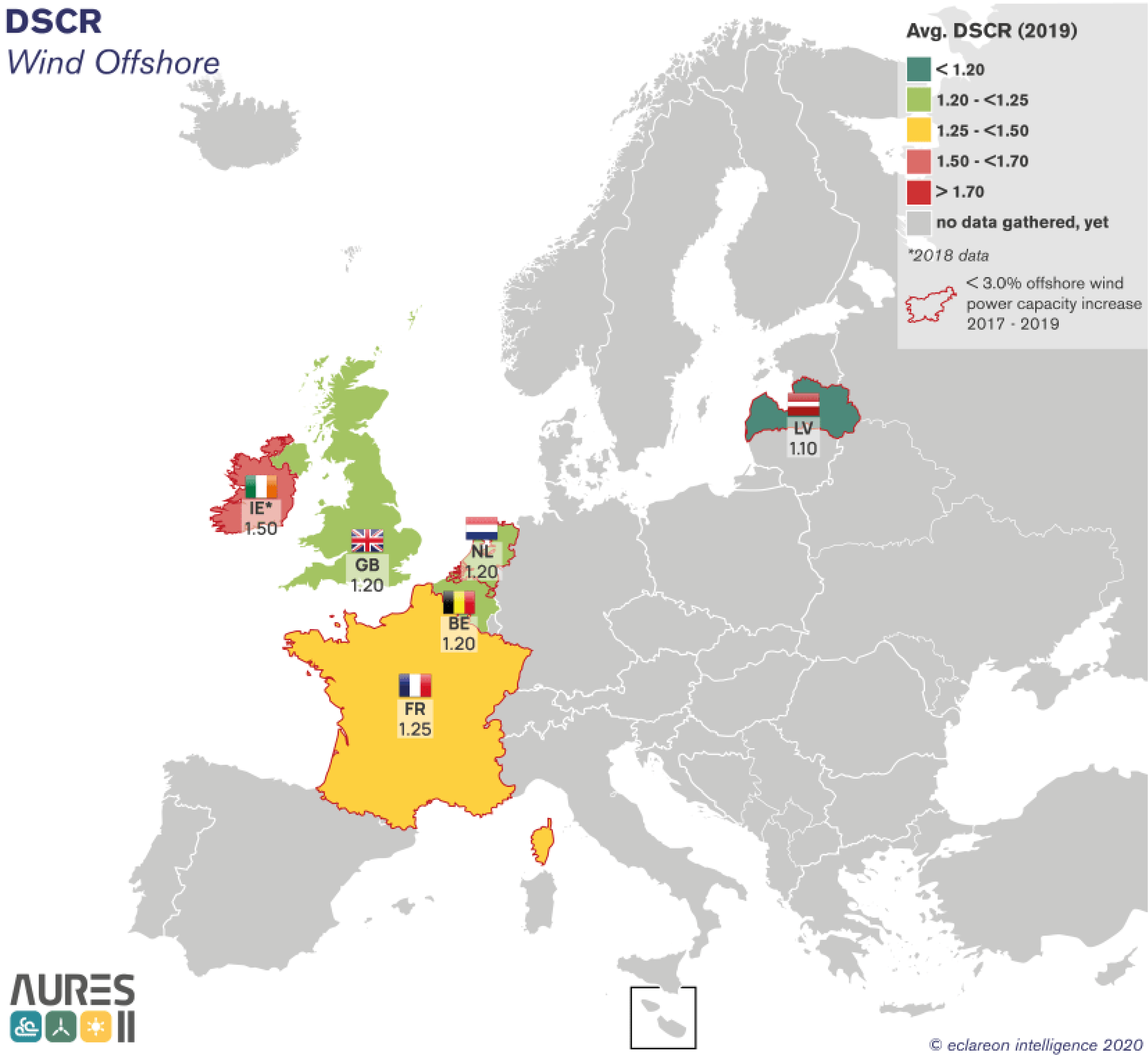


Figure 41. DSCR for offshore wind (2019).

