ENERGY TRANSITION READINESS INDEX 2022

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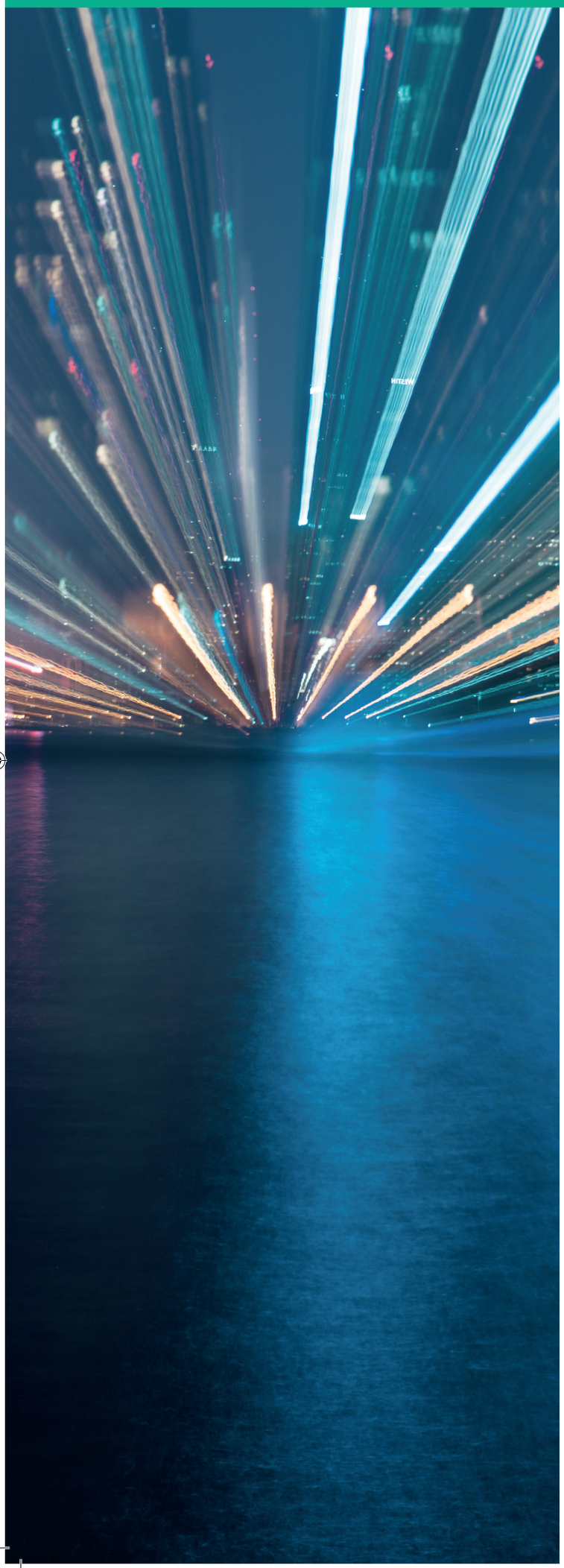

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This report has been prepared for the Association of Renewable Energy and Clean Technology (REA) by Robert Hull, Director of Riverswan Energy Advisory (roberthull@riverswan.co.uk). He is an independent consultant with over 30 years of experience in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

Foreword

Welcome to the REA's third Energy Transition Readiness Index (ETRI) report where we consider the status of 13 important, leading nations across Europe on their path to achieving their ambitious 2030 decarbonisation goals. All are committed to a Net Zero future, and all recognise that decarbonisation of their electricity systems is a vital pillar to achieving this.

As the REA, we have long advocated that renewable energy and clean technologies, delivered at all scales, and rewarded through deep flexibility markets, are the clear means to achieving this. Whilst many would argue that this case has been made, we can still see that the pathway to achieving this is fraught with both known and unforeseen challenges. The tragic war in Ukraine has in equal measures both galvanised and frustrated the pace of transition. When we asked Robert Hull to prepare this year's report, we knew that we could not ignore this shock wave to our energy systems and its ongoing impact.

In our first two reports, we examined the definition of what to be "ready" for the energy transition means, not just from the stated ambitions of the nations we have studied, but through the important "lens" of vital investors and developers of renewable energy and clean technology projects. Our survey of these important stakeholders reveals the level of confidence of developments over the last year, in the key important criteria that we use to develop the "readiness index":

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

The energy transition, enabled by flexibility market reform of electricity systems is well underway in many of these European countries, enabled by public policy, regulation, power markets and technology but the pace of progress varies widely. Some countries are still in the throes of initiating pilot schemes and demonstration projects. These must now be converted into concerted market developments.

From our perspective in the UK, the **REA Strategy** has already demonstrated how a fully decarbonised power system could be realised as early as 2032, well in advance of many Government targets if policy were to move faster. In this report's findings, we see that delays in policy implementation, despite existing ambitions, remain a consistent barrier across Europe. 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.

We are especially pleased to be sponsored by both Eaton and Eversheds Sutherland in this year's publication. Both companies, and their clients, are at the forefront of delivering the energy transition across Europe. We would like to thank them for their support and their invaluable insights during the development of this report.

The UK and Europe have the potential to become global leaders for flexibility services and deliver the benefits of renewables to all energy consumers. The energy crisis has sharpened the economic case too. This opportunity cannot wait any longer – it must be grasped now.

N. M. Skorupska

Dr Nina Skorupska CBE FEI
Chief Executive, REA

1. Executive summary

Transitioning to Net Zero is an urgent global challenge. Countries across Europe have set ambitious renewable electricity targets for 2030 to meet decarbonisation goals. Most will be met through new wind and solar renewables. But rapid growth in these variable renewables will need to be matched by rapid growth in flexible low carbon electricity resources e.g., flexible demand or storage, needed to balance generation and consumption and ensure security of supply when these renewables are not available.

Investment in these flexibility resources will also help electricity systems to become more efficient, reducing costs for customers struggling to pay their energy bills. Independent analysis shows these flexible electricity resources could deliver annual cost savings of up to €300 per customer in 2030[1].

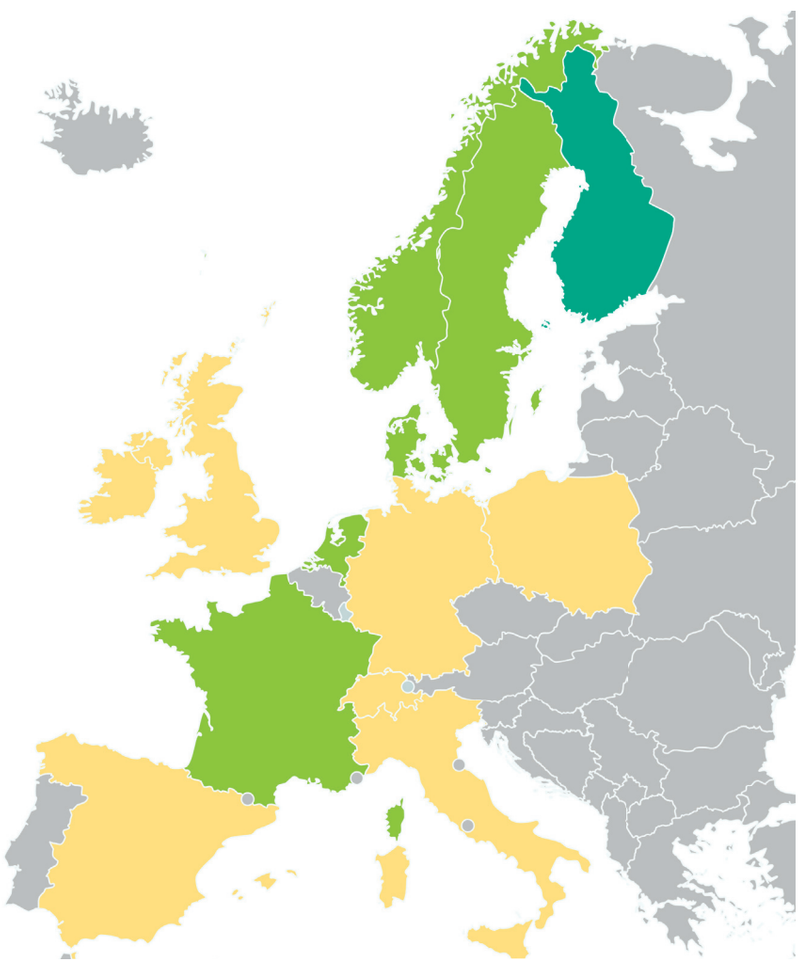
The growth needed in new flexibility resources offers major new investment opportunities, but easy access to electricity markets is needed to enable this investment. The transition to a decarbonised energy system depends on the successful attraction of this investment.

In this, our third Energy Transition Readiness Index report, we have ranked the progress of 13 European countries according to progress against:

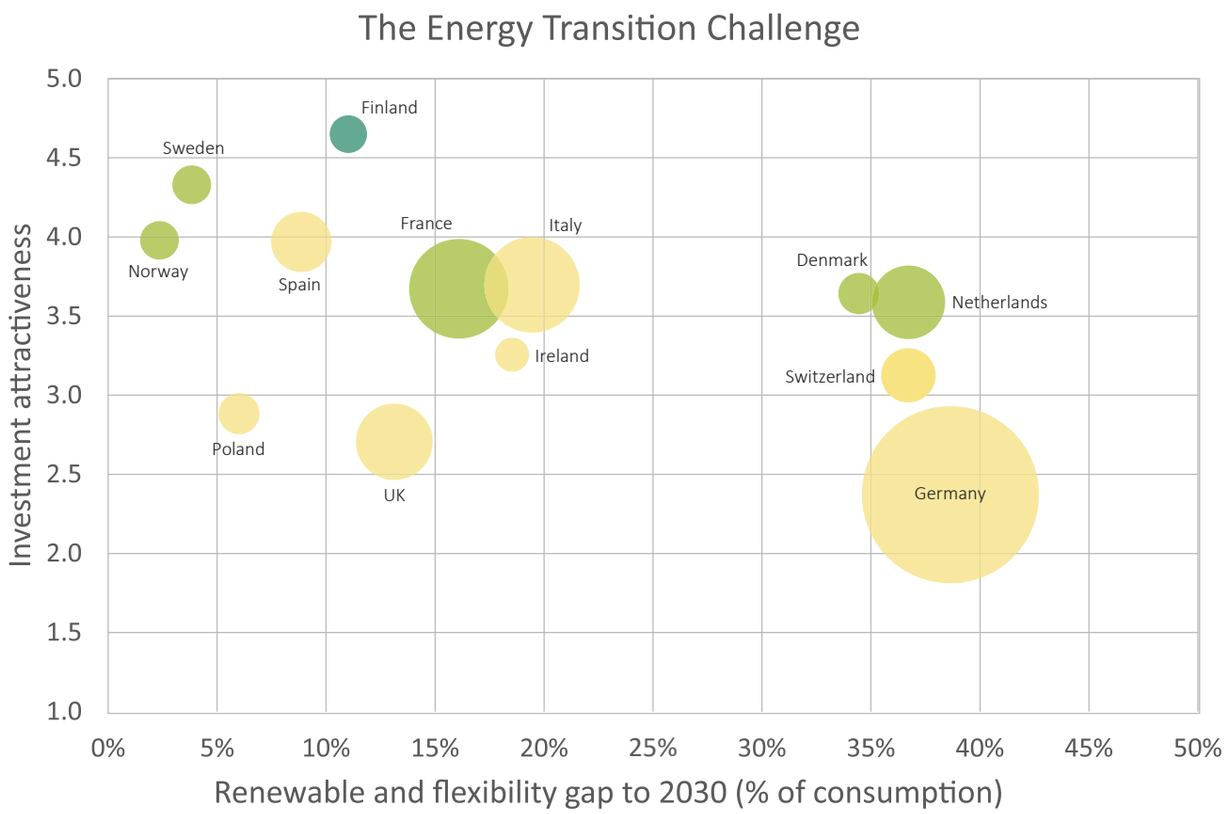
- Socio-political support for the energy transition
- Ability to exploit new technologies and business models
- Open market access for low carbon flexibility services

