ENERGY TRANSITION READINESS INDEX

2021

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CONTENTS

This report has been prepared for the Association of Renewable Energy and Clean Technology (REA) by Bob Hull. He is an independent consultant with over 30 years of experience in the power and utility industry in the UK and worldwide, formerly holding senior leadership roles with Ofgem, National Grid, and KPMG.

Foreword

What does it mean for a nation to be 'ready' for the energy transition to support a Net Zero future? More importantly how is this interpreted by vital investors and developers of renewable energy and clean technology projects? What are the measures to help them decide where to direct their efforts and support the growth of a net zero economy? Whilst public and political support for action is growing, countries are driving change to energy markets to facilitate this transition at substantially different rates.

Since the REA's first Energy Transition Readiness Index (ETRI) report in 2019, it is assuring to see that all nine countries from our first report are now committed to delivering a Net Zero energy system. The energy transition, enabled by flexibility market reform of electricity systems, is already well underway in many European countries, enabled by public policy, regulation, power markets, and technology, but the pace of progress varies. Our second ETRI report – once again prepared for the REA by Robert Hull and sponsored by Eaton – acknowledges these ambitions, but assesses the subsequent actions and the progress made too.
Now reporting on an additional three countries, we use these key measures:

- Socio-political support for the energy transition
- Ability to exploit new technologies and business models
- Open market access for flexibility services

ETRI 2021 demonstrates the huge flexibility market challenge that Europe faces in reaching the 2030 decarbonisation targets.

In particular, as a UK-based trade association, the REA are pleased that our country's Government and Ofgem (the regulator) have made steady progress over the past two years. However, the promise of pilot schemes and demonstration projects must now be converted into concerted market development. Indeed, the Government's own Smart Systems and Flexibility Plan recognises that an additional 20GW of flexibility will be needed by 2030, with a further 30GW required by 2050.

It is critical that the broad commitment to Net Zero is matched by an acceleration of a system transition that is smarter, decentralised and, ultimately, secure. The UK and Europe has the potential to become global leaders for flexibility services and deliver the benefits of renewables to all energy consumers. Yet this is an opportunity that cannot wait – it must be grasped now.

Dr Nina Skorupska CBE FEI
Chief Executive, REA

1. Executive summary

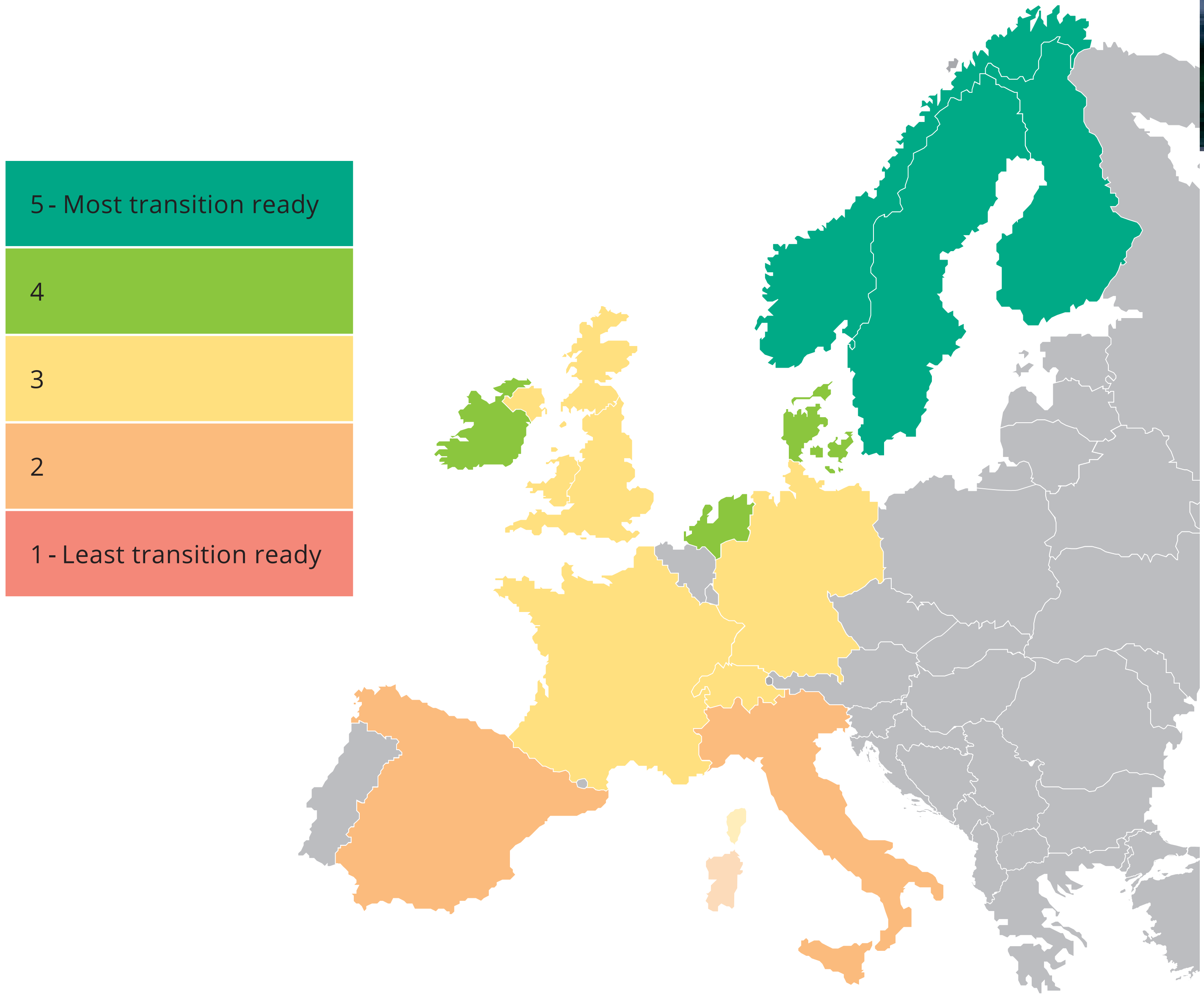
Countries across Europe have already set ambitious renewable electricity targets for 2030 to help meet decarbonisation goals, leading to rapid growth in renewable electricity generation and low carbon distributed energy technologies. But these targets may not be sufficiently ambitious as climate change impacts become more critical, and renewable electricity targets are likely to increase.

Flexibility in the consumption or generation of electricity is of vital importance to enable a high renewable electricity system. Rapid growth in variable renewable electricity generation, in particular wind and solar, means that vastly more low carbon flexible electricity resources are also needed to keep the balance of generation and consumption. The growth needed in these new flexibility resources offers major new investment opportunities, but easy access to electricity markets is needed to enable this investment.

We have engaged with experts across twelve Western European countries to assess and compare the transition of electricity flexibility markets in each country. In our second Energy Transition Readiness Index report, we have ranked each of these countries according to progress against:

- Socio-political support for the energy transition
- Ability to exploit new technologies and business models
- Open market access for flexibility services

Overall country rankings from this analysis are shown below:



The report shows that the energy transition, including flexibility market reform, is well underway in these countries, enabled by policy, market reforms and technology, but the pace of change varies.

All countries show strong ambition towards decarbonisation targets, but the higher-ranking ones have flexibility markets that better deliver fair, transparent, and simple access for all participants. Investment by new flexibility providers is encouraged through clear price signals and policies to enable flexibility technologies. Lower ranking countries have flexibility markets and policies that present barriers to investment by being complex, slow to change, and dominated by incumbents.

Overall, the report concludes that most countries are facing a huge flexibility challenge and prompt action is needed to achieve energy transition targets. The report has three main recommendations:

- **Quantify future flexibility needs:** the vast increases in flexibility resources needed to enable 2030 decarbonisation targets should be defined and should drive market and policy reforms.
- **Prioritise and accelerate flexibility market reforms:** policies to enable wider participation in flexibility markets must accelerate if the energy transition is not to be put at risk.
- **Design flexibility markets to attract investment:** reforms must create fair and predictable markets that give investment confidence to a wide range of potential new providers.

2. Introduction

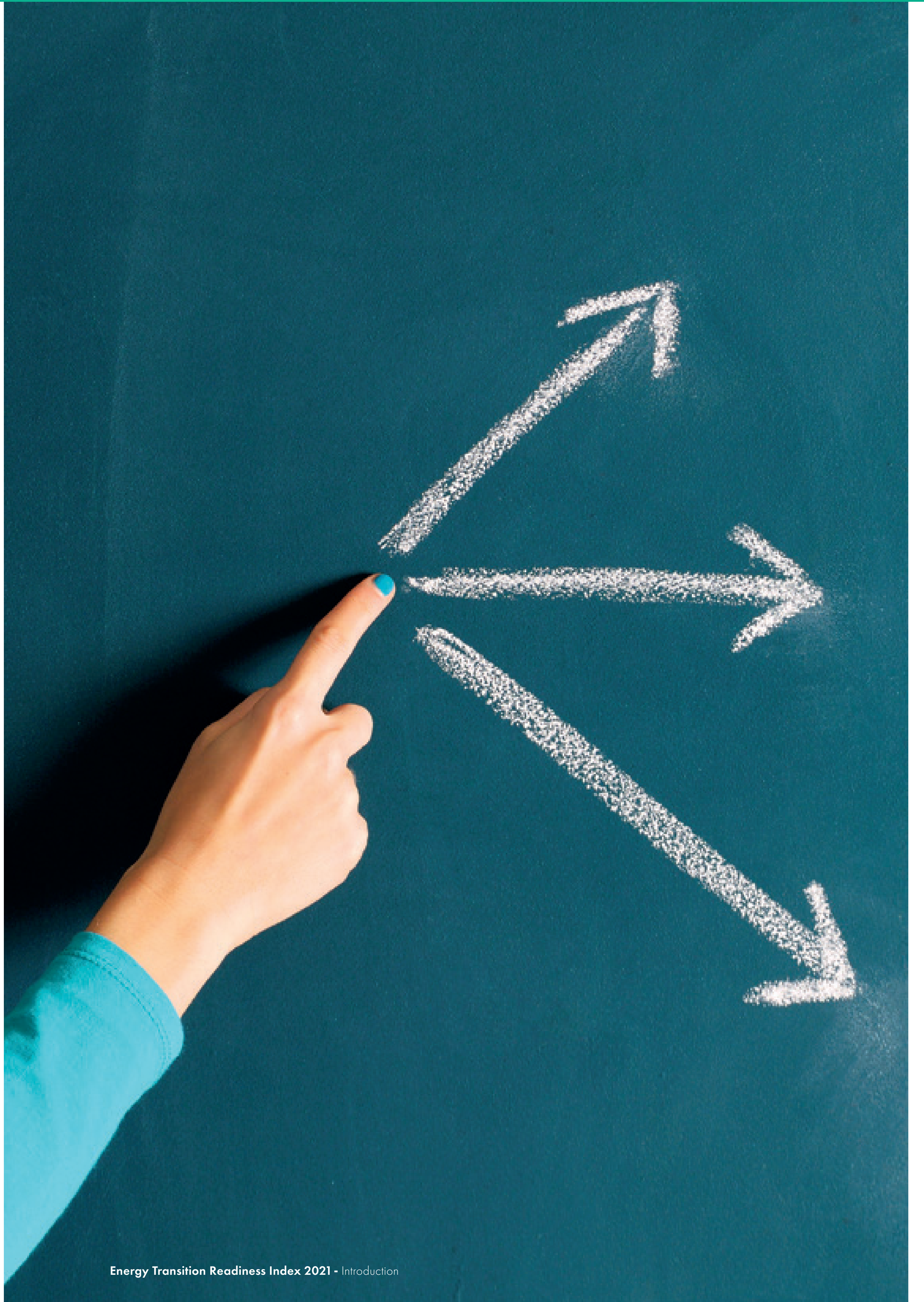
The 2021 ETRI report

In November 2019, the Association for Renewable Energy & Clean Technology (REA) published the first Energy Transition Readiness Index (ETRI). The report assessed the readiness of selected European electricity markets for the energy transition, from the perspective of private investors in flexibility services that support the deployment of renewable power and decarbonisation. This report assessed progress across nine Western European countries. The Netherlands, Norway, Sweden, Finland, Denmark, and Ireland ranked highest while Germany, UK and France lagged behind.

This 2021 ETRI study updates the ranking of the original nine countries to measure progress over the last two years, and has added Italy, Spain, and Switzerland, making a total of 12 countries. The report describes some of each country's key electricity market characteristics, assessing the current and future need for flexibility resources. Selected case studies have been included to demonstrate emerging best practices relating to the development of flexibility markets and technologies.