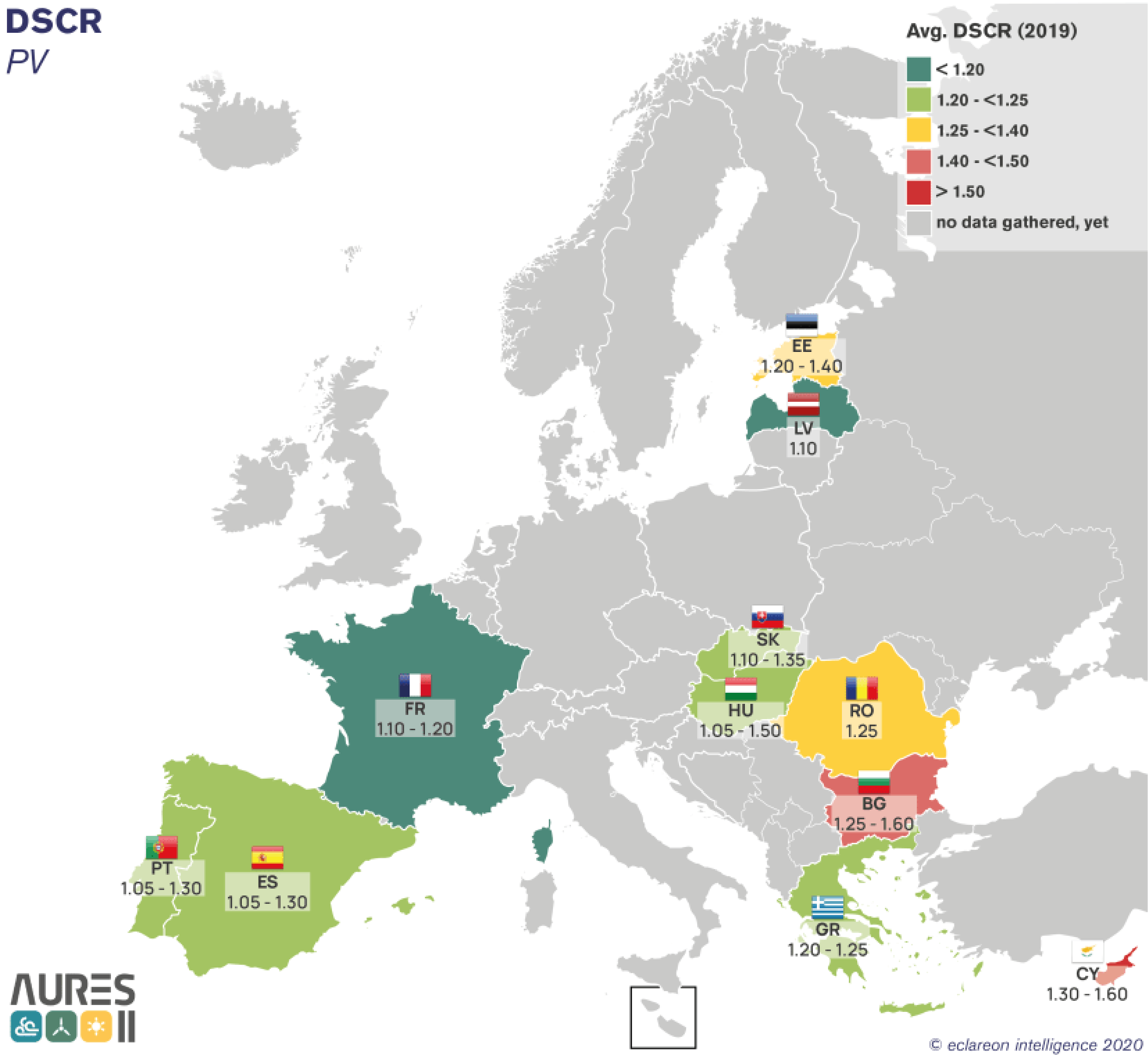


Figure 42. DSCR for solar PV (2019).