We have engaged with experts across these countries to assess and compare the transition of electricity markets in each country. Overall country rankings from this analysis are shown below:

	Overall rankings
5	Finland
4	Denmark, France, Netherlands, Norway, Sweden
3	Germany, Ireland, Italy, Poland, Spain, Switzerland, UK
2	
1	



[1]See Section 5 of this report for source and savings calculation.



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.

The urgent need for low carbon flexibility to displace gas is being highlighted by the current energy crisis, and investment momentum is building as a result. Low carbon flexibility opportunities, numbers of participants and investment volumes are all growing. But many barriers remain, both in technology enablers and in accessibility to markets. These barriers must be urgently addressed if the benefits are to be realised. Many countries are facing a huge flexibility challenge and prompt action is needed to achieve energy transition targets.

The report has three main recommendations:

- **Quantify and plan to address future flexibility needs:** the vast increases in flexibility resources needed to enable 2030 decarbonisation targets should be defined and should drive market and policy planning and reforms. There should be clear and co-ordinated accountability for forecasting and planning.

- **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. These reforms must create fair and predictable markets that give investment confidence to a wide range of potential new providers.

- **Urgently address current investment barriers:** there are often multiple barriers in existing markets to low carbon flexibility resources being deployed, ranging from grid access, metering, and market rules and IT systems. Increased momentum for low carbon flexibility investment has brought existing market barriers into sharper focus. For example, we would highlight:

  - Barriers to gaining grid access are becoming increasingly critical in several countries, including Germany, Ireland, Netherlands Poland, and the UK.

  - Barriers to flexibility market access can result from complex and unduly onerous technical standards and market rules, and slow change processes. This was highlighted for Germany and the UK.

2. Introduction

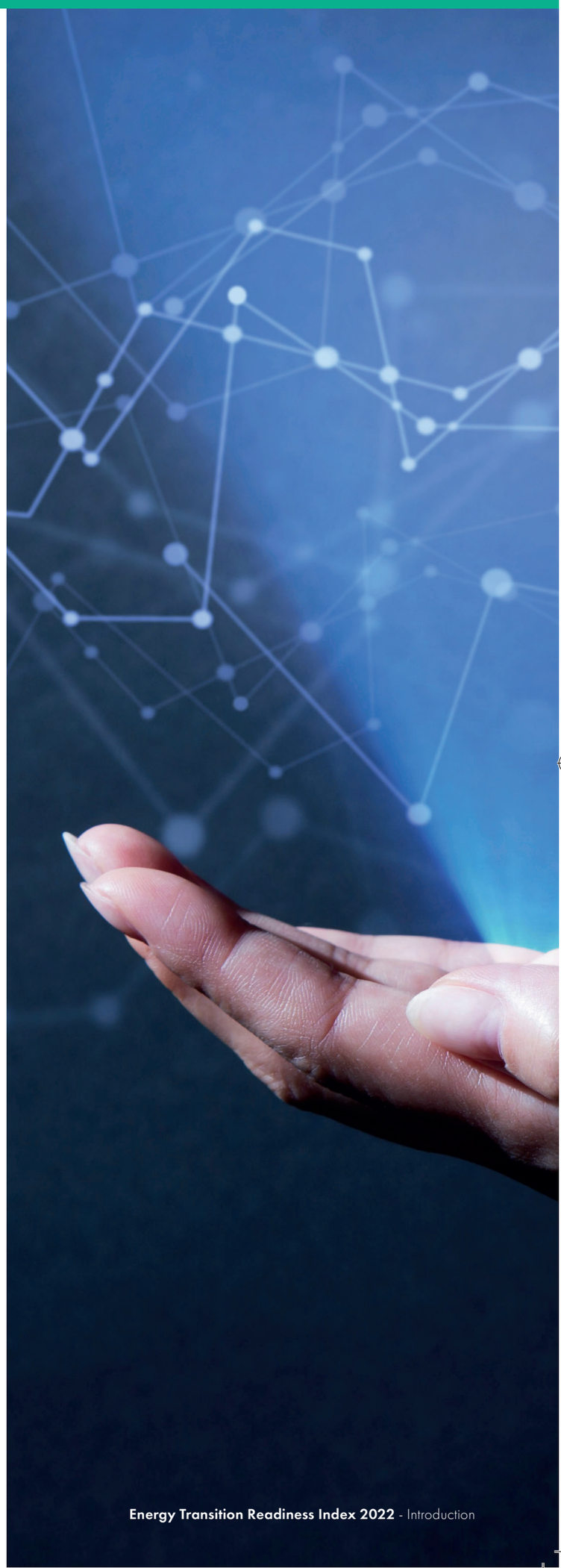
THE 2022 ETRI REPORT

Since 2019, the Association for Renewable Energy & Clean Technology (REA) has published an 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.

Last year's report assessed progress in 12 countries. This latest ETRI study updates the ranking of these countries and has added Poland, making a total of 13 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 previous reports, the assessment and scoring were based on a survey of experts representing investors in flexibility technologies across the different countries/regions selected, followed up by one-to-one interviews to understand the underlying reasons for responses. Survey respondents were also invited to comment upon how the current energy crisis had impacted their confidence in the achievement of the energy transition.

Grid stabilisation and flexibility services are becoming increasingly critical to support the further deployment of renewable power. This report includes some specific recommendations 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 and customer demand may vary significantly from minute to minute.

Flexibility is defined as the ability of electricity generation or customer demand to increase or decrease supply and demand. 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.

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., equipment certifications, metering limitations, grid connection constraints, or may be commercial barriers e.g., high trading costs or restrictive market rules.

ETRI 2022 – approach to evaluation

This paper sets out the results of a review of 13 European electricity markets. We have presented an index of market attractiveness for new investors in flexible electricity services, 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 the Nordic countries benefit from a large volume of flexible hydro generation; France has a large volume of power from its nuclear plant; and other countries have different levels of renewable electricity capacity. 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.

SURVEY QUESTIONS

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

Market access

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

Socio-political support

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

Technology potential

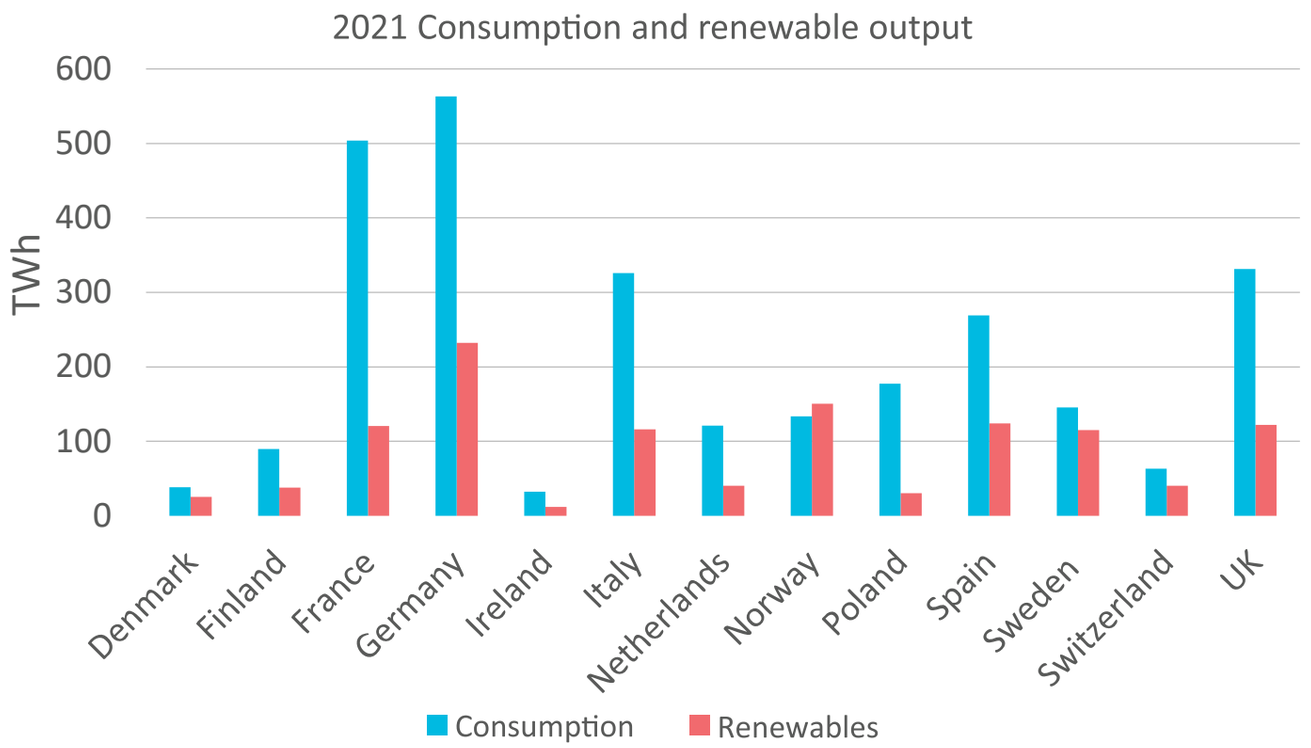
- Grid accessibility
- EV Infrastructure deployment enabled
- Digitisation enabled
- Innovation enabled

3. Electricity market characteristics

European renewable electricity - 2021[2]

The following chart compares the TWh of electricity consumption with that generated by all renewable resources (excluding nuclear) during 2021.