As for the 2019 report, the assessment and scoring were based on a survey of experts representing private investors in flexibility technologies across the different countries/ regions selected, followed up by one-to-one interviews to understand the underlying reasons for responses.

Grid stabilisation and flexibility services will support the further deployment of renewable power and clean technology systems - both at large and small scale. This report includes some specific recommendations for flexibility market policies that could help to 'level-up' to the best practices.



WHAT ARE FLEXIBILITY SERVICES?

The demand for flexibility services is increasing as vast new sources of variable renewable energy are added and replace the large fossil-fuel generators that have mainly provided these services in the past. Electricity systems must be able to operate in circumstances where renewable energy generation may vary significantly from minute to minute.

Flexibility is defined as the ability of electricity generation or customer demand to increase or decrease output. It is needed to respond to changing electricity system conditions and does this by providing flexibility services to electricity markets. These services provide support to balance generation and demand and stabilise the electricity system within operational limits especially when unexpected changes occur. The key flexibility resources are:

- Power flexibility – capacity for ramping up or ramping down electrical power output as needed to meet highly variable levels of demand, including holding output for use in reserve.
- Frequency flexibility – providing frequency response through rapid changes in output, including holding capability in reserve,
- Stability flexibility – providing sufficient levels of system inertia, dynamic voltage control, and short circuit management to maintain stability, including holding capability in reserve,
- Voltage flexibility – providing the capability to generate or absorb reactive power to manage voltage levels, including holding capability in reserve,
- Restoration – black start capability to restore the power system.

This transition to low carbon flexibility resources and growth has meant that new providers of flexibility services are emerging, including distributed generation, energy storage, demand response, and interconnection. These new providers can face challenges to investment and deployment because of barriers in accessing flexibility markets. These barriers may be technical e.g., certifications, metering, or grid connection, or commercial e.g., high trading costs or restrictive market rules.

3. Energy Transition Readiness Index - approach

Background

This paper sets out the results of a review of 12 European electricity markets. We have presented an index of market attractiveness for new investors in energy system flexibility capabilities, ranking the countries in terms of their relative attractiveness. The study has used publicly available information and interviews with an expert panel to determine the scores against detailed ideal state criteria.

Each of these markets has different characteristics - for example, Great Britain and Ireland have less flexible electrical interconnections with each other or with European electricity markets, resulting in different requirements for flexibility services. There are also different generation characteristics. Norway benefits from a large volume of flexible hydro generation, France has a sizeable supply of power from its nuclear plant, and other countries have different levels of renewable electricity capacity. Some countries are reliant on interconnector imports for flexibility. There are different market designs, product definitions, and operational practices as well.

While there are significant differences between markets, our analysis has considered the attractiveness of each market from the perspective of new investors and how they might perceive the attractiveness of each individual market, taking key differences into account.

APPROACH TO EVALUATION

In performing our evaluation, the key questions that have been asked are:

- Do the regulatory and market arrangements enable or restrict new investment in flexibility services?
- Is the socio-political background supportive or an impediment to investment?
- Are measures in place to help develop and deploy flexibility technologies?

These questions have been structured into the following assessment framework, which examines the key transition factors in each area.

Transition factors

Socio-political support

- Flexibility needs are recognised
- Supportive political and public consensus
- Public policy and regulation aligned

Technology potential

- Grid accessibility
- EV infrastructure deployment enabled
- Digitalisation enabled
- Innovation enabled

Market access

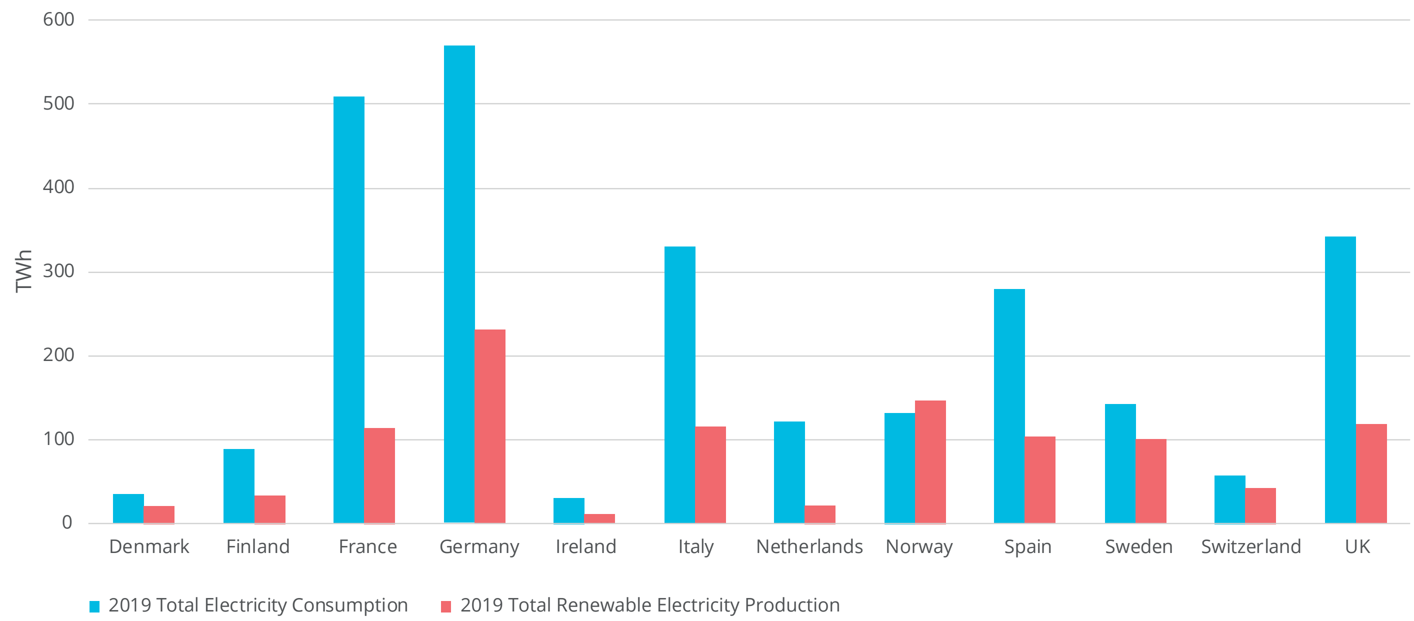
- Regulation enables fair access for all providers
- Trading - markets are open and effective
- Transaction costs are fair for flexibility

4. Electricity market characteristics

European renewable electricity - today[1]

Each country in the survey has previously set 2020 targets for the percentage of their electricity consumption to be supplied by renewable electricity. The following chart and table show the TWh, and percentage of electricity generated by all renewable resources i.e., wind, hydro, solar, biomass and geothermal (but excluding nuclear) during 2019.

2019 TOTAL RENEWABLE ELECTRICITY PRODUCTION



2019 ALL RENEWABLES AS A PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION

Country	%
Denmark	65%
Finland	38%
France	22%
Germany	41%
Ireland	36%
Italy	35%
Netherlands	18%
Norway	111%
Spain	37%
Sweden	71%
Switzerland	74%
UK	35%

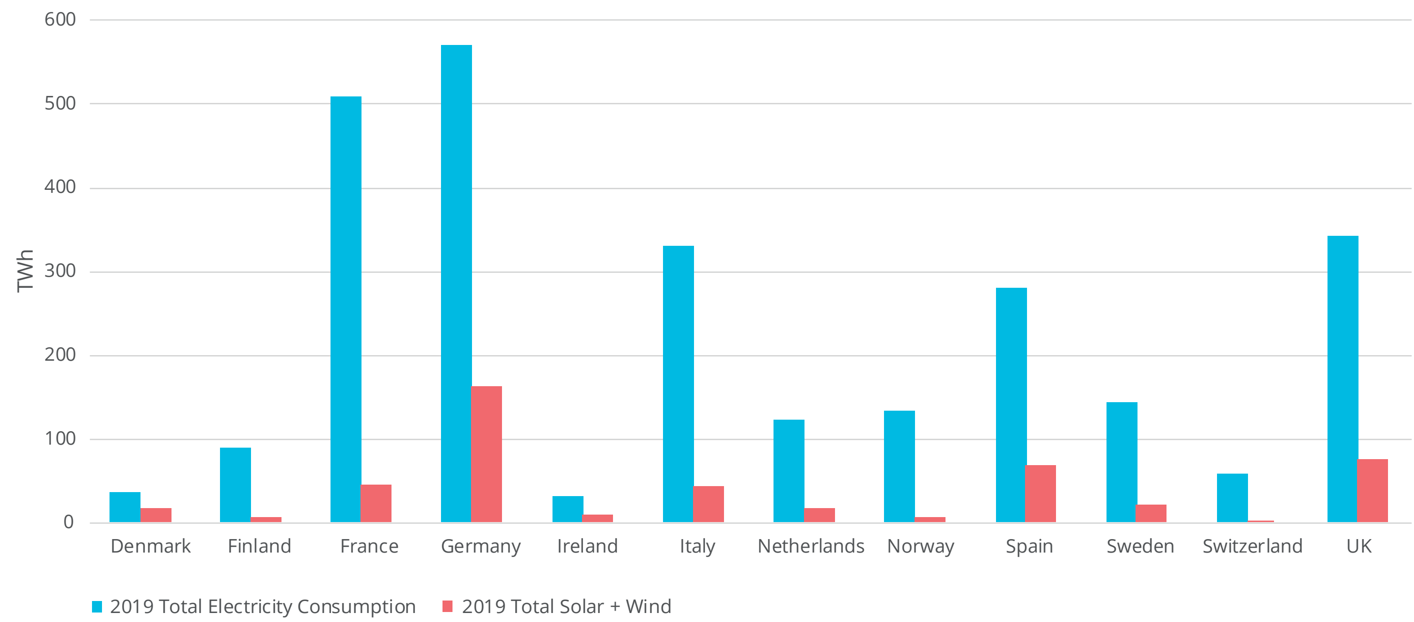
All countries show significant volumes of renewable electricity production in 2019. Denmark, Norway, Sweden, and Switzerland generated over 50% of their electricity from renewable resources, reflecting their high hydro capacity, or wind in the case of Denmark.

Despite having an average proportion of total renewable output, Germany had the highest TWh volume of output, reflecting that this is the largest electricity market in Europe.

[1] All data in this section has been derived from EU sources except Switzerland which has been derived from Swiss national statistics. Specific references are provided in Appendix A.

Renewable resources such as hydro and biomass can normally provide flexibility services whereas solar and wind will be less flexible, and therefore is likely to increase the demand for new low carbon flexibility resources. In order to illustrate this potential flexibility demand, the following chart and table show the TWh, and percentage of electricity provided in 2019 by combined solar and wind renewables in each country.

2019 WIND AND SOLAR ELECTRICITY PRODUCTION



2019 SOLAR AND WIND RENEWABLES AS A PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION

Country	%
Denmark	48%
Finland	7%
France	9%
Germany	29%
Ireland	31%
Italy	13%
Netherlands	13%
Norway	5%
Spain	24%
Sweden	15%
Switzerland	4%
UK	22%

This analysis illustrates that, in 2019, Denmark, Ireland and Germany have the highest proportions of solar and wind generation as a percentage of total electricity consumption. Germany has the highest TWh volume of solar and wind output, again reflecting the large overall market size. These countries are likely to need commensurately high volumes of flexibility resources.

Norway, France, Finland and Switzerland currently have the lowest proportion of solar and wind generation and so current flexibility needs are likely to be lower.

EUROPEAN DEMAND-SIDE FLEXIBILITY - TODAY

Flexible electricity resources are increasingly being located 'behind the meter' (BTM) with energy prosumers able to engage with wholesale electricity and flexibility markets. These distributed energy resources can be many and varied. But they all will need the communications, control, and data necessary to interact with flexibility and wholesale markets.

In order to assess the potential for demand-side flexibility across our selected countries, our study has considered the following:

- Smart meter penetration – the adoption rate for smart meters as a percentage of population
- Data driven demand – the MWh of demand consumed by data centres and associated physical infrastructure
- Battery electric vehicle (EV) penetration – the penetration rate for EV's as a percentage of the total fleet of on the road vehicles

The following table presents a comparison across the 12 countries. Data sources are provided in Appendix A.

2020 DEMAND-SIDE ENABLERS

Country	Smart meter penetration	Data driven demand	Electric vehicle penetration
	%	MW	%
Denmark	99%	n/a	1.2%
Finland	97%	151	0.3%
France	76%	209	0.6%
Germany	17%	581	0.6%
Ireland	4%	589	1.2%
Italy	99%	94	0.3%
Netherlands	82%	430	2.5%
Norway	98%	34	11.8%
Spain	100%	38	0.3%
Sweden	100%	76	1.1%
Switzerland	17%	94	0.9%
UK	46%	557	0.5%

Smart meters and associated communications systems are expected to provide a key component for monitoring and settlement of distributed flexibility service provision. Smart meter rollout has reached high levels in many countries, but Germany, Ireland and Switzerland have relatively low levels of penetration.