6.2 Annex II

Table 13. Preliminary Models

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
(Intercept)	0.044***	0.043***	0.042***	0.043***	0.043***	0.043***	0.043***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Natural Conditions	−0.000	−0.001	0.000	0.001	0.001	0.001	
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
Sector Experience	−0.004**	−0.002	−0.000	−0.001	−0.001	−0.001	
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	
Government Bonds		0.005***	0.005**	0.005**	0.006**	0.005**	0.005***
		(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Economic Growth		0.004**	0.003***	0.003*	0.003*	0.003	0.003*
		(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
Public Support			−0.000	0.000	0.000	0.000	
			(0.002)	(0.002)	(0.002)	(0.003)	
Governance Quality			−0.002*	0.000	0.001	0.001	
			(0.001)	(0.002)	(0.002)	(0.002)	
Auction Presence				−0.005***	−0.004*	−0.003*	−0.003*
				(0.002)	(0.002)	(0.002)	(0.002)
Low Market Risk					−0.002	−0.002	−0.001
					(0.002)	(0.002)	(0.002)
High Market Risk					−0.000	0.000	
					(0.002)	(0.002)	
Retroactive change						−0.000	
						(0.002)	
Long Term Security						−0.001	−0.001
						(0.002)	(0.001)
AIC	−494.298	−508.526	−506.165	−507.022	−503.877	−500.016	−511.148
BIC	−479.713	−489.080	−481.857	−480.284	−472.277	−463.553	−489.271
Log Likelihood	253.149	262.263	263.083	264.511	264.939	265.008	264.574
Num. obs.	84	84	84	84	84	84	84
Num. groups: organis	73	73	73	73	73	73	73
Num. groups: country	25	25	25	25	25	25	25
Var: organis (Intercept)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Var: country (Intercept)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Var: Residual	0.000	0.000	0.000	0.000	0.000	0.000	0.000

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Table 14. Comparison of models with different Random Effects

	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13
(Intercept)	0.044***	0.044***	0.042***	0.042***	0.043***	0.043***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Natural Conditions	0.003		0.001		0.001	
	(0.002)		(0.001)		(0.001)	
Sector Experience	−0.001		−0.001		−0.001	
	(0.002)		(0.001)		(0.002)	
Government Bonds	0.005*	0.005**	0.005**	0.005***	0.005**	0.005***
	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Economic Growth	0.003	0.002	0.003*	0.003**	0.003	0.003*
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Public Support	0.000		−0.000		0.000	
	(0.003)		(0.003)		(0.003)	
Governance Quality	0.002		0.001		0.001	
	(0.002)		(0.002)		(0.002)	
Auction Presence	−0.006**	−0.004**	−0.003*	−0.003*	−0.003*	−0.003*
	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Low Market Risk	−0.002	−0.001	−0.001	−0.001	−0.002	−0.001
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
High Market Risk	−0.000		0.001		0.000	
	(0.003)		(0.002)		(0.002)	
Retroactive change	−0.000		0.000		−0.000	
	(0.003)		(0.002)		(0.002)	
Long Term Security	−0.000	−0.000	−0.001	−0.001	−0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
AIC	−494.580	−503.527	−501.932	−513.121	−500.016	−511.148
BIC	−460.549	−484.081	−467.901	−493.674	−463.553	−489.271
Log Likelihood	261.290	259.764	264.966	264.560	265.008	264.574
Num. obs.	84	84	84	84	84	84
Num. groups: country	25	25			25	25
Var: country (Intercept)	0.000	0.000			0.000	0.000
Var: Residual	0.000	0.000	0.000	0.000	0.000	0.000
Num. groups: organis			73	73	73	73
Var: organis (Intercept)			0.000	0.000	0.000	0.000