CHART 1: TOTAL CONSUMPTION AND RENEWABLE ELECTRICITY PRODUCTION (2021)



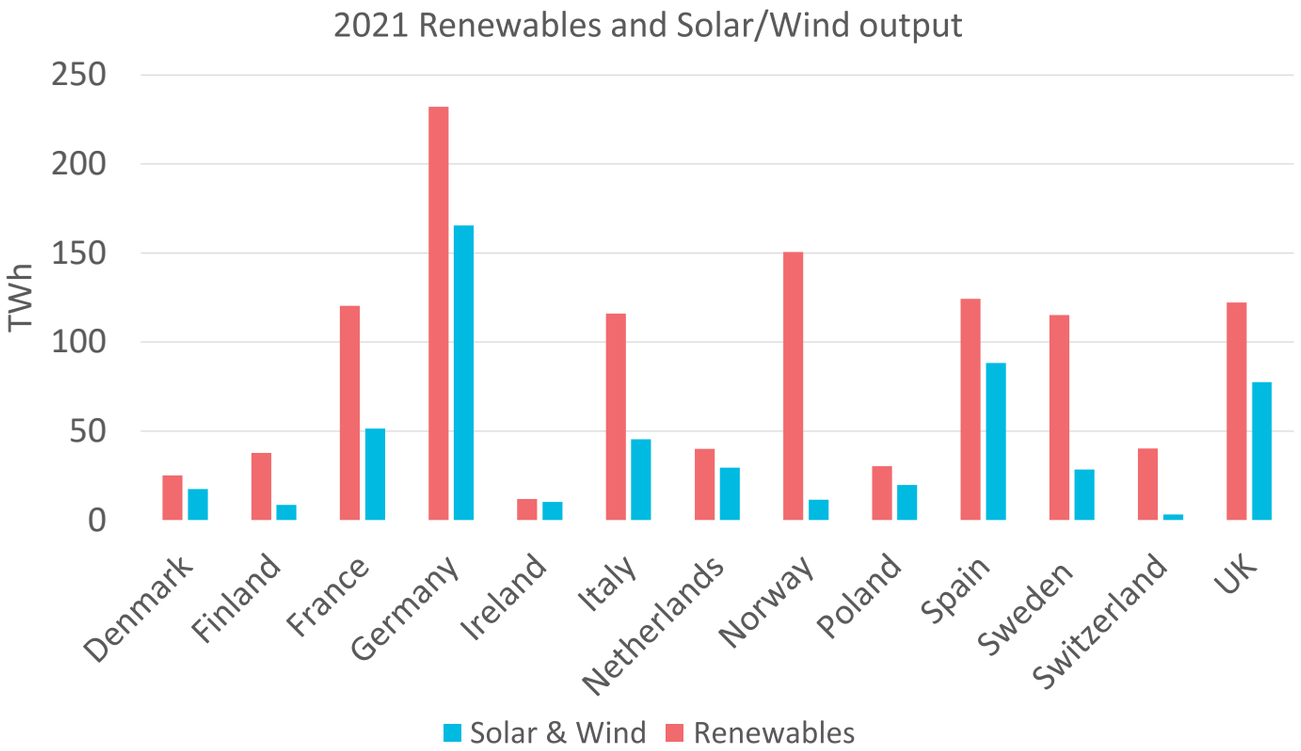
All countries show significant volumes of renewable electricity production in 2021. Denmark, Norway, Sweden, and Switzerland generated over 50% of their electricity consumption from renewable resources, reflecting their high hydro capacity, or wind in the case of Denmark. Despite having an average proportion of total renewable output, Germany had the highest TWh volume of output, reflecting that this is the largest electricity market in Europe.

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 compares the TWh of electricity provided in 2021 by solar and wind renewables with the total renewable output in each country.

[2]Data derived from EU sources & Ember database https://ember-climate.org/data/data-explorer/. Specific references are in Appendix A.

CHART 2: TOTAL RENEWABLE AND SOLAR/WIND ELECTRICITY PRODUCTION (2021)



The following table shows the percentage of electricity provided in 2021 by solar and wind renewables in each country.

TABLE 1: 2021 ALL RENEWABLES AS A PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION

Country	Total Renewables %	Solar & Wind %
Denmark	66%	45%
Finland	42%	9%
France	24%	10%
Germany	41%	29%
Ireland	36%	31%
Italy	36%	14%
Netherlands	33%	24%
Norway	113%	8%
Poland	17%	11%
Spain	46%	33%
Sweden	79%	19%
Switzerland	63%	5%
UK	37%	23%

This analysis illustrates that, in 2021, 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. This is due to the high proportion of Nuclear and/or Hydro generation in these countries.

Denmark had 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.

EUROPEAN DEMAND-SIDE FLEXIBILITY – 2021

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.

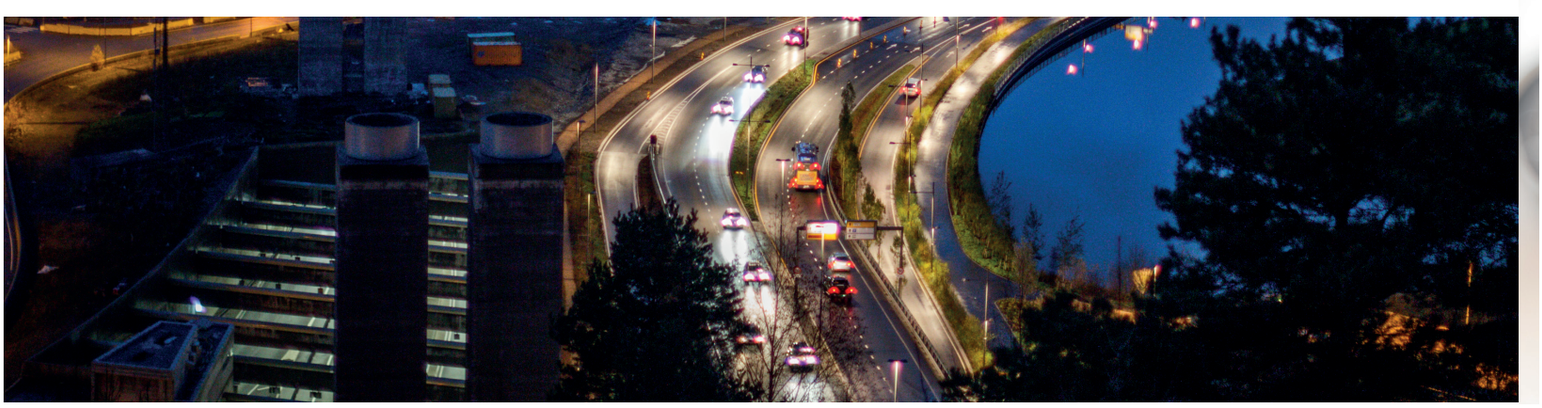
In order to assess the potential for demand-side flexibility across our selected countries, our study has assessed the following for 2021:

- Battery electric vehicle (EV) penetration – the total number of EVs, the number of EVs per 1,000 households, and the percentage of EVs in new vehicle registrations.
- Heat pump (HP) penetration – the total number of heat pumps, the number of HPs per 1,000 households, and the number of new HPs during 2021.
- Smart meter penetration – the total number of smart meters as a percentage of households.

The following table presents a comparison across the 13 countries. Data sources are provided in Appendix A.

TABLE 2: 2021 DEMAND-SIDE FLEXIBILITY RESOURCES AND ENABLERS

Country	Electric Vehicles			Heat Pumps			Smart Meter penetration
	Total ('000's)	Number per 1,000 homes	% of new registrations	Total ('000's)	No./1,000 homes	Number added in 2021 per 1,000 homes	
Denmark	57	21	13%	590	217	25	99%
Finland	20	7	10%	1,388	452	44	97%
France	407	11	10%	4,599	124	17	85%
Germany	666	15	14%	1,518	35	4	17%
Ireland	21	10	8%	74	36	13	34%
Italy	120	5	5%	2,773	106	15	99%
Netherlands	238	30	20%	290	37	9	85%
Norway	457	175	65%	1,706	654	50	98%
Poland	17	1	2%	395	24	7	12%
Spain	81	3	3%	1,545	60	8	100%
Sweden	113	24	19%	2,156	451	24	100%
Switzerland	75	16	13%	603	132	11	17%
UK	392	14	12%	318	11	1	45%



Flexible demand from electric vehicles and from heat pumps are well suited to participate in flexibility markets and will be able to provide significant future volumes of flexible demand at a distributed system level. The analysis shows:

- ***Electric vehicles*** - Norway is leading on electric vehicle uptake with both a high level of customer penetration and a high proportion of new registrations. While rollout is increasing across most other countries, Poland, Spain and Italy show both the lowest fleet numbers and new registrations.

- ***Heat pumps*** - Norway, Sweden and Finland are leading on heat pump uptake, again with both a high level of penetration and a high level of new installations. The UK has both the lowest level of heat pump penetration and additional installations.

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, Poland, and Switzerland have relatively low levels of penetration. Numbers in Ireland and the UK are increasing as smart meter rollout programmes are being implemented.

Another important area of potential flexible demand (and supply) is data centres. Data centres accounted for 2.7% (or 138 TWh) of European electricity demand in 2018, and their consumption is expected to rise by 28% to around 180 TWh by 2030[3].

Finally, there is considerable growth in battery storage installations across Europe. Data published by the European Association for Storage of Energy (EASE) in June 2022, highlights that around 5 GW of energy storage had been installed across Europe by the end of 2021, with another 5 GW expected to be installed by the end of 2022. Installations comprise both grid scale (front-of-meter) batteries, and behind-the-meter batteries. UK, Ireland, and France appear to lead grid-scale battery installations, with Germany and Italy leading behind-the-meter installations.

EUROPEAN ELECTRICITY FLEXIBILITY NEEDS IN 2030

Each of the countries in our survey has also set emission reduction targets for 2030, together with associated targets for renewable electricity. Most national targets assume that 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.

Table 3 shows Norway, Denmark, and Switzerland aiming to reach 100% or more in renewable electricity by 2030. Germany has increased its target to 80% from 65%. Most other countries show major increases over 2021 levels except for France with 40% and Poland with 23%.

The following chart shows these targets for all renewable electricity production (excludes nuclear) in TWh for 2030 and compares them with the equivalent value for 2021.