Flexible demand from electric vehicles and from data centres and associated digital infrastructure are well suited to participate in flexibility markets and are both expected to provide significant future volumes of flexible demand at a distributed system level.

Electric vehicle penetration is currently at relatively low levels in most countries, except Norway, but high levels of growth are expected in all countries through to 2030. Data driven demand is also increasing, with a significant proportion based in Ireland and Netherlands compared to their overall electricity consumption.

EUROPEAN ELECTRICITY FLEXIBILITY NEEDS - 2030

Each of the countries in our survey has also set emission reductions targets for 2030, together with associated targets for renewable electricity. Most of these new renewable resources will be variable wind and solar, which in turn will drive an increased need for flexible electricity resources to enable decarbonisation and security of supply.

The table on the right shows Norway, Denmark, and Switzerland aiming to reach 100% or more in renewable electricity by 2030, with the excess being exported. All other countries show major increases over 2019 levels.

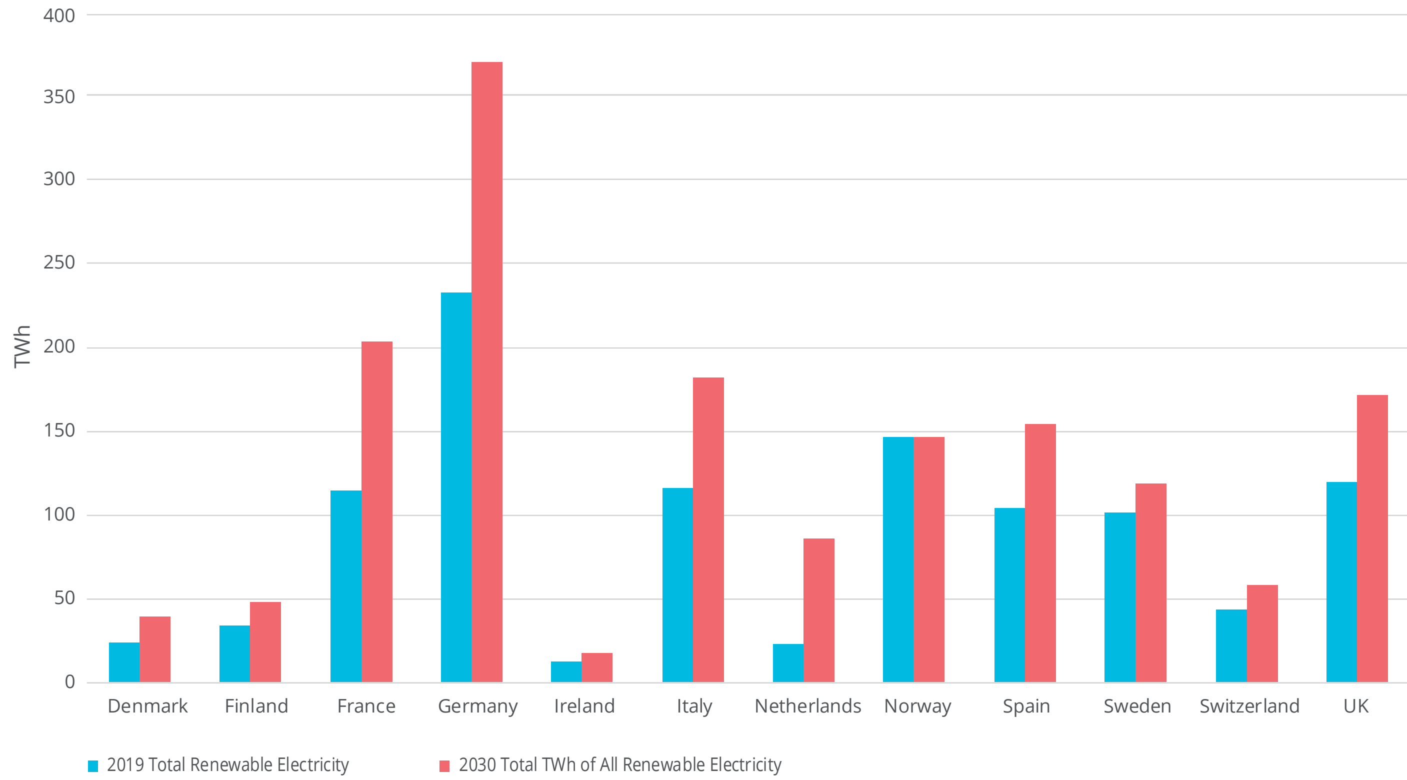
These forecasts are based on targets set in 2020 by the EU and/or by national governments, but these are expected to increase as new targets are set to accelerate progress to decarboni-sation.

2030 TARGET PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION SUPPLIED BY RENEWABLE ELECTRICITY[2]

Country	2019 - %	2030 - %
Denmark	65%	110%
Finland	38%	53%
France	22%	40%
Germany	41%	65%
Ireland	36%	55%
Italy	35%	55%
Netherlands	18%	70%
Norway	111%	111%
Spain	37%	55%
Sweden	71%	83%
Switzerland	74%	100%
UK	35%	50%

The following chart shows these targets for all renewable electricity production (includes all forms of renewable electricity but excludes nuclear) in TWh for 2030[3] and compares them with the equivalent value for 2019.

FORECAST 2030 RENEWABLE ELECTRICITY PRODUCTION

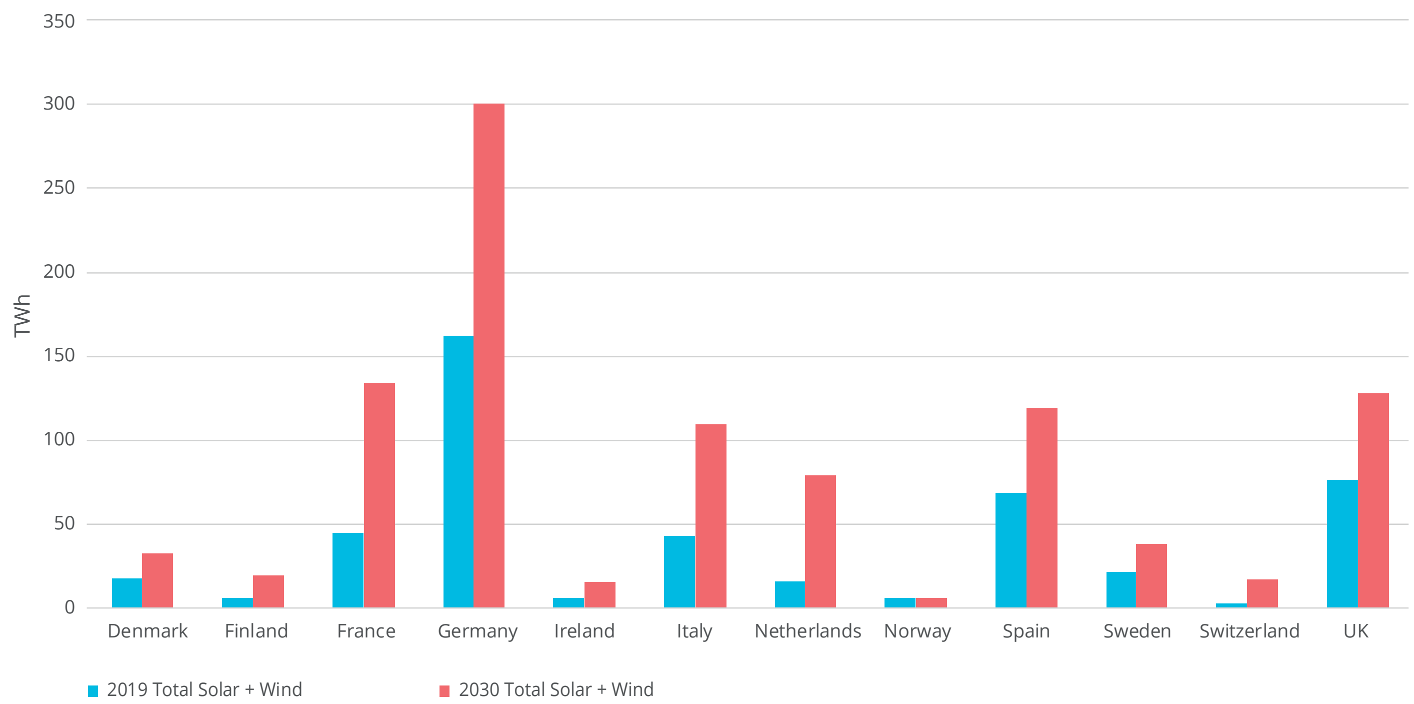


[2] Based on national forecasts declared in 2020; estimated constant level for Norway.
[3] Forecasts are based on latest country-specific targets for % of renewable electricity production in 2030, assuming constant electricity demand.

The chart shows significant increases in forecast total renewable electricity production for many countries. Norway, Denmark, and Switzerland are targeting renewable electricity at 100% or more of total consumption. All other counties are targeting 50% or higher except France which is targeting 40%, reflecting the retention of a significant proportion of nuclear electricity.

Most of this new renewable electricity generation is expected to be derived from wind and solar. The following chart illustrates potential forecast growth in wind and solar resources between 2019 and 2030, assuming all growth is delivered by these technologies.

POTENTIAL FORECAST FOR 2030 WIND AND SOLAR ELECTRICITY PRODUCTION



The table on the right shows the potential TWh increase over 2019 levels of solar and wind combined for each country, together with the growth rates needed to achieve 2030 renewable electricity targets with just solar and wind resources.

POTENTIAL ADDITIONAL SOLAR AND WIND TO MEET 2030 TARGETS

Country	TWh	% solar & wind growth
Denmark	16	93%
Finland	13	220%
France	90	201%
Germany	138	85%
Ireland	6	59%
Italy	66	154%
Netherlands	63	392%
Norway	0	0%
Spain	51	74%
Sweden	17	78%
Switzerland	15	645%
UK	52	69%

A review of national renewable energy plans suggest that all countries described above (excepting Norway which already has renewable electricity output exceeding national consumption) expect to reach their 2030 targets primarily through increasing renewable electricity output from new solar and wind resources.

Some countries, notably the Netherlands and Switzerland appear to be targeting very high growth rates compared to 2019 levels – however, the TWh targets are proportionately lower compared to other larger countries. Germany appears to face the largest challenge in reaching its 2030 targets, with an additional 138TWh of solar and wind renewable resources being required.

As described earlier, this dramatic growth in variable renewable electricity resources will need to be enabled by equivalent levels of low carbon flexible electricity resources, which may be sourced from electricity storage, flexible demand, flexible generation, or interconnection.

Whereas many of the countries in this survey should be able to benefit from flexibility provided by electricity interconnection, the scale of this capability may be at risk in the future. Neighbouring countries dependent on wind or solar resources may experience common weather patterns with common impacts on generation capacity.

Finally, these renewable TWh targets and growth rates, and associated flexibility needs, may have to increase significantly if electricity decarbonisation pathways are accelerated as is expected.

Energy Transition Readiness Index 2021 - Electricity market characteristics

5. Energy transition readiness - Evaluation results

Approach

A common questionnaire was used to obtain the views and scoring of industry experts in each country covered by the survey, and the comparative results were then reviewed by an expert panel to ensure consistency. The scoring was carried out using the following 1 to 5 scale.

5 - Most ideal state
4
3
2
1 - Least ideal state

OVERALL READINESS RANKINGS

The overall rankings for each country are illustrated in the diagram below. It shows the range of country rankings between the most ideal state, and the least ideal state.

OVERALL RANKINGS

Least ideal state	1.	2.	3.	4.	5.	Most ideal state
		Italy Spain	France Germany Switzerland UK	Denmark Ireland Netherlands	Finland Norway Sweden	

The higher-ranking countries are primarily differentiated by having flexibility markets that better deliver fair, transparent, and simple access for all participants. Investment by new flexibility providers is encouraged through clear price signals and policies to enable flexibility technologies. The Nordic countries that score highest in our survey already have significant hydro-based flexibility resources and potentially have less of a flexibility transition challenge.

Lower ranking countries have flexibility markets and policies that present barriers to investment by being complex, slow to change, and dominated by incumbents.

All countries in this survey have demonstrated strong ambitions for realising clean energy targets and have strategies for achieving them. But the key theme that emerges is that the implementation of flexibility markets to unlock new flexible decentralised electricity resources in energy systems with high variable renewables is mostly falling short, and risks undermining the energy transition.