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$

Table 15. Model with categorical market risk

	Model 25	Model 26	Model 27	Model 28	Model 29
(Intercept)	0.039***	0.042***	0.042***	0.042***	0.040***
	(0.004)	(0.001)	(0.001)	(0.001)	(0.003)
Natural Conditions	0.000	0.000	−0.000		
	(0.001)	(0.001)	(0.001)		
Sector Experience	−0.001	−0.001	−0.001		
	(0.001)	(0.001)	(0.001)		
Government Bonds	0.005**	0.005**	0.004*	0.006***	0.005***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
Economic Growth	0.003**	0.003**	0.003*	0.003**	0.003**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Governance Quality	−0.000	−0.001	−0.001		
	(0.002)	(0.002)	(0.003)		
Public Support	0.000	0.000	0.000		
	(0.001)	(0.002)	(0.002)		
Auction Presence	−0.003	−0.003	−0.002	−0.003*	−0.003*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Categorical Market Risk	0.002				0.002
	(0.002)				(0.002)
Low Market Risk		−0.002	−0.001	−0.001	
		(0.002)	(0.002)	(0.002)	
High Market Risk		0.000	0.000		
		(0.002)	(0.002)		
Retroactive change			0.001		
			(0.002)		
Long Term Security			−0.001		
			(0.002)		
AIC	−506.345	−504.497	−501.782	−513.657	−513.517
BIC	−479.606	−475.327	−467.751	−496.642	−496.501
Log Likelihood	264.172	264.249	264.891	263.829	263.758
Num. obs.	84	84	84	84	84
Num. groups: organis	73	73	73	73	73
Var: organis (Intercept)	0.000	0.000	0.000	0.000	0.000
Var: Residual	0.000	0.000	0.000	0.000	0.000

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

Table 16. Models with all technologies, with and without a dummy for wind offshore.

	Model 21	Model 22	Model 23	Model 24	Model 25	Model 26
(Intercept)	0.042***	0.042***	0.042***	0.042***	0.042***	0.042***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Wind Offshore	−0.000		−0.000		−0.001	
	(0.003)		(0.003)		(0.003)	
Natural Conditions	0.001	0.001	0.001	0.001		
	(0.001)	(0.001)	(0.001)	(0.001)		
Sector Experience	−0.000	−0.000	−0.000	−0.000		
	(0.001)	(0.001)	(0.001)	(0.001)		
Government Bonds	0.006***	0.006***	0.007***	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
Governance Quality	0.000	0.000	0.000	0.000		
	(0.002)	(0.002)	(0.002)	(0.002)		
Public Support	0.002	0.002	0.001	0.002		
	(0.002)	(0.002)	(0.002)	(0.002)		
Economic Growth	0.002	0.002	0.002	0.002	0.002	0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Auction Presence	−0.004**	−0.004**	−0.004**	−0.004**	−0.003**	−0.003**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Low Market Risk	−0.001	−0.001	−0.002	−0.002	−0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
High Market Risk	−0.000	−0.000	−0.000	−0.000		
	(0.002)	(0.002)	(0.002)	(0.002)		
Retroactive change			−0.000	−0.000		
			(0.002)	(0.002)		
Long Term Security			0.000	0.000		
			(0.001)	(0.001)		
AIC	−566.064	−568.041	−562.096	−564.074	−573.297	−575.200
BIC	−533.001	−537.522	−523.946	−528.468	−552.950	−557.397
Log Likelihood	296.032	296.021	296.048	296.037	294.648	294.600
Num. obs.	94	94	94	94	94	94
Num. groups: organis	76	76	76	76	76	76
Var: organis (Intercept)	0.000	0.000	0.000	0.000	0.000	0.000
Var: Residual	0.000	0.000	0.000	0.000	0.000	0.000

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

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AURES II is a European research project on auction designs for renewable energy support (RES) in the EU Member States.

The general objective of the project is to promote an effective use and efficient implementation of auctions for RES to improve the performance of electricity from renewable energy sources in Europe.

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