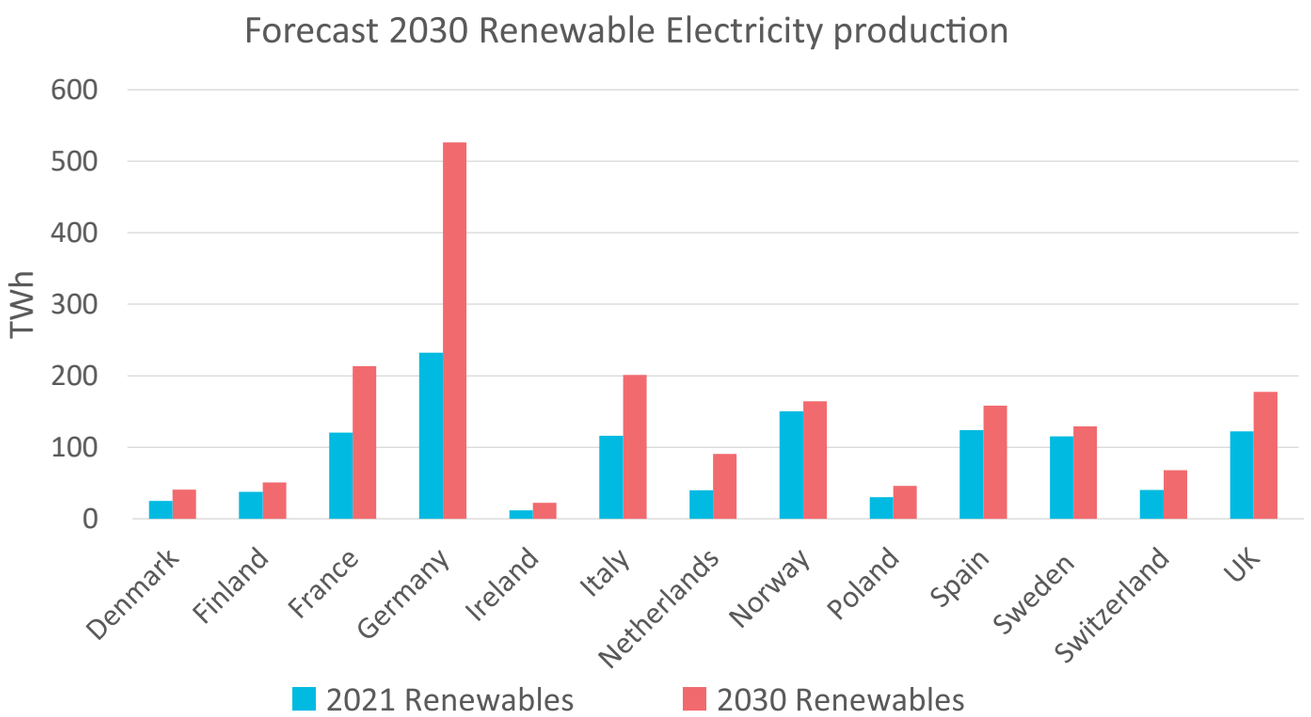
TABLE 3: 2030 TARGET PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION SUPPLIED BY RENEWABLE ELECTRICITY

Country	2021	2030
Denmark	66%	100%
Finland	42%	53%
France	24%	40%
Germany	41%	80%
Ireland	36%	55%
Italy	36%	55%
Netherlands	33%	70%
Norway	113%	115%
Poland	17%	23%
Spain	46%	55%
Sweden	79%	83%
Switzerland	63%	100%
UK	37%	50%

[3]https://digital-strategy.ec.europa.eu/en/library/energy-efficient-cloud-computing-technologies-and-policies-eco-friendly-cloud-market

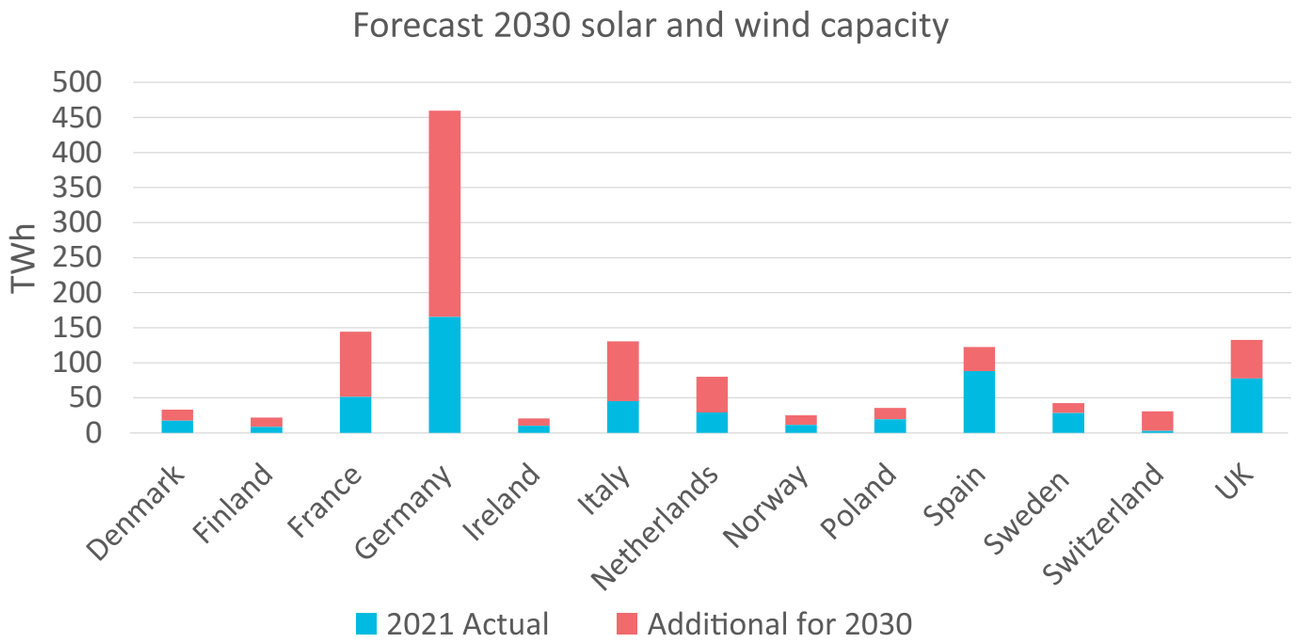
[4]https://ease-storage.eu/publication/emmes-6-0-june-2022/

CHART 3: FORECAST 2030 RENEWABLE ELECTRICITY PRODUCTION



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 2021 and 2030, assuming all growth is delivered by these technologies.

CHART 4: POTENTIAL FORECAST FOR 2030 WIND AND SOLAR ELECTRICITY PRODUCTION



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.

Table 4 below shows the potential TWh increase over 2021 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. Annual electricity consumption forecasts for 2030 have been derived from published national forecasts. Where such information was not available, a consumption increase of 7% between 2021 and 2030 was applied.

TABLE 4: POTENTIAL ADDITIONAL SOLAR AND WIND TO MEET 2030 TARGETS

Country	TWH	% GROWTH
Denmark	16	92%
Finland	13	156%
France	93	181%
Germany	294	178%
Ireland	11	106%
Italy	85	188%
Netherlands	51	172%
Norway	14	123%
Poland	16	81%
Spain	34	39%
Sweden	14	49%
Switzerland	28	911%
UK	55	71%

Some countries, notably Switzerland, appear to be targeting very high growth rates compared to 2021 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 294 TWh 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 in the form of electricity storage, flexible demand, flexible generation, or interconnection.

At present, most of the countries in this survey can benefit from flexibility provided by electricity interconnection. But the scale of this capability may be at risk in the future. This is because 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.

4. Energy transition readiness - Evaluation results

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

Rating
5 – Most transition ready
4
3
2
1 – Least transition ready

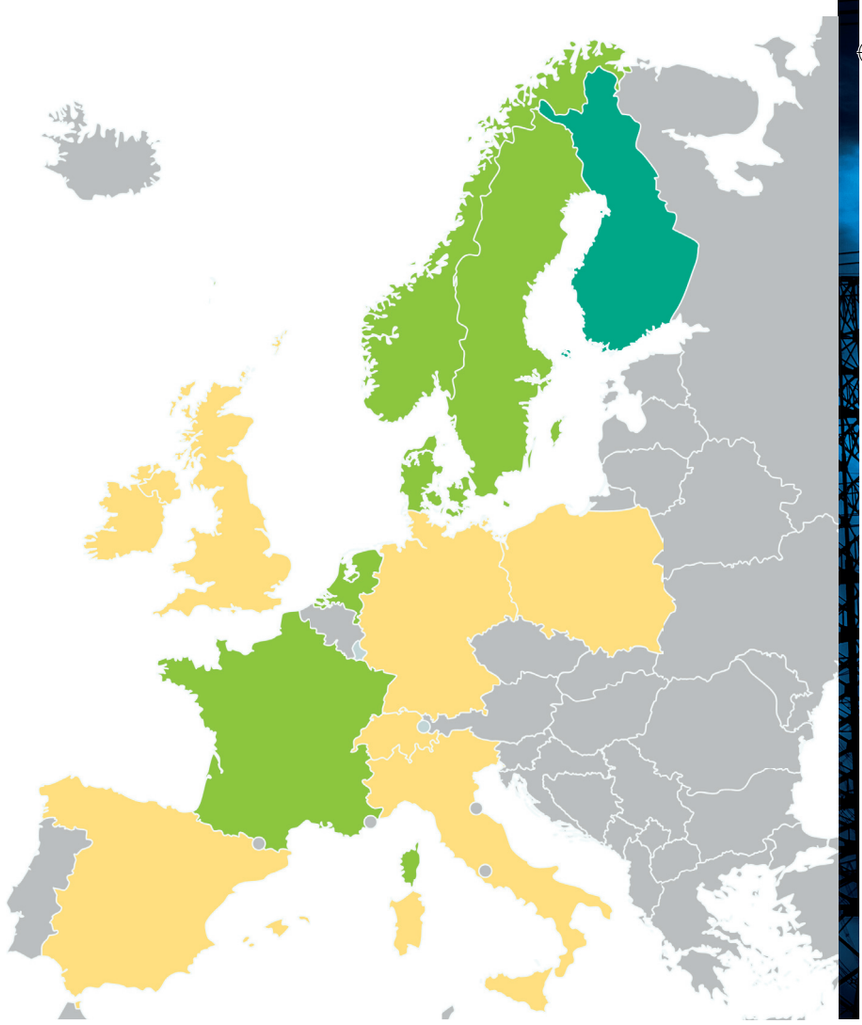
The supporting analysis for each country, as summarised in Appendix A, and Appendix B shows the full scorecard with responses for each assessment area.

Energy crisis - In addition to the standard evaluation questions, survey respondents were asked about how the current energy crisis impacted their confidence in the future deployment of renewables and flexibility resources to realise the energy transition.

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 transition-ready state, and the least transition-ready state.