The individual assessment categories are described in more detail below.

MAIN READINESS CATEGORY RANKINGS

1. SOCIO-ECONOMIC RANKING

Least ideal state	1.	2.	3.	4.	5.	Most ideal state
			France Germany Italy Netherlands Spain Switzerland UK	Denmark Ireland	Finland Norway Sweden	

The scores were all 3 or above in this area, demonstrating that there was a generally strong social and political ambition towards realising the transition to a clean energy system. However, the lower scoring countries gave a lower degree of confidence that these ambitions would be delivered.

In high scoring countries, there is a clear roadmap for the energy transition involving all key participants, whereas in lower scoring countries the roadmap and roles of individual industry participants are less clear.

In addition, in high scoring countries, there is a clear public social and economic acceptance of the energy transition and of the costs and mitigations involved. In lower scoring countries, this may not be so well understood or accepted.

In high scoring countries, there is a strong political commitment to a zero-carbon economy, and this is translated into a strong and 'fit-for-purpose' regulatory framework that will deliver the objectives particularly in the area of flexibility. The lower scoring countries have weaker commitments to deliver the regulatory reform necessary to incentivise investment in flexibility resources.

2. TECHNOLOGY FACTOR RANKING

Least ideal state	1.	2.	3.	4.	5.	Most ideal state
			France Germany Ireland Italy Spain Switzerland UK	Denmark Finland Netherlands Sweden	Norway	

The scores were all 3 or above in this area, demonstrating that there was a generally strong ambition towards enabling new technological development. Norway scored highest because of its leadership role in encouraging electric vehicle adoption and their associated use for flexibility services.

In high scoring countries, the grid network is easily able to integrate new distributed flexibility resources, whereas lower scoring countries will have technical or operational barriers that inhibit the application of distributed flexibility services.

For EV infrastructure, high scoring countries may be expected to have a clear roadmap for providing EV charging signals and bi-directional charging so that EVs can participate in the flexibility market. However, progress appears relatively slow across all countries except Norway.

In high scoring countries, digital technologies i.e., communications, flexibility dispatch systems, smart meters, data standards, and IT systems across markets, are a key enabler for flexibility markets. In lower scoring countries not all this digital infrastructure is in place.

Finally, high performing countries have a clear route for enabling technology innovation through opportunities to participate in flexibility markets perhaps using regulatory sandboxes, whereas in lower performing countries there are often barriers to connection of new technologies to the grid.

3. MARKET ACCESSIBILITY RANKINGS

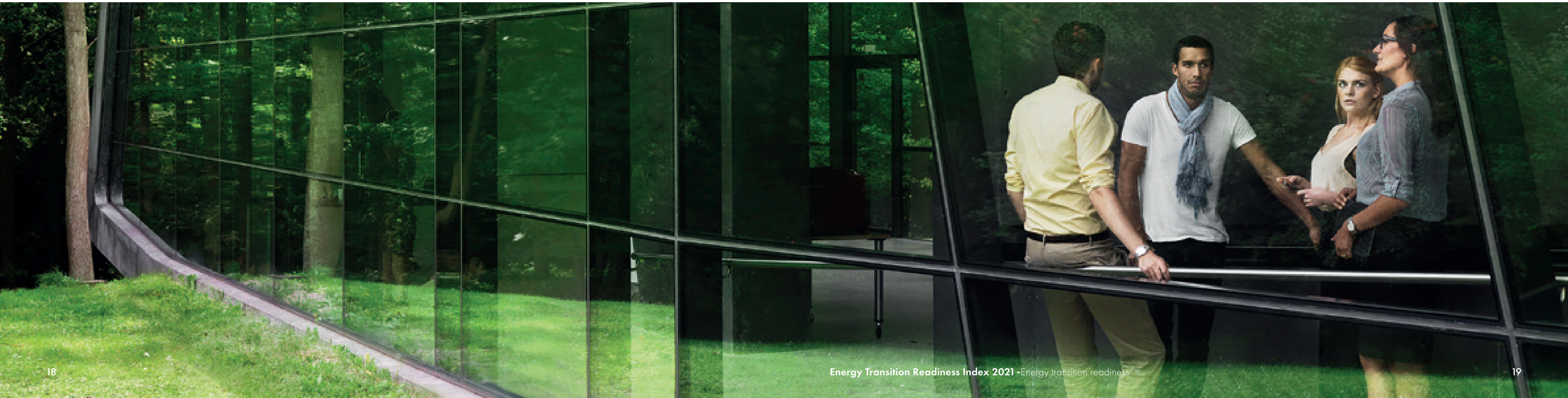
Least ideal state	1.	2.	3.	4.	5.	Most ideal state
	Italy Spain	France Germany UK	Switzerland	Denmark Ireland Netherlands Norway	Finland Sweden	

There was a wider range of scores in this area. Nordic countries were considered to have open, accessible flexibility markets whereas those in Italy and Spain were currently considered to be less well developed.

In high scoring countries, regulatory arrangements and market rules allow a wide range of distributed flexibility resources to participate in a variety of markets, but in lower scoring countries, there are often unclear rules, conflicts, and market access barriers, thereby hindering development.

Market trading arrangements range from transparent markets that allow different contract terms and volumes that enable flexibility and aggregation, to those where trading of flexibility is limited.

In high scoring countries, market transaction costs are equitable with other technologies, whereas in lower scoring countries, these can penalise flexibility and present a barrier.



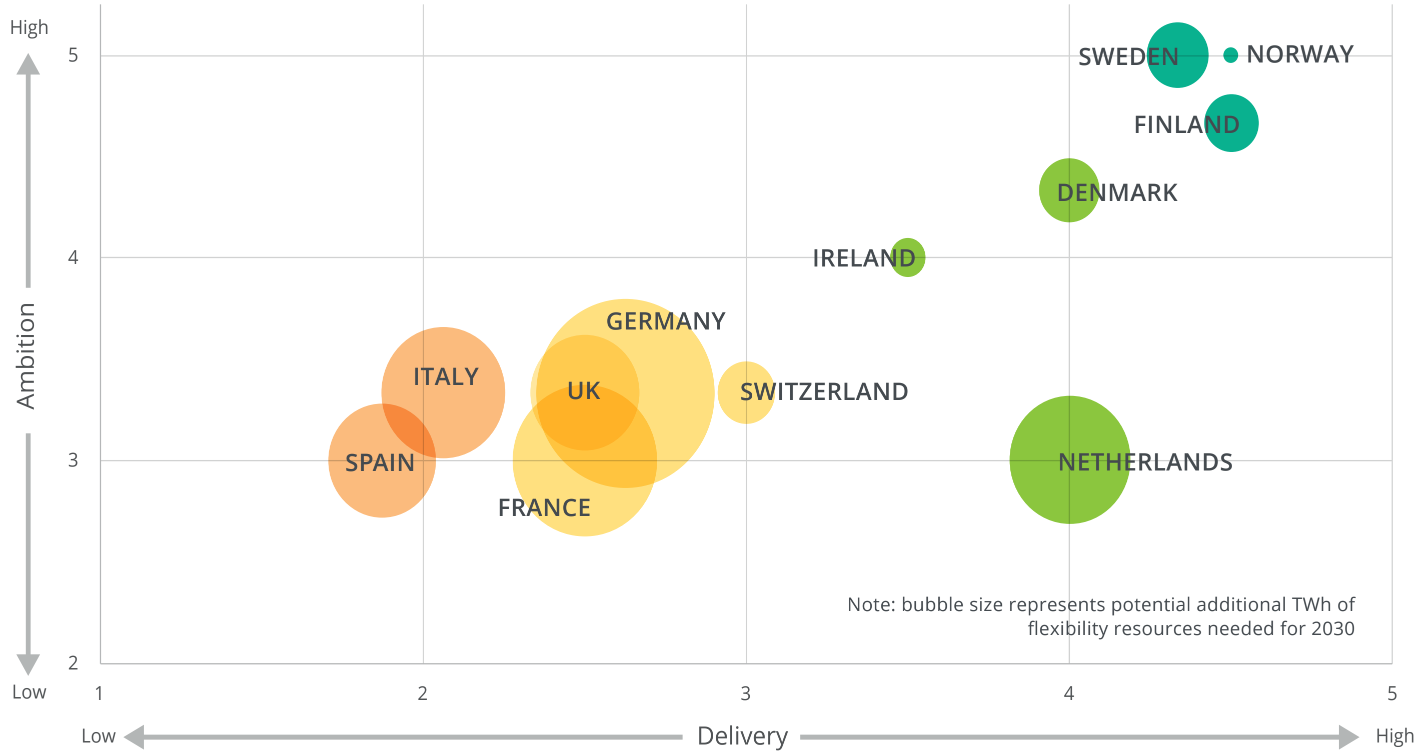
6. Looking forward - the energy transition implementation challenge

The scale of the flexibility challenge

The evaluation data also allows us to assess the overall level of energy transition ambition for each country against the progress in delivering against this ambition. The following chart plots ambition scores for each country against delivery progress[4].

The chart illustrates that the Nordic countries, Netherlands, and Ireland, which score highest in the overall readiness rankings, also demonstrate the greatest ambition and ability to deliver. But these are countries with smaller electricity markets and levels of electricity consumption. They appear to be more agile and able to adapt.

ASSESSMENT OF AMBITION AND DELIVERY PROGRESS



The bubbles in the chart for each country represent the potential additional flexibility resources that will be needed for 2030 based on current renewable energy targets.

The countries with the largest need for new flexibility resources i.e., France, Germany, Italy, the Netherlands, Spain and the UK appear to face significant challenges in delivering the scale of flexibility resources needed to support the energy transition and decarbonisation.

[4] Ambition is measured by the average socio-economic score for each country. Delivery is measured by the average of the technology and market scores for each country. The size of the bubble for each country represents the additional TWh of flexibility resources to accommodate additional variable renewables by 2030.

THE POTENTIAL COST OF / FLEXIBILITY SHORTFALLS

Shortfalls in the provision of flexibility resources are likely to result in unnecessarily high levels of balancing and grid reinforcement costs and present risks to the security of supply and decarbonisation targets.

For example, in Germany, the amount of renewable energy curtailed because of system balancing requirements was high in 2019, totalling 6,482 GWh. This was a significant increase of around 17% compared to the previous year (2018: 5,403 GWh). The amount of energy curtailed thus corresponded to 2.9% of the total amount of energy generated by renewable energy installations (2018: 2.6%). The amount of compensation paid in 2019 was about €1,058m, up around €340m on 2018 (2018: €719m)[5].

Similarly in the UK, between 2015 and 2019, renewable curtailment costs caused by system balancing requirements rose from £90 to £145 million per year. This cost nearly doubled in 2020 to £282 million[6]. These costs are expected to increase with the greater future levels of variable renewable generation.

In the future, flexible distributed energy resources such as electric vehicles and demand response will have an increasing role in enabling the transition to a decarbonised electricity system. Independent research by Bloom-bergNEF[5] shows that these resources could reduce electricity costs in the UK by around £2.5 billion per annum by 2040. If these resources are unable to participate in flexibility markets, then consumer bills could be higher than necessary, and decarbonisation delayed.

THE BENEFITS OF FLEXIBILITY RESOURCES

As illustrated above, the availability of additional flexibility resources, including distributed energy technologies, can help reduce:

- The amount of variable renewable output that is curtailed, thereby accelerating the achievement of decarbonisation targets.
- The cost of curtailing renewable output, thereby adding additional balancing costs and increasing bills to consumers.

Furthermore, the development of flexible distributed energy technologies such as demand response, storage and other behind the meter technologies, can bring economic benefits, including:

- More control for prosumers (consumers with distributed energy resources) on their energy bills, empowering them to participate directly in energy markets.
- Significant volumes of local installer resources, bringing benefits to local and national economies through the training and delivery of skilled installation work.
- Technology and supply chain development, adding economic value through the development and application of new advanced technologies, including potential export opportunities.
- Increased taxation receipts for national economies resulting from the increased economic activity.

[5] Flexibility Solutions for High-Renewable Systems 2018 - U.K. Login | BloombergNEF (bnef.com)
[6] https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/ElectricityGas/CollectionCompanySpecificData/Monitoring/KernaussagenEng_MB2020.pdf;jsessionid=5DC7D0981DA20610B30A2E647126E884?__blob=publicationFile&v=2
[7] https://reports.electricinsights.co.uk/q4-2020/record-wind-output-and-curtailment/

7. The energy transition and flexibility market access

The achievement of the energy transition will require a substantial increase in the use of Distributed Energy Resources (DER) to provide flexibility. But a key requirement for distributed energy resources to participate in flexibility markets is the availability of suitable market platforms to enable trading.