	Overall rankings
5	Finland
4	Denmark, France, Netherlands, Norway, Sweden
3	Germany, Ireland, Italy, Poland, Spain, Switzerland, UK
2	
1	



The changes in overall rankings since our 2021 survey have been improvements in the scores for France, Italy and Spain, and reductions in those for Ireland, Norway and Sweden.

The higher-ranking countries are primarily differentiated by having effective energy transition policies, enabling electricity markets that flexibility technologies can access fairly and easily, as well as encouraging investment by new flexibility providers through clear price signals.

Lower ranking countries may generally be considered to have transition policies and technology enablers that are less effective in encouraging the adoption of flexible technologies. Their electricity markets present barriers to investment by being difficult to access, and slow to change.

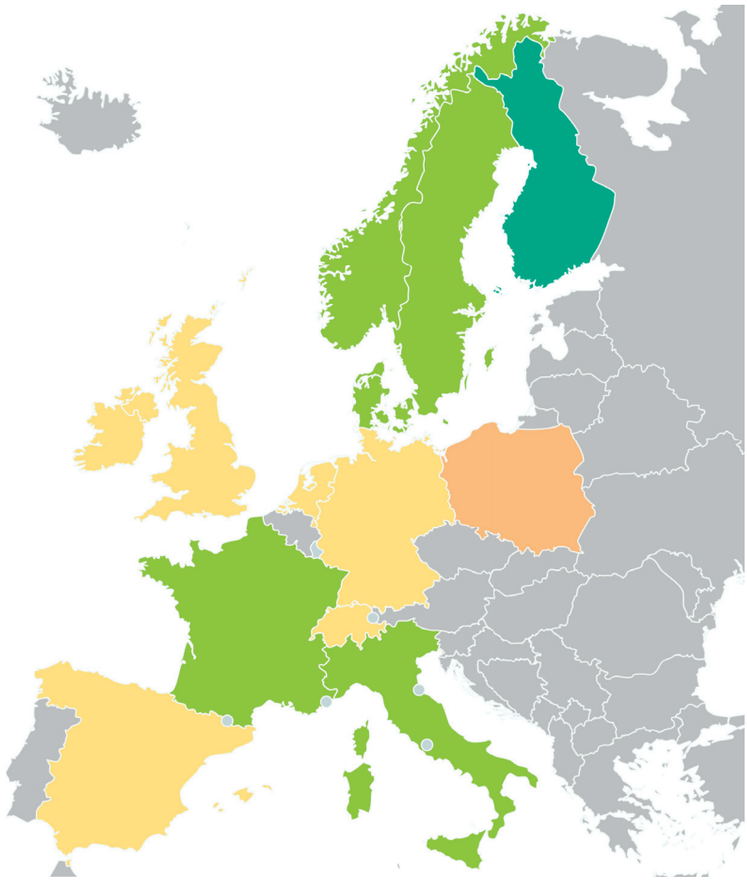
All countries in this survey have demonstrated strong ambitions for realising clean energy targets and have strategies for achieving them. While much progress has been made, a key ongoing barrier to the energy transition is the effective implementation of open flexibility markets. The ability to unlock 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.

1. SOCIO-ECONOMIC RANKING

This section assessed whether the socio-political background was supportive of, or an impediment to, investment.

	Socio-economic ranking
5	Finland
4	Denmark, France, Italy, Norway, Sweden
3	Germany, Ireland, Netherlands, Spain, Switzerland, UK
2	Poland
1	



Summary of comments

Clear roadmap - in high scoring countries, there was a clear roadmap for the energy transition involving all key participants whereas in lower scoring countries the roadmap and roles of individual industry participants were less clear. Finland scored highest in this category and Poland scored lowest.

Acceptance of transition - in higher scoring countries, there was a clear public social and economic acceptance of the energy transition and the costs and mitigations involved, including for those in fuel poverty. In lower scoring countries, this may not be so well understood or accepted. Finland and France scored highest in this category, while Poland scored lowest.

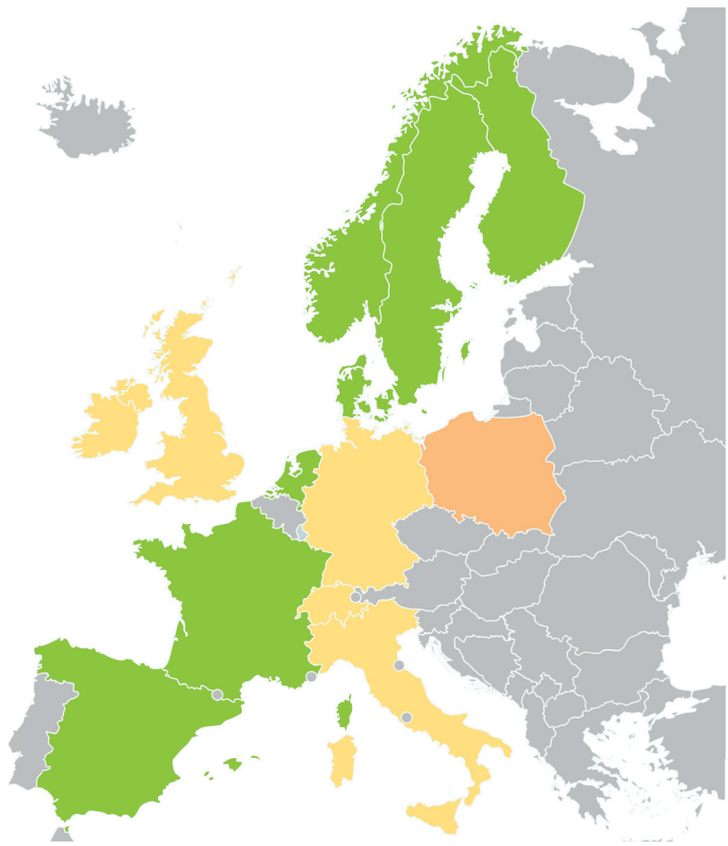
Regulation and delivery - in high scoring countries, there is a strong political commitment to a zero-carbon economy, and this is translated into a strong and 'fit-for-purpose' regulatory framework that will deliver the objectives particularly around flexibility. The lower scoring countries have weaker commitments to delivering the regulatory reform necessary to incentivise investment in flexibility resources. Finland scored highest in this category and Poland scored lowest.

In our 2021 survey, the scores were all 3 or above in this category, demonstrating that there was a generally strong social and political ambition towards realising the transition to a clean energy system. The 2022 survey still shows high scores but there was an overall decline in confidence (a 10% reduction in average scores) about delivery of the energy transition, mainly resulting from concerns about the current energy crisis. The low score for Poland reflects the early stage of the country's energy transition delivery ambitions.

2. TECHNOLOGY ENABLER RANKING

This section assessed whether the technology landscape was an enabler of, or an impediment to, investment.

	Technology enabler ranking
5	
4	Denmark, Finland, France, Netherlands, Norway, Spain, Sweden
3	Germany, Ireland, Italy, Switzerland, UK
2	Poland
1	



Summary of comments

Grid accessibility - 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. Finland scored highest in this area and Poland was lowest. Germany, Ireland, Italy, Netherlands, Switzerland and the UK were also considered to have increasing market barriers due to grid accessibility constraints.

Electric vehicles - for EV infrastructure, high scoring countries may be expected to have a clear roadmap for providing bidirectional charging to EVs so that they can participate in flexibility markets. However, progress remains relatively slow across all countries except Norway.

Digital - in high scoring countries, digital technologies comprising communications, flexibility dispatch systems, smart meters, data standards, and IT systems constitute a key enabler for flexibility markets. In lower scoring countries not all this digital infrastructure is in place. Germany and Poland score lowest in this area.

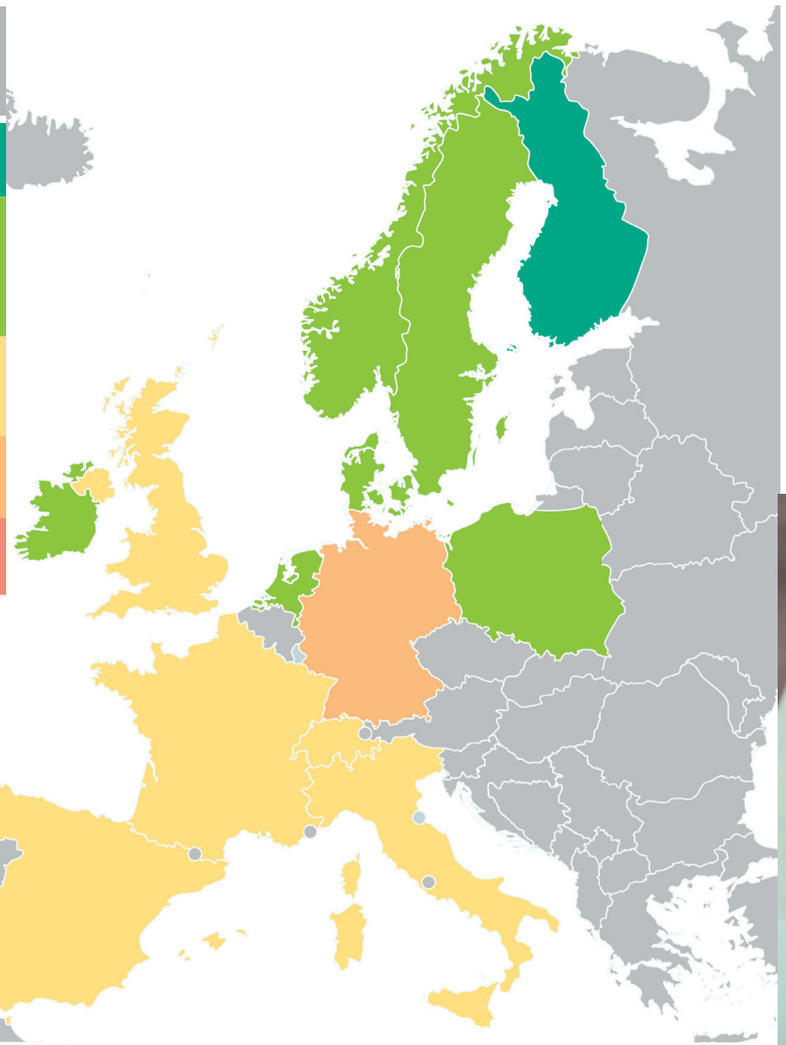
Innovation - high performing countries have a clear route for enabling technology innovation through opportunities to participate in flexibility markets perhaps using regulatory sandboxes, whereas in lower performing countries there are often barriers to connection of new technologies to the grid. Norway scores highest in this category, with Poland the lowest.

In our 2021 report, the scores were all 3 or above in this area, demonstrating that technology enablers were generally contributing well to the energy transition. Norway scored highest because of its leadership role in electric vehicle adoption and the associated use of EVs for flexibility services. In this 2022 report, Norway continues to be a leader in electric vehicle and heat pump adoption. Poland is the lowest with the greatest barriers to new technological development.

3. MARKET ACCESSIBILITY RANKING

This section assessed whether energy market regulation and operation was supportive of, or an impediment to, investment.

	Market accessibility ranking
5	Finland
4	Denmark, Ireland, Netherlands, Norway, Poland, Sweden
3	France, Italy, Spain, Switzerland, UK
2	Germany
1	



Summary of comments

Regulation - in high scoring countries, regulatory arrangements and market rules allow a wide range of distributed flexibility resources to participate in a variety of markets. In lower scoring countries, there are often unclear rules, conflicts, and market access barriers that hinder development. Finland scored highest in this category, while Germany scored lowest.

Market trading arrangements – in high scoring countries, market trading arrangements provide transparent markets that allow different contract terms, trading volumes (including aggregation) that enable effective flexibility trading. In lower scoring countries, trading of flexibility is limited. Finland scored highest in this category, while Germany scored lowest.

Market transaction costs - in high scoring countries, market transaction costs are equitable with other technologies, whereas in lower scoring countries, they can penalise flexibility and present a barrier. Finland scored highest in this category.

The survey showed that most countries were considered to have accessible market arrangements but there were significant differences in how flexibility resources were able to participate in markets. In France and Poland for example, the market arrangements were in place, but flexibility resources were generally less competitive than incumbent generation. In Germany, it was thought that market access was restricted and to a lesser degree also in France, Italy, Spain, Switzerland and the UK.

THE CURRENT ENERGY CRISIS

Survey respondents were invited to comment upon how the current energy crisis had impacted their confidence in the achievement of the energy transition.

Key points that were highlighted included the following:

- High and volatile electricity prices had improved the economics of renewable and flexibility technologies and interest in deploying them had increased significantly. The crisis had stimulated an acceleration in energy transition investment.
- But the wider negative economic impacts resulting from the energy crisis meant that many individuals and businesses were not able to afford such investments at this time.
- Furthermore, it was thought that public and political support for the energy transition and decarbonisation would be relegated behind security of supply and affordability concerns.

This last point was also evident in the survey scores for socio-economic support, where the average overall scores decreased by around 10% compared to the previous survey in 2021.

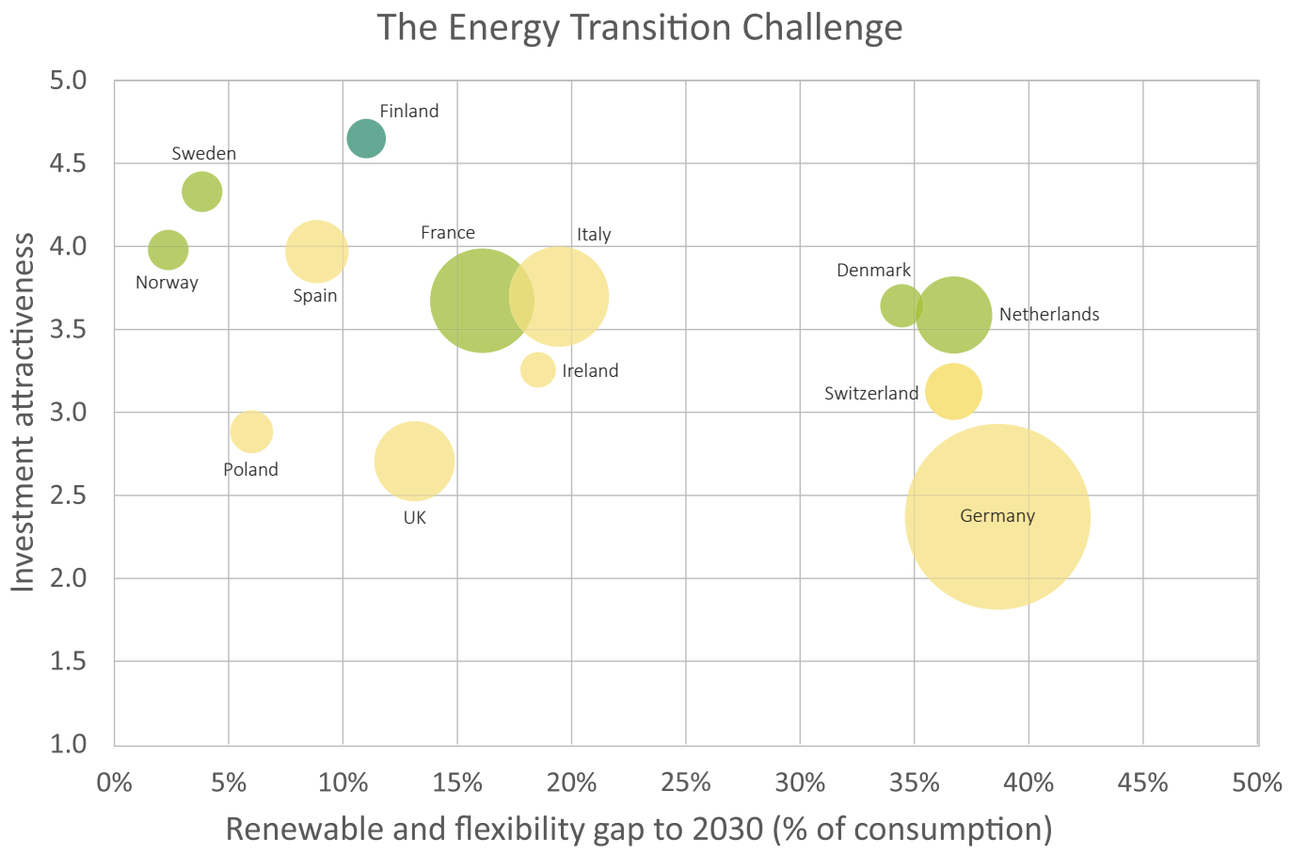
5. Looking forward – the energy transition implementation challenge

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 progress in delivering against this ambition. The following chart plots investment attractiveness as measured by the average of survey results for each country against the renewable energy gap between 2021 and 2030. This gap may also be considered to represent the flexibility gap.

The bubbles in the chart for each country represent the TWh of potential additional solar/wind and associated flexibility resources that will be needed to achieve 2030 renewable energy targets.

CHART 5: ASSESSMENT OF ATTRACTIVENESS AND SIZE OF THE CHALLENGE



Investor attractiveness - the countries in the top half of the chart are indicating above average investor attractiveness, and those in the bottom half of the chart have a below average investor attractiveness. This suggests that the lower scoring countries of Germany, Poland, and UK have greater market barriers to investment.

The gap to 2030 targets – the countries on the right-hand side (Germany, Denmark, the Netherlands and Switzerland) have set the most ambitious targets for 2030. These targets appear the most challenging to achieve in the time available.

It is noticeable that Germany, the largest electricity market in Europe, scores lowest for investor attractiveness yet the scale of Germany's challenge is the largest of all countries.

The chart represents the renewable energy targets for 2030, with the majority expected from wind and solar capacity. The considerable growth required will need to be accompanied by comparable growth in flexibility resources. Rapid growth in these renewable and flexibility resources will increase the risk of bottlenecks in supply chains e.g., for solar panels and batteries from China.

If these renewable and flexibility resources are not available then decarbonisation targets may not be met, and costs to consumers may be higher than necessary.

THE BENEFITS OF FLEXIBILITY RESOURCES

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. This also has the benefit of reducing the cost of curtailing renewable output, thereby reducing costs to consumers. It can also reduce the need for additional grid investment and peak generation capacity.

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 resulting from the increased economic activity.

An increasing number of studies are being undertaken to assess the benefits from the deployment of flexibility resources. Two relevant studies are summarised below:

Flexibility in Europe: Smart Energy Europe/DNV (2022)

Analysis published in 2022 by Smart Energy Europe and DNV has sought to quantify the benefits available from demand-side flexibility in 2030. The report analyses a theoretical 2030 scenario for demand-side flexibility where customers change their consumption and generation based on external market signals[5].

The report analysed the application of flexibility for annual demand of 4,500 TWh across the EU27. It assumed that flexibility markets were available for demand-side flexibility resources and assessed the potential benefits that could be realised in 2030 if these markets were in place.

The results of this analysis indicated that:

- 37.5 million tonnes can be saved annually in GHG emissions.
- €11.1 - €29.1 bn can be saved annually in distribution grid investments.
- €71 bn saved annually by consumers directly (equating to €300 annual savings per EU27 customer in 2030[6]).
- 15.5 TWh would be the avoided renewable curtailment.
- €2.7 bn would be saved annually in avoided peak generation capacity.

[5] https://smarten.eu/wp-content/uploads/2022/10/DNV-study-event-Press-release.pdf
[6] Assuming 240m electricity customers in EU27

Flexibility in GB: Carbon Trust/Imperial College London (2021)

Analysis[7] published in 2021 by Carbon Trust and Imperial College London concluded that investing in flexibility delivers material net savings of between £9.6bn/year and £16.7bn/year in 2050 (equating to between £340 and £600 annual savings per GB customer[8] in 2050).

The report states that this value is delivered by a portfolio of flexibility technologies including battery storage, thermal storage (in homes and integrated with heat networks), interconnectors and a range of demand-side response technologies across domestic, non-domestic and EV demands. High levels of flexibility deployment are required from different sources to help deliver the scale of savings in a net zero system.

The savings predominantly come from avoidance of gas generation, reduced reliance on carbon negative technologies and reduced network reinforcement. Beyond technologies such as these, flexible operation of systems like hybrid heat pumps and coordination of the hydrogen system (production, storage, conversion and use) help to maximise synergies with the wider system.

While these are different studies, over different time horizons, they both indicate significant cost savings available from deployment of flexibility resources alongside renewables.

[7] https://prod-drupal-files.storage.googleapis.com/documents/resource/public/Flexibility_in_GB_report.pdf
[8] Assuming 28m GB customers

6. Demand-side flexibility resources – transition examples

Achieving the energy transition will require a substantial increase in the use of demand-side flexibility resources. This will require significant investment in the growth of these resources and technologies, alongside the opening of markets through which they can operate. Across Europe, there are many examples of how these markets and flexible resources are beginning to emerge.