Across Europe, there are many market participants, especially aggregators and virtual power plants, seeking to develop initiatives to enable access to flexibility markets for distributed energy resources. Examples of the development and application of potential market platforms include:

- **NODES** has been working with DSOs and TSOs across Europe to provide a trading platform that allows the asset owners of flexibility to stack revenues across the different aspects of the market, i.e., for network congestion, for reserve/response and in the wholesale market.
- **Electron** has been working with UK Distribution Network Operators to provide a trading platform for flexibility resources. A trial project enabled wind generators on the Orkney Islands to contract with demand-side resources during a renewable curtailment period.
- **DER participation in Nordic balancing markets** – in Norway and Sweden, Tibber is providing a platform to allow EV's and other distributed resources to trade in balancing markets.
- **UK distribution network congestion** – the Picloflex and Flexible Power platforms are being used to run tenders for distributed electricity resources instead of network reinforcement.

In order to maximise the benefit from DER participation in flexibility markets, it will be important that close to real-time trading, and the associated short and long-term price signals are available for all flexibility products in the same way as for large generators. This will require advanced design and development of flexibility market platforms with associated rules and process that enable this access for small scale resources without discrimination or barriers to entry.

These demonstration projects and trials provide valuable experience about the challenges in implementing these advanced markets, but progress in developing these into active markets at scale will need to accelerate if DER is to be able to participate effectively in enabling the energy transition.

DEMAND-SIDE FLEXIBILITY MARKETS - CASE STUDIES

Further detail about the NODES and Electron examples is provided in the case studies below, potentially illustrating how advanced flexibility markets for DER could work.

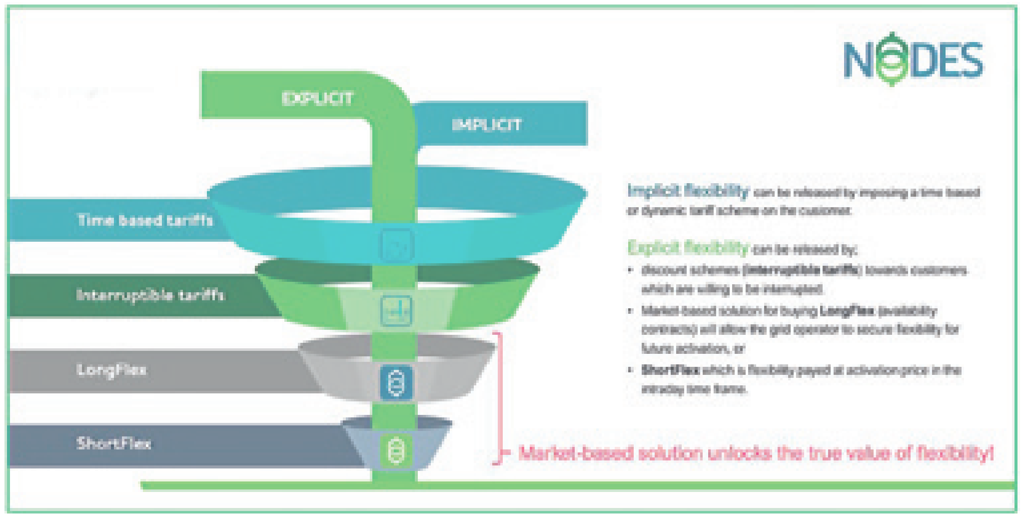
Case study 1: The NODES flexibility marketplace

Market design

NODES has been working with DSOs across Europe to allow the asset owners of flexibility to stack revenues across the different aspects of the market, enabling them to sell flexibility directly to the DSO in their time of need, or into the reserve market to support the TSO whilst continuing to balance their position in the wholesale market.

The NODES market enables the purchase of LongFlex (securing flexibility in the future, via an availability payment) which allows DSOs to secure the option to have access to flexibility over a defined time period, providing system security and stability. This can then be linked to a ShortFlex market (the immediate purchase of flexibility) where flexibility can be bought by the DSO to address an immediate need.

WHY MARKET-BASED FLEXIBILITY?



Source:
NODES market design presentation

The NODES ShortFlex market allows flexibility providers to offer their assets into the market where the different technologies can compete on a level playing field against each other, ensuring that the DSO is able to buy the right type of flexibility, at the right time, in the right location at the lowest price available.

PROJECT TRIALS

The NODES marketplace is being trialled in projects across Europe, including in Germany, UK, Sweden and Norway. One example is the Mitnetz project in Germany.

THE MITNETZ PROJECT[8]:

NODES established a project with a German Distribution System operator, Mitnetz. The purpose of the project was to see if a market-based solution could facilitate better use of flexibility assets in the local area, to alleviate grid congestions, due to an oversupply of energy.

The aim of the project was to demonstrate how flexibility can be used to reduce or limit the curtailment of renewable generation due to network congestions. Flexibility was offered into the NODES market from a nearby industrial park, where the flexibility provider can down regulate or up regulate their availability towards the DSO.

A Market price was created, and the DSO could then buy their availability, this leads to a reduction in the curtailment costs paid towards the renewable energy provider. The outcome of this project saw a significant reduction in curtailment costs as well as a saving of 240t of CO_2.

[8]Market Based Congestion Management https://nodesmarket.com/wp-content/uploads/2019/10/Market-based-Congestion-Management.pdf

Case study 2: Trial of a real-time local marketplace in Orkney, UK

The need: mitigating losses from renewable curtailment

The Orkney Islands, in Northern Scotland, can generate 130% of its annual electricity demand from installed renewable capacity. However, in windy periods, the local network operator (SSEN) is often forced to curtail turbines to reduce grid congestion. Many new turbines frequently see 40 – 60% of their available capacity curtailed. This results in significant lost revenue and low utilisation rates.

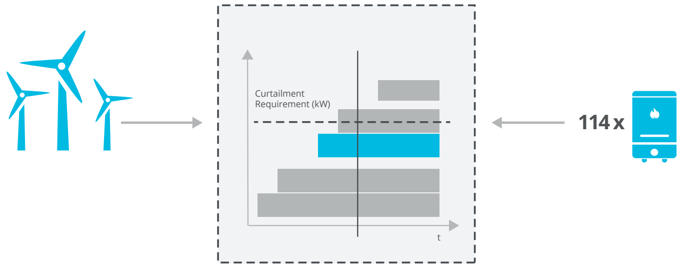
At the same time, the region hosts high rates of electrification, fuel poverty, as well as thermal generation with priority grid access rights. New tools are needed to maximize decarbonization through efficient grid management.

The solution: a price signalled marketplace for network capacity

Electron[9] introduced a local market platform for "Demand Turn Up" VPP platform provider, Kaluza, connected 114 customer-owned storage resources to the platform to respond to price signals from two 900kW wind generators owned by Community Energy Scotland.

Generators send the market platform a continuous signal of the price they are willing to pay to avoid curtailment and real-time curtailment volume signals. Demand-side resources can accept this price and begin dispatching in as little as 10 seconds. All generators and assets send signals in real-time using API calls. The market platform manages coordination between generators and assets.

ELECTRON TRADING ENGINE



The outcome

The Electron market platform introduces real-time (i.e., 10 seconds) contracts to be generated as soon as a curtailment signal is received. Using an integrated platform, contracts can be completed as soon as the curtailment event is over, or the asset is no longer able to participate.

Real-time operation helps generators avoid overpayment if curtailment events are short. Each party can commit to the trading durations that benefit their needs. Generators only pay for what they require, and customers are fairly compensated.

Using the Electron Trading Engine, wind generators on the Orkney Islands continue to contract with customer-owned, demand-side resources during a curtailment event. For example, in June 2020, 3000 unique trades were completed during 40 hours of curtailment.

This is an example of a DSO facilitated asset-to-asset market rather than a DSO managed market. The dynamic trading model was enabled by active network management systems already being in place and because renewables were encouraged to connect ahead of network upgrades.

[9]https://electron.net/projects/project-trader-orkney-uk/

8. Conclusions and recommendations

This paper has reviewed the energy transition readiness across 12 European countries. It has:

- Examined the current key electricity market characteristics in each country and looked ahead to 2030, and the implications of meeting increased renewable energy targets.
- Obtained views from experts in each country about the readiness for the energy transition, considering the socio-political environment, the development of flexibility markets, and the technology enablers needed for these markets to develop.

CONCLUSIONS

The following conclusions have been drawn from these assessments.

Key market characteristics

The main themes that were demonstrated by the assessment were:

a) **There is a high future need for flexibility resources** - high volumes of new flexibility resources will be needed (especially in the larger economies of France, UK, Germany, Italy, and Spain) if 2030 decarbonisation targets (and any further acceleration) are to be met. Distributed flexibility technologies will have an increasingly important role to play.

b) **But current levels of distributed energy resources are low** - the development of distributed energy resources is at an immature stage in most countries, perhaps except for Norway where EV use is growing rapidly, allowing the potential for participation at scale in flexibility markets.

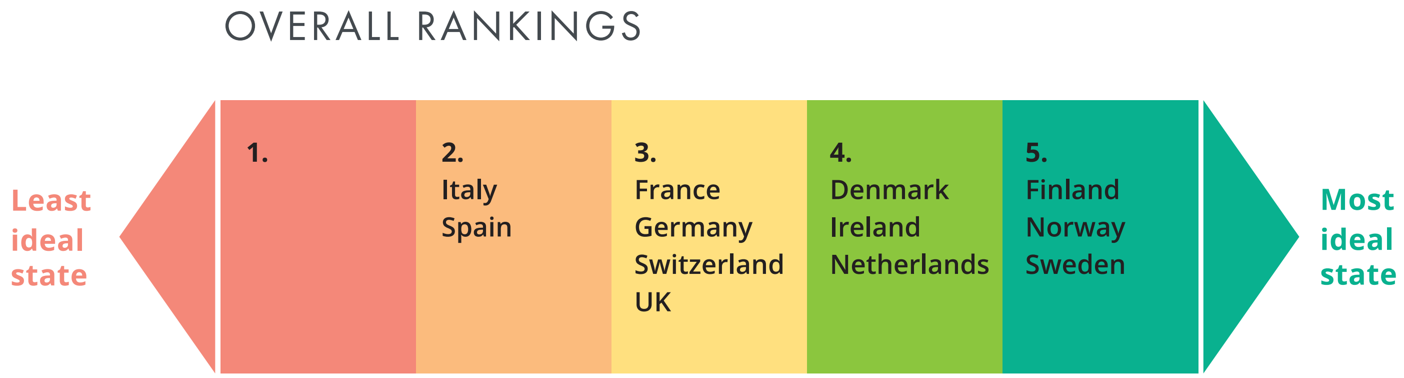
An assessment of ambition against energy transition delivery progress shows:

c) **Smaller countries appear to transition faster** - the Nordic countries, Netherlands, and Ireland, appear to demonstrate the greatest progress in the transition to renewables and development of associated flexibility markets. They appear to be more agile and able to adapt their electricity markets

d) **Larger countries face greater flexibility challenges** - the countries with the largest need for new flexibility resources i.e., France, UK, Germany, Italy, and Spain, appear to face greater risks of shortfalls in the provision of flexibility resources. This is likely to result in high levels of balancing costs and present risks to the security of supply and decarbonisation targets.

ENERGY TRANSITION READINESS INDEX

The results of the survey are shown in the diagram below, with Scandinavian countries showing the greatest degree of readiness, and Spain and Italy at the other end of the spectrum. These represent the market attractiveness from an investor perspective.



The main themes that were demonstrated by the assessment were:

a) **Political and public support** for the energy transition is generally strong, with high ambition. But policy delivery and regulatory/change implementation is often complex, uncoordinated, and slow, with the legacy industry seeking to protect their commercial interests.

b) **Open and fair flexibility markets** for distributed energy resources are a common ambition, but most are at early stages of development, and change can be slow and complex. New distributed energy participation can face commercial and regulatory barriers. The transition from pilot projects to large scale implementation can be slow. The emergence of different market designs e.g., to displace grid reinforcement or to reduce renewable curtailment can present unforeseen market barriers as well as opportunities.

c) **Technology enablers** such as grid access, metering and communications can often present additional costs and barriers to flexibility market participation. Also, policies to incentivise EV and V2G resources are patchy and generally underdeveloped. Innovation and trials are proceeding but often do not proceed to implementation.

The report demonstrates that the energy transition to decarbonised electricity markets, including flexibility market reform, is generally well underway in the survey countries, enabled by policy, market reforms and technology, but the pace of change varies.

All countries in the survey show strong ambition towards decarbonisation targets, but the higher-ranking ones have flexibility markets that better deliver fair, transparent, and simple access for all participants. Investment by new flexibility providers is encouraged through clear price signals and policies to enable flexibility technologies.