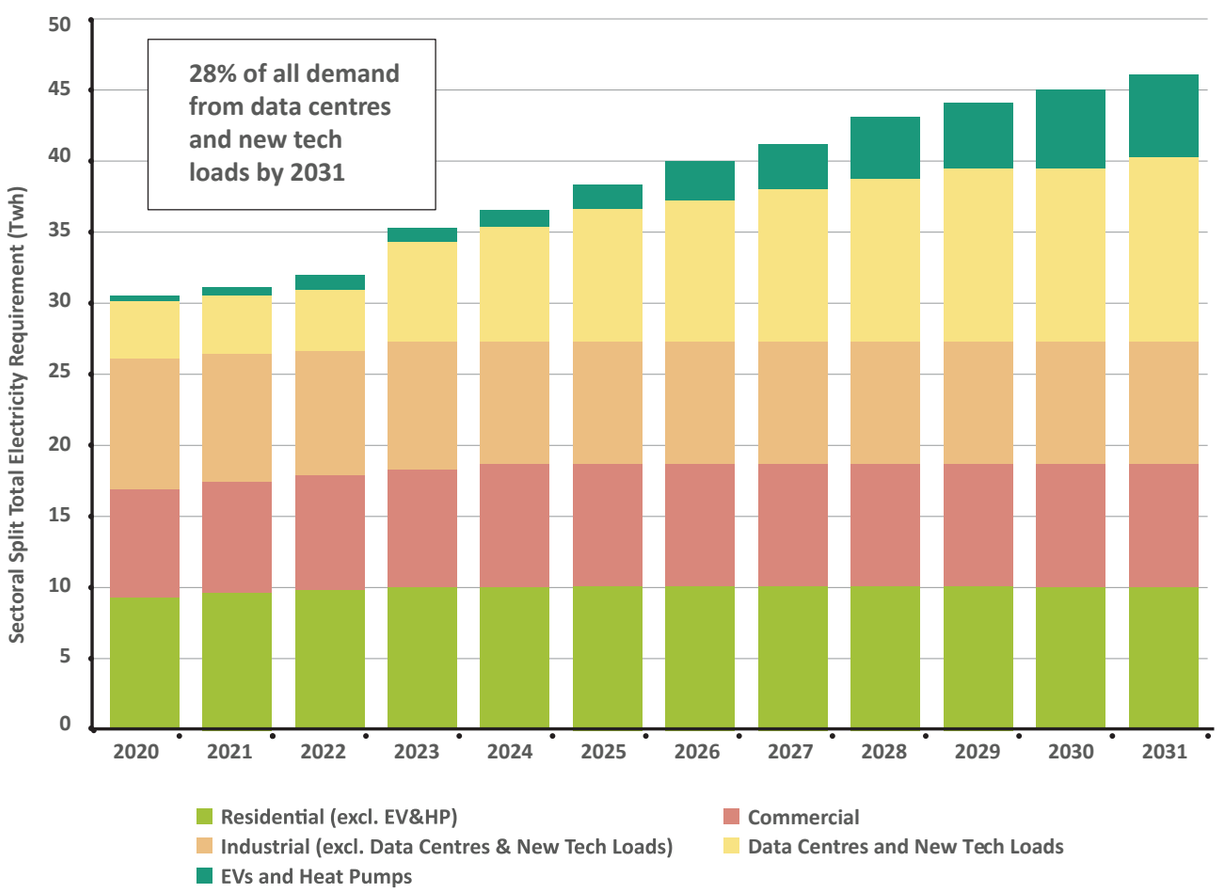
Three examples are set out below, illustrating the roles of a flexibility provider, a flexibility procurer, and a flexibility marketplace.

Example 1: Ireland - Data centre flexibility services

The European data centre market is growing rapidly due to the increased adoption of innovative digital technologies. It is estimated that data centres accounted for 2.7% of Europe's electricity demand in 2018 and this demand will reach 3.2% by 2030 (an additional 40 TWh) if growth continues on the current trajectory. A key driver for European electricity demand growth to 2030 is the connection of new data centres.

Take the example of Ireland where peak annual electricity demand in 2021 is around 5,000 MW with about 1,700 MW (or 30%) contracted to data centres and other large energy users. Demand from large energy users is expected to continue to increase in future as shown in the following table. In their latest Capacity Outlook, EirGrid estimate that 28% of total demand will come from data centres and new tech loads by 2031.[10]

CHART 6: EIRGRID CAPACITY OUTLOOK DEMAND FORECAST TO 2031



Data centres are typically large facilities with extensive energy management capability, including their own Uninterruptible Power Supplies (UPS) from batteries. As such, they have the potential to provide local flexibility services by altering electricity demand or generation, either by controlling internal processes (e.g. heating and cooling demand), or using on-site storage or generation.

A Microsoft[11] data centre in Dublin is using UPS batteries to provide interactive flexibility services to the Irish electricity system. These batteries have been approved for connection to the grid. Microsoft partnered with power management company Eaton to develop a grid-interactive UPS, ensuring the functionality of the UPS and secure communication between the data centre and the utility. Microsoft also partnered with local energy services and solutions provider, Enel X, to enter the EirGrid-run flexibility services market in Ireland.

Analysis performed by Baringa[12] suggests that if grid-interactive UPS systems were to replace the grid services currently provided by fossil fuel power plants in Ireland, about two million metric tons of carbon dioxide emissions could be avoided in 2030.

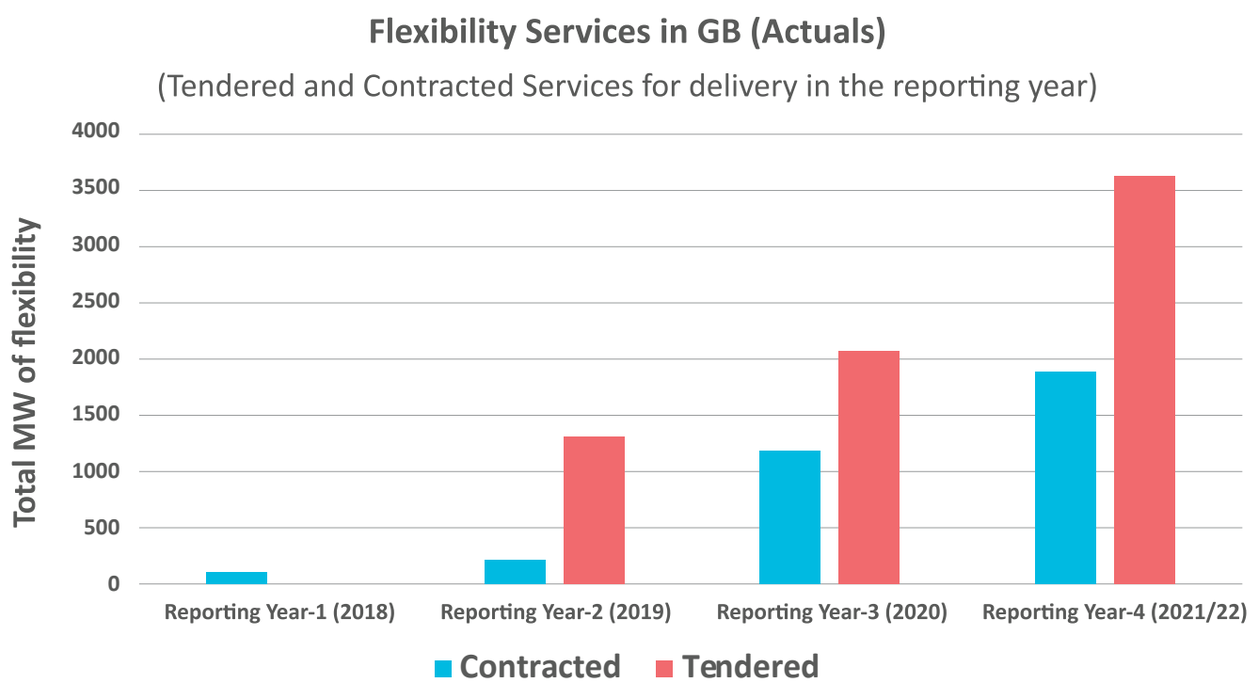
[9] https://digital-strategy.ec.europa.eu/en/library/energy-efficient-cloud-computing-technologies-and-policies-eco-friendly-cloud-market
[10] https://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid_SONI_Ireland_Capacity_Outlook_2022-2031.pdf

Example 2: UK - Distribution network flexibility services

Since 2018, distribution network operators (DNOs) in the UK have been tendering and procuring various flexibility services to help manage congestion in the local electricity grids[13]. Regular auctions are held to procure these services from demand-side flexibility providers.

The following chart, published by the UK Energy Networks Association (ENA) in their 2022/23 Flexibility report shows the aggregate flexibility services tendered and contracted since 2018.

CHART 7: ENA DNO FLEXIBILITY SERVICES IN GB[14]



The chart shows a steadily increasing profile, with the results for 2021/22 showing that almost 2 GW of flexibility resources were contracted between DNOs and demand-side flexibility providers.

[11] https://news.microsoft.com/innovation-stories/ireland-wind-farm-datacenter-ups/
[12] https://www.baringa.com/getmedia/ec2a2d07-f87e-46d9-b67b-32fcec0af3e5/Baringa_Irish_Decarbonisation_G-UPS_Study_Report_v4_0
[13] https://www.energynetworks.org/creating-tomorrows-networks/open-networks/flexibility-services
[14] https://www.energynetworks.org/industry-hub/resource-library/?search=ON22-WS1A-P0+Flexibility+Figures+2022%2F23&id=267

Example 3: Norway - the NorFlex flexibility marketplace (NODES)

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 marketplace is being trialled in projects across Europe. A recent example is the NorFlex project in Norway which is described below.

NorFlex pilot overview

NorFlex is a pilot project where NODES operates a flexibility market in the DSO Agder Energi Nett and Glitre Energi Nett grids in southern Norway. The market opened for trading during autumn of 2020, and the pilot is set to finish in April 2023. This report presents NODES experience with operating the market between October 2020 and March 2022.