Lower ranking countries present barriers to investment by having flexibility markets and associated policies and rules that are more complex, and slow to change, with market design and operation strongly influenced by incumbents.

RECOMMENDATIONS

Overall, the report concludes that most countries in the survey are facing a huge flexibility challenge in reaching 2030 targets and the challenge is likely to increase. Prompt action is needed to achieve energy transition and decarbonisation targets without incurring unnecessary additional costs. Three main recommendations are suggested:

1. Quantify future flexibility needs:
A vast increase in new flexibility resources is expected to be needed to achieve 2030 targets for decarbonisation. Whereas clear targets are commonly set for proportions of renewable energy generation, the required volumes, locations and capabilities of flexible resources, including distributed resources, needed to minimise renewable curtailment and ensure secure grid operation may not be.

> "TARGETS FOR FUTURE FLEXIBILITY REQUIREMENTS SHOULD BE DEFINED AND QUANTIFIED SO THAT ASSOCIATED POLICIES AND MARKET REFORMS CAN BE DEVELOPED."

2. Prioritise and accelerate flexibility market reforms:
Future flexibility needs are becoming increasingly critical and should be prioritised in electricity market reforms as highly as decarbonisation policy. Policies and associated incentives to deliver fair, transparent, and easily accessible markets for new flexibility resources must accelerate if the energy transition is not to be put at risk. Market reforms should actively seek to unlock and realise the potential of distributed energy resources.

> "ELECTRICITY MARKET POLICIES SHOULD PRIORITISE REFORMS THAT ENABLE GROWTH IN ALL FORMS OF FLEXIBILITY RESOURCES."

3. Design flexibility markets to attract investment:
In order to provide the confidence needed to attract investment, flexibility market reforms must create fair and open markets that allow all flexibility and distributed energy resources to compete and earn a return on their investments and assets.

Investors are seeking stability and predictability from the market and regulatory regimes to ensure that investments with long payback periods can be funded. Uncertainty about the scope, timing and impact of regulatory change can deter investment.

The key factors will include:

Market factors:

- a clear regulatory and market framework for participation by all flexibility resources that can adapt effectively to enable new products, services, and new participants
- market signals and incentives should be designed to ensure that longer-term flexibility targets can be realised
- clear definition of products and contract timescales for different flexibility markets e.g., response, reserve, grid congestions, curtailment, and how flexibility resources may participate in different markets
- visibility of market information such as long- and short-term procurement volumes, commercial terms, traded volumes, and prices
- non-discriminatory transaction costs, including asset certification, levies, and grid access charges

Technology factors:

- grid connections which enable the integration of distributed flexibility resources including EVs and Vehicle to Grid (V2G) resources, low carbon technologies, demand response and storage
- clear definition and provision of digital enabling technologies for communications, control, metering and settlement across markets
- clear pathways for transition of pilot technology projects to large scale application

Delivering these initiatives should help to deliver investor confidence and enhance competition in flexibility markets, delivering both economic and decarbonisation benefits as a result.

> "FUTURE FLEXIBILITY MARKETS SHOULD BE DESIGNED TO GIVE CONFIDENCE TO INVESTORS IN A WIDE RANGE OF POTENTIAL NEW FLEXIBILITY SERVICES."

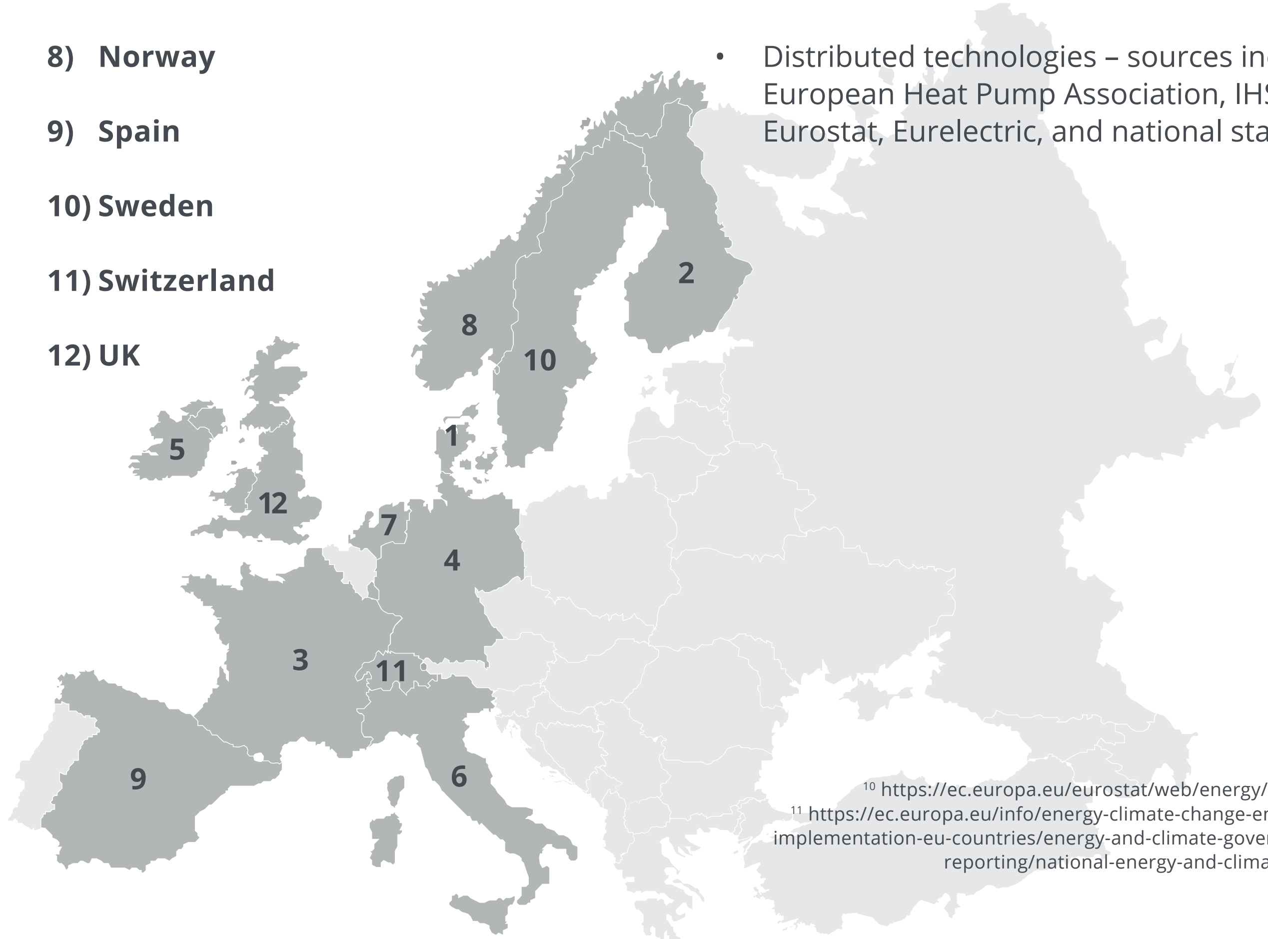
Appendix A - country summaries

This appendix includes further details and analysis of the key electricity market, distributed energy resources (DER) and enabling technologies for each of the survey countries. Survey results are provided together with a summary of comments from experts in individual countries.

Survey countries

Summary information is provided in this appendix for the following countries:

1) **Denmark**
2) **Finland**
3) **France**
4) **Germany**
5) **Ireland**
6) **Italy**
7) **Netherlands**
8) **Norway**
9) **Spain**
10) **Sweden**
11) **Switzerland**
12) **UK**



Data sources

Country data was sourced from:

Electricity market data – actual data for 2019[10] was obtained from Eurostat data and forecasts for 2030 were sourced from National Energy and Climate Plans[11] for EU countries and national reports for non-EU countries.

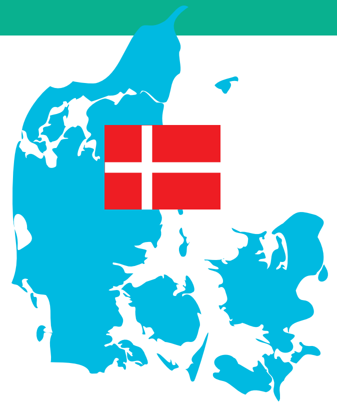
Annual electricity consumption forecasts for 2030 have been kept constant with 2019, reflecting the relatively limited change currently forecast in country plans (at about 5%). This may be considered a prudent approach as increases in consumption forecasts would likely lead to increased levels of variable renewables and the associated flexibility requirements.

Distributed energy technologies – The data for distributed energy products and enabling technologies have been derived from:

- Transport data – from the European Automobile Manufacturers Association (ACEA), the International Energy Agency and national statistics.
- Distributed technologies – sources included European Heat Pump Association, IHS Markit, Eurostat, Eurelectric, and national statistics.

[10] https://ec.europa.eu/eurostat/web/energy/data/shares
[11] https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

Denmark



Markets - In 2019, Danish annual renewable production (mainly wind) represented 65% of annual consumption. Denmark has targeted 110% renewables output for 2030, which could increase wind and solar output by 16TWh.

DER - Denmark has 1% penetration of electric vehicles in 2020, with electric vehicles representing about 7% of all new vehicle registrations. About 0.5 million heat pumps are installed. Smart meter penetration is high.

Survey - The individual survey scores for Denmark are shown right.

Electricity markets	2019 actual	2030 estimate
Annual consumption (TWh)	35	35
Annual renewable production (TWh)	23	39
Renewable % of annual consumption	65%	110%
Annual solar and wind production (TWh)	17	33
Solar and wind % of annual consumption (TWh)	48%	93%

Distributed energy products and applications	2020 actual
Homes with electricity supply (million)	2.72
BTM rooftop solar (MW)	517
Domestic heat pumps ('000's)	449
Total Battery EV's ('000's)	31,886
% BEV penetration	1%
Physical and IT infrastructure (MW)	n/a

Enabling technologies	2020 actual
Smart meter penetration	99%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
4	5	4

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
4	4	4	4

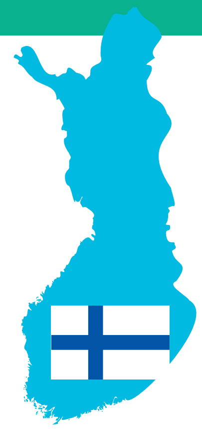
MARKET FACTORS

Regulations	Compensation structures	Transaction costs
5	3	4

Denmark is recognised as an energy transition leader with major wind deployment being successfully realised, and a supply chain established. But there are uncertainties about future implementation, and opportunities for wider industry participation in policy development can be limited.

- There is a strong political and public consensus about the energy transition, including costs. Policy aims are clear, but implementation policies and regulatory frameworks are uncertain.
- Grid availability and investment is good, but flexibility needs are undeveloped. Smart metering is not mandatory, but the deployments are going well. Generally, innovation funding is available, but the use of pilots could be improved.
- Market design and availability of market information enables access for flexibility resources, but market rules are difficult to change for new participants/products. Some of the technical compliance standards can be onerous.

Finland



Markets - In 2019, Finnish annual renewable production represented 38% of annual consumption. Most renewables were hydro, with only around 7% derived from solar and wind. Finland has targeted 53% renewables output for 2030, which could increase wind and solar output by 13TWh.

DER - Finland has less than 1% penetration of electric vehicles in 2020, with electric vehicles representing about 4% of all new vehicle registrations. Over 1 million heat pumps are installed. Smart meter penetration is high.

Survey - The individual survey scores for Finland are shown right.

Electricity markets	2019 actual	2030 estimate
Annual consumption (TWh)	89	89
Annual renewable production (TWh)	34	47
Renewable % of annual consumption	38%	53%
Annual solar and wind production (TWh)	6	19
Solar and wind % of annual consumption (TWh)	7%	41%

Distributed energy products and applications	2020 actual
Homes with electricity supply (million)	3.07
BTM rooftop solar (MW)	212
Domestic heat pumps ('000's)	1,100
Total Battery EV's ('000's)	10
% BEV penetration	0.3%
Physical and IT infrastructure (MW)	151

Enabling technologies	2020 actual
Smart meter penetration	97%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
5	4	5

TECHNOLOGY FACTORS

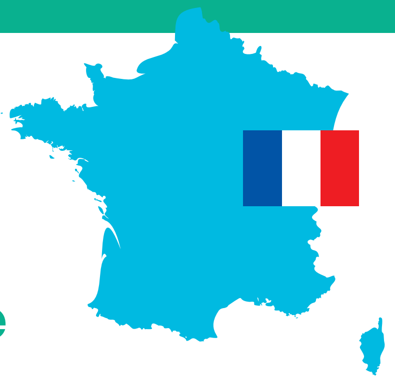
Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
5	4	5	4

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
5	3	5

Overall, Finland has clear policy goals and implementation plans for delivering the energy transition, but there are some delays in delivering change. Similar to Norway and Sweden, Finland has fewer challenges to achieving energy transition compared to some other countries.

- Support for decarbonisation and the energy transition is generally strong, but there are some concerns about cost impacts. Political and regulatory alignment is good.
- There is a strong grid network, offering access for renewables and distributed energy. Digital enablers are in place, enabling flexibility markets through aggregators. Good support for innovation but there could be more opportunities for pilots.
- Market rules are fair and allow access by new DER technologies. Flexibility markets generally work well, but product changes requested by new market participants can be slow to realise.



France

Markets - In 2019, French annual renewable production represented 22% of annual consumption, with the remainder dominated by nuclear generation. France has targeted 40% renewables output for 2030, which could increase wind and solar output by 89TWh.

DER - France has 1% penetration of electric vehicles in 2020, but with electric vehicles representing around 10% of all new vehicle registrations. Over 1GW of rooftop solar is installed. Smart meter penetration is high.

Survey - The individual survey scores for France are shown right.

Electricity markets	2019 actual	2030 estimate
Annual consumption (TWh)	509	509
Annual renewable production (TWh)	114	203
Renewable % of annual consumption	22%	40%
Annual solar and wind production (TWh)	45	134
Solar and wind % of annual consumption (TWh)	9%	26%

Distributed energy products and applications	2020 actual
Homes with electricity supply (million)	37.00
BTM rooftop solar (MW)	1,312
Domestic heat pumps ('000's)	176
Total Battery EV's ('000's)	200
% BEV penetration	1%
Physical and IT infrastructure (MW)	209

Enabling technologies	2020 actual
Smart meter penetration	76%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
3	4	4

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
3	4	3	4

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
2	2	2

Overall, there is a clear policy goal towards decarbonisation, but high nuclear capacity means there is less urgency to decarbonise further. As such, progress towards the energy transition and growth of renewables and DER is limited by the interests of the nuclear industry and allied legacy interests.

- The public and political consensus for the energy transition is increasing, but little information is available about the social cost implications. Longer term policy goals are in place and, while policy delivery and regulatory change is underway, there are delays and regulatory uncertainty, which deters investment by new participants.

- Grid access is limited by the complexity and slow speed of the grid access process and lack of metering/supporting technologies. Grid flexibility needs are at an early stage and projects are limited due to complexity and uncertainty. There are incentives to deliver 1 million EVs by 2022, but V2G is not yet available. Digitalisation standards are unclear and uncertain.

- There is limited potential for distributed energy technologies to access flexibility markets. This is mainly due to the strength of the grid and dominance of existing nuclear/hydro capacity – resulting in a limited accessible market size.

Germany

Markets - In 2019, German annual renewable production represented 41% of annual consumption, with solar and wind comprising 29% of annual consumption. Germany has targeted 65% renewables output for 2030, which could increase wind and solar output by 138TWh.

DER - Germany has 1% penetration of electric vehicles in 2020, with electric vehicles representing around 7% of all new vehicle registrations. Over 37GW of rooftop solar is installed. Smart meter penetration is low.

Survey - The individual survey scores for Germany are shown right.

Electricity markets	2019 actual	2030 estimate
Annual consumption (TWh)	570	570
Annual renewable production (TWh)	233	371
Renewable % of annual consumption	41%	65%
Annual solar and wind production (TWh)	163	301
Solar and wind % of annual consumption (TWh)	29%	53%

Distributed energy products and applications	2020 actual
Homes with electricity supply (million)	43.00
BTM rooftop solar (MW)	37,450
Domestic heat pumps ('000's)	1,100
Total Battery EV's ('000's)	309
% BEV penetration	1%
Physical and IT infrastructure (MW)	581

Enabling technologies	2020 actual
Smart meter penetration	17%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
3	4	3

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
4	4	2	3

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
2	2	2

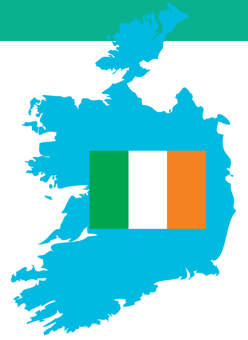
Overall, there is a strong consensus about the energy transition, but progress is limited by the political challenge of replacing brown coal with renewables, and different priorities between regional and federal government. While policy direction is clear, delivery of policy and regulatory change is uncertain and slow.

- Decision making is subject to multiple (and often short-term) local political interests and agendas, resulting in a lack of alignment about delivery actions. Delivery of the energy transition is slow and delayed as a result. Confidence in regulation is good but this is undermined by the political and regulatory misalignment.

- Grid design is effective but access to flexibility opportunities is limited. There is strong policy support for both EVs and EV charging but delivery is slow, and V2G has yet to be established. Metering and communications standards are unclear, presenting a market barrier. The innovation landscape is mainly led by the private sector.

- Flexibility markets are restricted to larger participants and are generally closed to new smaller entrants (although some local access is available). There are restrictions on revenue stacking, making it difficult for new technologies to enter and compete.

Ireland



Markets - In 2019, Irish annual renewable production (mainly wind) represented 36% of annual consumption. Ireland has targeted 55% renewables output for 2030, which could increase wind and solar output by 6TWh.

DER - Ireland has 1% penetration of electric vehicles in 2020, with electric vehicles representing about 5% of all new vehicle registrations. The large number of data centres in Ireland means there is c590MW of this potentially flexible demand resource. Smart meter penetration is low.

Survey - The individual survey scores for Ireland are shown right.

Electricity markets	2019 actual	2030 estimate
Annual consumption (TWh)	31	31
Annual renewable production (TWh)	11	17
Renewable % of annual consumption	36%	55%
Annual solar and wind production (TWh)	10	16
Solar and wind % of annual consumption (TWh)	31%	50%

Distributed energy products and applications	2020 actual
Homes with electricity supply (million)	2.05
BTM rooftop solar (MW)	115
Domestic heat pumps ('000's)	44
Total Battery EV's ('000's)	26
% BEV penetration	1%
Physical and IT infrastructure (MW)	589

Enabling technologies	2020 actual
Smart meter penetration	4%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
4	4	4

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
4	2	4	4

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
4	5	5

Ireland has an accelerated approach to decarbonise electricity with a growing public awareness of the need to transition to renewables, particularly wind. There is good access to flexibility markets, and there is a proactive approach to innovation.

- There is a strong political and public consensus for change and recognition it will involve both business and social change. There is strong support for renewable energy. While goals are clearly set out, there are concerns that the policies and governance to implement transition are not yet in place.
- Grid access permits high levels of renewable adoption, making use of flexibility where possible, but there are some critical areas of grid congestion. V2G is enabled but currently has low volumes and take-up. Flexibility service standards are defined reasonably well but standards for metering and communications are complex and uncertain. Generally positive support for innovation and trials by the TSO.
- There is an open and transparent flexibility market design. There are few commercial barriers, but the market design encourages the use of aggregators for participation.

Italy

Markets - In 2019, Italian annual renewable production represented 35% of annual consumption, with solar and wind comprising 13% of annual consumption. Italy has targeted 55% renewables output for 2030, which could increase wind and solar output by 66TWh.

DER - Italy has less than 1% penetration of electric vehicles in 2020, with electric vehicles representing around 4% of all new vehicle registrations. Over 37GW of rooftop solar is installed. Smart meter penetration is high.

Survey - The individual survey scores for Italy are shown right.

Electricity markets	2019 actual	2030 estimate
Annual consumption (TWh)	330	330
Annual renewable production (TWh)	115	182
Renewable % of annual consumption	35%	55%
Annual solar and wind production (TWh)	43	109
Solar and wind % of annual consumption (TWh)	13%	33%

Distributed energy products and applications	2020 actual
Homes with electricity supply (million)	26.20
BTM rooftop solar (MW)	71
Domestic heat pumps ('000's)	2,400
Total Battery EV's ('000's)	100
% BEV penetration	0.3%
Physical and IT infrastructure (MW)	94

Enabling technologies	2020 actual
Smart meter penetration	99%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
4	3	3

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
4	3	3	3

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
1	1	1

Overall, the long-term vision and the policy goals are becoming much more clearly defined. But there is a concern that new market players are not involved in the decisions to implement the policy.

Public and political consensus is growing but the cost and social implications are not well understood. Government policy has been put in place and a new minister has been appointed to lead the energy transition. There is a lack of a consensus with evidence of regional differences.

- While policy is clear, delivery is slow. Smaller new entrant companies face lobbying from existing market participants. Regulatory uncertainty presents a difficult environment for new market entrants to invest.
- Grid accessibility is mixed, with potential problems with grid access in southern Italy. Incentives for EV's are limited and V2G is not currently possible. Metering standards may present barriers to flexibility. Innovation is being led by the private sector.
- It's not currently possible for distributed energy resources to participate in flexibility markets. There do not appear to be any other discriminatory restrictions in place, but specific metering requirements add additional cost.

Netherlands

Markets - In 2019, the Netherlands annual renewable production (mainly wind and solar) represented 18% of annual consumption. The Netherlands has targeted 70% renewables output for 2030, which could increase wind and solar output by 53TWh.

DER - The Netherlands has 2% penetration of electric vehicles in 2020, with electric vehicles representing around 25% of all new vehicle registrations. Over 5GW of rooftop solar is installed. Smart meter penetration is high.

Survey - The individual survey scores for the Netherlands are shown right.

Electricity markets	**2019 actual**	**2030 estimate**
Annual consumption (TWh)	122	122
Annual renewable production (TWh)	22	85
Renewable % of annual consumption	18%	70%
Annual solar and wind production (TWh)	16	79
Solar and wind % of annual consumption (TWh)	13%	65%

Distributed energy products and applications	**2020 actual**
Homes with electricity supply (million)	7.96
BTM rooftop solar (MW)	5,577
Domestic heat pumps ('000's)	237
Total Battery EV's ('000's)	214
% BEV penetration	2%
Physical and IT infrastructure (MW)	430

Enabling technologies	**2020 actual**
Smart meter penetration	82%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
4	2	3

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
3	4	4	4

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
4	3	4

In the last ETRI survey, the Netherlands was rated as leading in energy transition readiness across the countries surveyed. The latest scoring reflects that while strong public and political support remains for the energy transition, other issues have taken priority.

- A diverse political landscape means that the energy transition currently sits below other public/political priorities. Industry governance is not aligned with transition aims, and legacy players can present barriers. Policies and plans not keeping pace with market developments.
- Grid connection timescales can be slow. There are few incentives for the use of flexibility resources, including V2G. Flexibility market access is complex for smaller customers, so access is mainly via aggregators. There is reasonable support for innovation/pilot projects.
- Flexibility markets are fair and open. Smaller DER access the markets through aggregation. Some concerns that market rules and complexity may favour traditional market participants and impose additional costs on smaller ones.

Norway

Markets - In 2019, Norwegian annual renewable electricity production exceeded annual consumption, making Norway a net exporter of renewable electricity. Most renewable output was derived from hydro, with only around 5% derived from solar and wind. Similar renewable output levels are assumed in 2030.

DER - Norway has a high level of penetration of electric vehicles, reaching 12% in 2020, and electric vehicles represent some 75% of all new vehicle registrations. Over 1 million domestic heat pumps are installed. Smart meter penetration is high.

Survey - The individual survey scores for Norway are shown right.

Electricity markets	**2019 actual**	**2030 estimate**
Annual consumption (TWh)	132	132
Annual renewable production (TWh)	146	146
Renewable % of annual consumption	111%	111%
Annual solar and wind production (TWh)	6	6
Solar and wind % of annual consumption (TWh)	5%	5%

Distributed energy products and applications	**2020 actual**
Homes with electricity supply (million)	2.61
BTM rooftop solar (MW)	24
Domestic heat pumps ('000's)	1,300
Total Battery EV's ('000's)	330
% BEV penetration	12%
Physical and IT infrastructure (MW)	34

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
5	5	5

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
4	5	5	5

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
4	5	5

Enabling technologies	**2020 actual**
Smart meter penetration	98%

Overall, a strong and clear policy direction in support of the energy transition, but some concerns that delivery may be slowed by commercial interests of existing industry participants.

- There is strong public and political consensus for the energy transition, recognising that Norway is already well advanced. There is strong political and regulatory alignment.
- Policies and incentives for EVs and EV charging are highly successful. There are no policy barriers to V2G but there are few vehicles able to participate at present.
- Flexibility market access for distributed technologies is under development and there is no discrimination against these flexible technologies. However, market rule change can be slow and existing market participants may be able to influence change more easily.

Spain

Markets - In 2019, Spanish annual renewable production represented 37% of annual consumption, with solar and wind comprising 24% of annual consumption. Spain has targeted 55% renewables output for 2030, which could increase wind and solar output by 51TWh.

DER - Spain has less than 1% penetration of electric vehicles in 2020, with electric vehicles representing around 2% of all new vehicle registrations. Less than 1GW of rooftop solar is installed. Smart meter penetration is high.

Survey - The individual survey scores for Spain are shown right.

Electricity markets	**2019 actual**	**2030 estimate**
Annual consumption (TWh)	280	280
Annual renewable production (TWh)	103	154
Renewable % of annual consumption	37%	55%
Annual solar and wind production (TWh)	68	119
Solar and wind % of annual consumption (TWh)	24%	42%

Distributed energy products and applications	**2020 actual**
Homes with electricity supply (million)	25.80
BTM rooftop solar (MW)	910
Domestic heat pumps ('000's)	936
Total Battery EV's ('000's)	63
% BEV penetration	0.3%
Physical and IT infrastructure (MW)	38

Enabling technologies	**2020 actual**
Smart meter penetration	99.6%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
3	4	4

TECHNOLOGY FACTORS

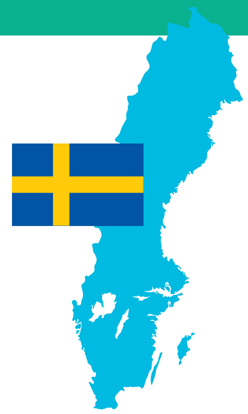
Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
3	2	3	3

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
1	1	1

Overall, while Spain has a significant proportion of renewable production, markets for flexibility resources are currently underdeveloped. The Government is developing post-covid recovery plans which include an important focus on the energy transition, but the pathway is not yet clear.

- The need for policy action to address the energy transition is widely accepted, but the implementation pathway and funding to support it is unclear. A major acceleration is expected to come with allocation of EU funding for the post-covid recovery plan.
- Grid congestion and a lack of digitalisation presents a barrier to the development of flexibility resources, including V2G. Additional investment is needed to enable access by flexibility resources.
- It's not currently possible for distributed energy resources to participate in flexibility markets. Current legislative drafting is considering how the role of aggregators may be defined and implemented, as part of measures to create a more competitive marketplace.



Sweden

Markets - In 2019, Swedish annual renewable production represented 71% of annual consumption. Most renewables were hydro, with only around 15% derived from solar and wind. Sweden has targeted 83% renewables output for 2030, which could increase wind and solar output by 17TWh.

DER - Sweden has just over 1% penetration of electric vehicles in 2020, with electric vehicles representing some 10% of all new vehicle registrations. Around 2 million heat pumps are installed. Smart meter penetration is high.

Survey - The individual survey scores for Sweden are shown right.

Electricity markets	**2019 actual**	**2030 estimate**
Annual consumption (TWh)	142	142
Annual renewable production (TWh)	101	118
Renewable % of annual consumption	71%	83%
Annual solar and wind production (TWh)	21	38
Solar and wind % of annual consumption (TWh)	15%	27%

Distributed energy products and applications	**2020 actual**
Homes with electricity supply (million)	4.78
BTM rooftop solar (MW)	771
Domestic heat pumps ('000's)	2,000
Total Battery EV's ('000's)	56
% BEV penetration	1%
Physical and IT infrastructure (MW)	76

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
5	5	5

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
5	4	5	4

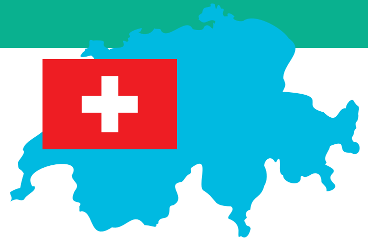
MARKET FACTORS

Regulations	Compensation structures	Transaction costs
5	4	5

Enabling technologies	**2020 actual**
Smart meter penetration	100%

Overall, there are clear policy goals that are linked to clear implementation plans to realise the energy transition. These recognise that Sweden is already well advanced in the energy transition.

- There is political and public consensus in support of energy transition, including about cost implications. There is clear policy, governance, delivery, and regulatory certainty.
- There is strong grid capability, with clear standards for communication and metering available. V2G accessibility is available. A positive environment for innovation but sandbox trials could be enhanced.
- Good market access and few barriers for distributed flexibility resources but there are some product limitations e.g., most contracts are for one year.



Switzerland

Markets - In 2019, Swiss annual renewable production (mainly hydro and solar)[12] represented 74% of annual consumption. Switzerland has targeted 100% renewables output for 2030, which could increase wind and solar output by 15TWh.

DER - Switzerland has 1% penetration of electric vehicles in 2020, with electric vehicles representing around 8% of all new vehicle registrations. Over 2GW of rooftop solar is installed. Smart meter penetration is low.

Survey - The individual survey scores for Switzerland are shown right.

Electricity markets	**2019 actual**	**2030 estimate**
Annual consumption (TWh)	58	58
Annual renewable production (TWh)	43	58
Renewable % of annual consumption	74%	100%
Annual solar and wind production (TWh)	2	17
Solar and wind % of annual consumption (TWh)	4%	30%

Distributed energy products and applications	**2020 actual**
Homes with electricity supply (million)	4.58
BTM rooftop solar (MW)	2,418
Domestic heat pumps ('000's)	361
Total Battery EV's ('000's)	43
% BEV penetration	1%
Physical and IT infrastructure (MW)	94

Enabling technologies	**2020 actual**
Smart meter penetration	17%

[12] https://www.bfe.admin.ch/bfe/en/home/supply/statistics-and-geodata/energy-statistics/electricity-statistics.html

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
3	4	3

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
4	2	4	4

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
3	3	3

Overall, there is strong public and political support for the energy transition. Switzerland is aligning with EU approaches, including market design and delivery of change. But regional governance structures in Switzerland mean that the pace of reform implementation varies.

- The lower scores on policy and alignment are due to the governance structure of Switzerland, with many implementation decisions taken at a regional Canton level. There is less central co-ordination as a result. The regulatory environment is uncertain at present due to the speed of industry change, but there is recognition that an underlying stability will emerge long-term.
- Overall, the grid is strong, and can accommodate bi-directional flows. V2G is in its infancy, waiting for industry to demonstrate the concept. While metering and communications were not major barriers, changes to standards are difficult and complex to adapt. Some DSOs are proactive in encouraging innovation pilots.
- There are no major market access roadblocks but access for new flexibility technologies or services is not incentivised. Markets follow the EU design, so local change is difficult to influence and realise. The local grid code adds complexity.

UK

Markets - In 2019, UK annual renewable electricity production represented 35% of annual consumption, with solar and wind representing 22% of annual electricity consumption. The UK Government's advisors have targeted 50% renewable energy output for 2030, which could increase wind and solar output by around 52TWh.

DER - The UK has less than 1% penetration of electric vehicles in 2020, and electric vehicles represent around 7% of all new vehicle registrations. Over 11GW of rooftop solar is installed. Smart meter rollout is 46% complete.

Survey - The individual survey scores and comments for the UK are shown right.

Electricity markets	2019 actual	2030 estimate
Annual consumption (TWh)	342	342
Annual renewable production (TWh)	119	171
Renewable % of annual consumption	35%	50%
Annual solar and wind production (TWh)	76	128
Solar and wind % of annual consumption (TWh)	22%	37%

SOCIO-POLITICAL FACTORS

Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
3	4	3

TECHNOLOGY FACTORS

Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation
3	3	2	4

MARKET FACTORS

Regulations	Compensation structures	Transaction costs
2	2	2

Distributed energy products and applications	2020 actual
Homes with electricity supply (million)	27.80
BTM rooftop solar (MW)	11,680
Domestic heat pumps ('000's)	260
Total Battery EV's ('000's)	206
% BEV penetration	0.5%
Physical and IT infrastructure (MW)	557

Enabling technologies	2020 actual
Smart meter penetration	46%

Overall, there is strong public and political support for the transition and the UK has set ambitious long-term goals. But extensive consultation on policy direction often leads to decisions being delayed or changed. Weak alignment across governance bodies means that the delivery of policy goals is highly uncertain, especially in the short term.

- While long term goals are aligned, the delivery of change is complex and slow, with mandates of the governing and operational bodies not aligned. This often leads to decisions being delayed. Regulatory and policy certainty is weak for new technology players.
- Grid visibility is low, and connections are slow and costly to realise. Flexibility needs, and bi-directional flows are not enabled to any great degree. Local energy flexibility markets are not available, but flexibility tenders are becoming increasingly used as an alternative to long term network investment needs. Policies to support V2G are weak. Digital standards are very complex and difficult to change and present a significant market barrier. A positive environment for innovation, with many different trials, but subsequent deployment is slow.
- Flexibility markets are open but favour technologies such as legacy fossil fuel generators or grid scale batteries above smaller devices. Aggregators can access these markets but face competition from companies able to cross-subsidise from other markets. Market rules can be adapted to enable DER, but change can be slow. Higher than necessary transaction costs due to compliance and IT costs add a barrier to the deployment of DER.

The UK Government and regulator, Ofgem, has recently published a Smart Systems and Flexibility Plan 2021[13] showing that around 30GW of new low carbon flexibility resources (a 20GW increase) will be needed by 2030, and 60GW (a 50GW increase) by 2050. The plan envisages that these flexibility needs will be met by storage, flexible demand and generation, and interconnectors.

[13] https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021

Appendix B – detailed scorecards

RATING

5 - Most ideal state
4
3
2
1 - Least ideal state

SOCIO-POLITICAL FACTORS

	Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment	Socio-political factors overall average	Overall average across all three assessment areas
Definition of ideal state	Clear road map, all market participants are involved in the decision-making process	Energy transition is accepted and endorsed, negative socio-economic impacts are safe guarded	Strong political and/or statutory commitment to zero carbon economy fully supported by regulatory framework to strongly incentivise investment in flexibility resources		
Denmark	4	5	4	4	4
Finland	5	4	5	5	5
France	3	4	4	3	3
Germany	3	4	3	3	3
Ireland	4	4	4	4	4
Italy	4	3	3	3	2
Netherlands	4	2	3	3	4
Norway	5	5	5	5	5
Spain	3	4	4	3	2
Sweden	5	5	5	5	5
Switzerland	3	4	3	3	3
UK	3	4	3	3	3
Definition of least ideal state	No visibilty on further market development, constantly changing market environment	Energy transition increases social inequality	Weak or no political commitment to zero carbon targets combined with no regulatory mandate to incentivise investment in flexibility resources		

TECHNOLOGY FACTORS

	Grid Reliability	EV Infrastructure and EV charging	Digital technology Enablers	Innovation	Technology factors overall average	Overall average across all three assessment areas
Definition of ideal state	Integration of flexibility sources is backed and supported by grid infrastructure	Charging signals incentivising flexibility to minimise system costs, bi-directional charging enabled	Harmonised communication, dispatch, measurement & verification IT systems across markets	Market is technology open, implementation of new technology is straightforward		
Denmark	4	4	4	4	4	4
Finland	5	4	5	4	4	5
France	3	4	3	4	3	3
Germany	4	4	2	3	3	3
Ireland	4	2	4	4	3	4
Italy	4	3	3	3	3	2
Netherlands	3	4	4	4	4	4
Norway	4	5	5	5	5	5
Spain	3	2	3	3	3	2
Sweden	5	4	5	4	4	5
Switzerland	4	2	4	4	3	3
UK	3	3	2	4	3	3
Definition of least ideal state	Grid infrastructure presents a barrier to flexibility	No participation in the electricity market	Analog meters, self reporting / inspection readings required	Market is closed to new technologies		

MARKET FACTORS

	Regulations	Compensation structures	Transaction costs	Market factors overall average	Overall average across all three assessment areas
Definition of ideal state	Clear regulatory framework for flexible assets. Product requirements and regulatory arrangements enable a range of resources to participate even in different markets	EMarket bids with different time scales and sizes reward flexibility	The transaction costs of flexibility are fairly allocated. This could include an appropriate asset certification regime, absence of double charging for storage, equal and fair VAT, policy levies and network charges		
Denmark	5	3	4	4	4
Finland	5	3	5	5	5
France	2	2	2	2	3
Germany	2	2	2	2	3
Ireland	4	5	5	4	4
Italy	1	1	1	1	2
Netherlands	4	3	4	4	4
Norway	4	5	5	4	5
Spain	1	1	1	1	2
Sweden	5	4	5	5	5
Switzerland	3	3	3	3	3
UK	2	2	2	2	3
Definition of least ideal state	Unclear rules. Low visibility, bias towards a specific type of resources.	No market signals for flexibility	Transaction costs penalise flexibility		

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