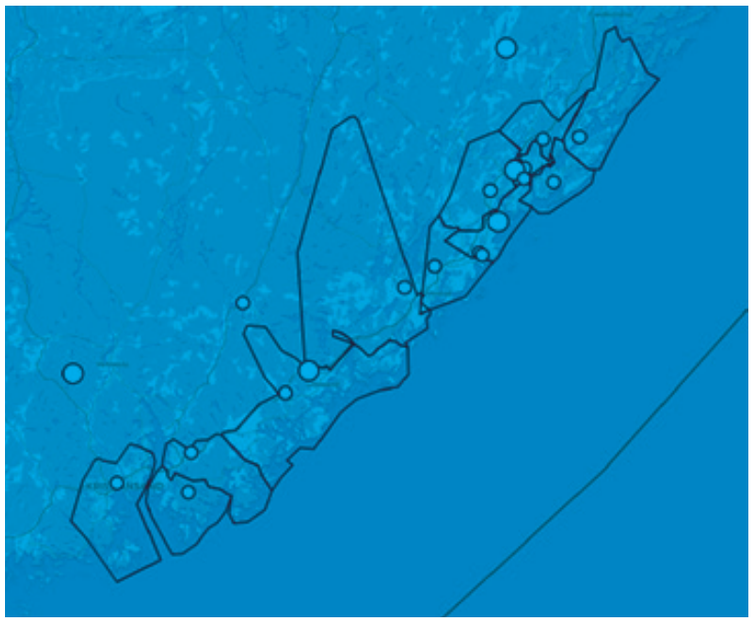
Electrification of transport, and heating in industry, commercial buildings, and homes is happening at a rapid pace and this is putting pressure on distribution grids. The goal of the project is to demonstrate how flexibility can be used by the DSO to:

- Increase efficiency of grid operations
- Increase grid connection capacity
- Postpone grid investments

Eight different flexibility service providers are participating in the pilot, offering flexibility from more than 2,300 assets in industry, commercial buildings, batteries, and homes. The minimum tradable quantity is 1 kW, allowing all assets to participate in the market on equal terms.

Agder Energi Nett has divided its grid into several different local markets representing congestion on different voltage levels. By using functionality in NODES these markets are linked together such that flexibility offered in the low voltage grid is also available for activation at higher voltage levels.

Figure 1: NorFlex market topography



The pilot is also investigating TSO-DSO coordination, enabling both DSO and TSO to tap into flexibility from distributed assets. At local market gate closure two hours ahead of physical delivery, any remaining unmatched orders were aggregated to Statnett's mFRR market.

Trading is done in dedicated trading periods, the first one in October 2020 and the last one ending 31 March 2022. In total 618 MW of flexibility at a value of 5,374,297 NOK was traded and activated.

7. Conclusions

This report has reviewed the energy transition readiness across 13 European countries. It has:

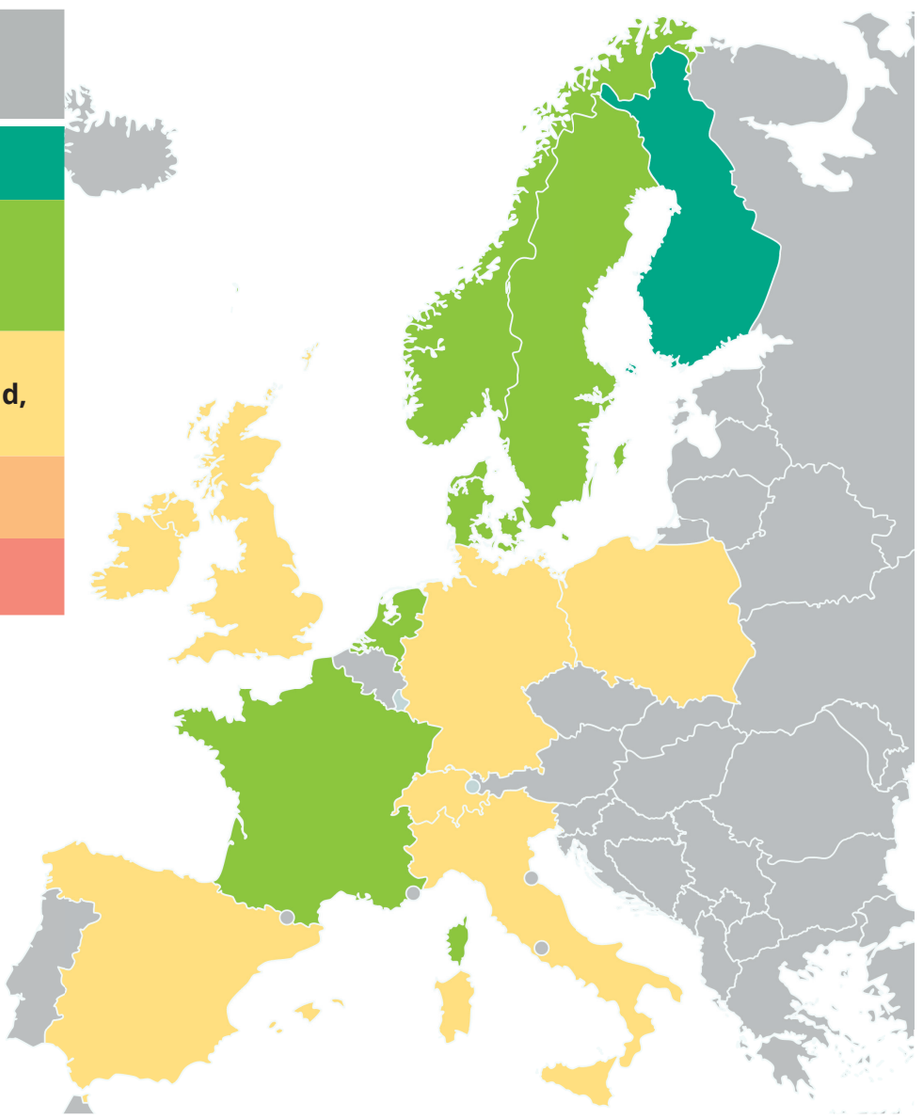
- Obtained views from experts in each country about the readiness for the energy transition, considering the socio-political environment, the development of flexibility markets, and the technology enablers needed for these markets to develop.
- Obtained views from these experts about the impact of the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

Energy Transition Readiness Index (ETRI)

This index assesses the relative energy transition readiness for each country from an investor perspective, representing the investment and market attractiveness.

The results of the survey are shown in the diagram below, with Finland showing the greatest degree of readiness. Since our 2021 survey there have been improvements in the scores for France, Italy and Spain, and reductions in those for Ireland, Norway and Sweden.

	Overall rankings
5	Finland
4	Denmark, France, Netherlands, Norway, Sweden
3	Germany, Ireland, Italy, Poland, Spain, Switzerland, UK
2	
1	



Higher-ranking countries generally 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.

The report continues to show that the energy transition to decarbonised electricity markets, including flexibility market reform, is steadily increasing, enabled by policy, market reforms and technology, but the pace of change varies.

The scale and potential of the flexibility marketplace is becoming better understood. There are many new participants emerging, bringing new skills, solutions, technologies, and investment capital.

Key themes that emerged from the survey are:

- **Political and public support** for the energy transition has weakened since our last report. Concerns that policy delivery and regulatory/change implementation can be complex, uncoordinated, and slow have increased.

- **Technology enablers** such as grid access are becoming a more significant barrier, particularly in Germany, Ireland, Poland, and the UK. Policies to incentivise EV charging and bidirectional operation remain patchy and underdeveloped.

- **Open and fair flexibility markets** for distributed energy resources are a common ambition, but most are at the early stages of development and change can be slow. Commercial and regulatory barriers often prevent the participation of new low carbon distributed energy assets in flexibility markets.

The current energy crisis

The survey asked respondents to comment on how the current energy crisis had impacted their confidence in the achievement of the energy transition. Key points that were highlighted include:

- High and volatile electricity prices had improved the economics of renewable and low carbon flexibility technologies and deployment was accelerating, which could result in a faster energy transition. The crisis could lead to a significant acceleration of the transition.

- It was recognised that the energy crisis could make such investments unaffordable for some. There was also a concern that, in the medium to longer term, public and political support would prioritise security of supply and affordability and so commitment to the energy transition could therefore decline. This could result in a slow-down and missed targets.

Market characteristics

Our assessment illustrated the high volumes of new renewable and flexibility resources that will be needed if 2030 decarbonisation targets are to be met. Demand-side flexibility technologies will have an increasingly important role to play, and the volumes of electric vehicles, heat pumps, and other demand-side technologies e.g., storage, will need to be increased significantly.

Our analysis showed that Germany, Denmark, the Netherlands, and Switzerland had set themselves the most ambitious transition targets to reach by 2030 and faced the biggest challenges in achieving them.

We estimate that, in aggregate, the 13 countries we assessed in this survey will require more than 700 TWh additional renewable capacity by 2030, together with the new flexibility resources needed to enable this capacity.

Benefits of flexibility

A recent European industry study suggests that the deployment of demand-side flexibility resources could result in annual cost savings of up to some €300 per customer in 2030, plus annual savings of 37.5 million tonnes in GHG emissions. A similar study in the UK suggested that annual savings of up to £600 per customer could be realised in 2050 (these studies are referenced in Section 5 of this report).

8. Recommendations

This report highlights the importance that low carbon flexibility resources will play in achieving the energy transition. The benefits are significant, delivering cost savings, decarbonisation and enhancing security of supply. The current energy crisis is demonstrating the importance of low carbon flexibility resources as a substitute for gas.

In our 2021 report, we made the following recommendations to address the flexibility challenge, and we consider them to be even more relevant today – these are:

- **Identify future low carbon flexibility needs and delivery plans:** A vast increase in new low carbon flexibility resources is needed to achieve 2030 decarbonisation targets. Forecasts for future flexibility requirements should be quantified so that associated plans, policies, and market reforms can be developed.

  Appropriate governance is needed to urgently deliver low carbon flexibility plans. Multiple organisations e.g., government, regulator, TSO/DSO, may be responsible for different aspects of flexibility planning, reform, and delivery. It will be important for clear responsibilities and accountabilities to be established.

- **Accelerate flexibility market reforms:** 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.

  In order to provide the confidence needed to attract investment, flexibility markets must be fair and open, allowing all flexibility and demand-side flexibility resources to compete. Investors are seeking predictability from the market and regulatory regimes to ensure that investments with long payback periods can be funded. Long-term price signals are needed to attract investment.

Future low carbon flexibility needs are being highlighted by the energy crisis, and investment momentum is building as a result. Low carbon flexibility opportunities, numbers of participants and investment volumes are all growing. But many barriers remain, both in technology enablers and in accessibility to markets. These barriers must be urgently addressed if the benefits are to be realised. As such we also recommend that:

- **Urgently address investment barriers:** There are often multiple barriers in existing markets to low carbon flexibility resources being deployed. These include grid access, metering, market rules and IT systems. Increased momentum for low carbon flexibility investment has brought existing market barriers into sharper focus. For example, we would highlight:

  - Barriers to gaining grid access are becoming increasingly critical in several countries, including Germany, Ireland, Netherlands, Poland, and the UK.

  - Barriers to flexibility market access can result from complex and unduly onerous technical standards, and slow change processes.

The relevant authorities, national Governments, regulator, and transmission and distribution system operators (TSO/DSO) should jointly prioritise the development of coordinated plans to remove these barriers.

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

Appendix A – country summaries

This appendix includes further details and analysis of the electricity markets, 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) **Poland**
10) **Spain**
11) **Sweden**
12) **Switzerland**
13) **UK**

Data sources

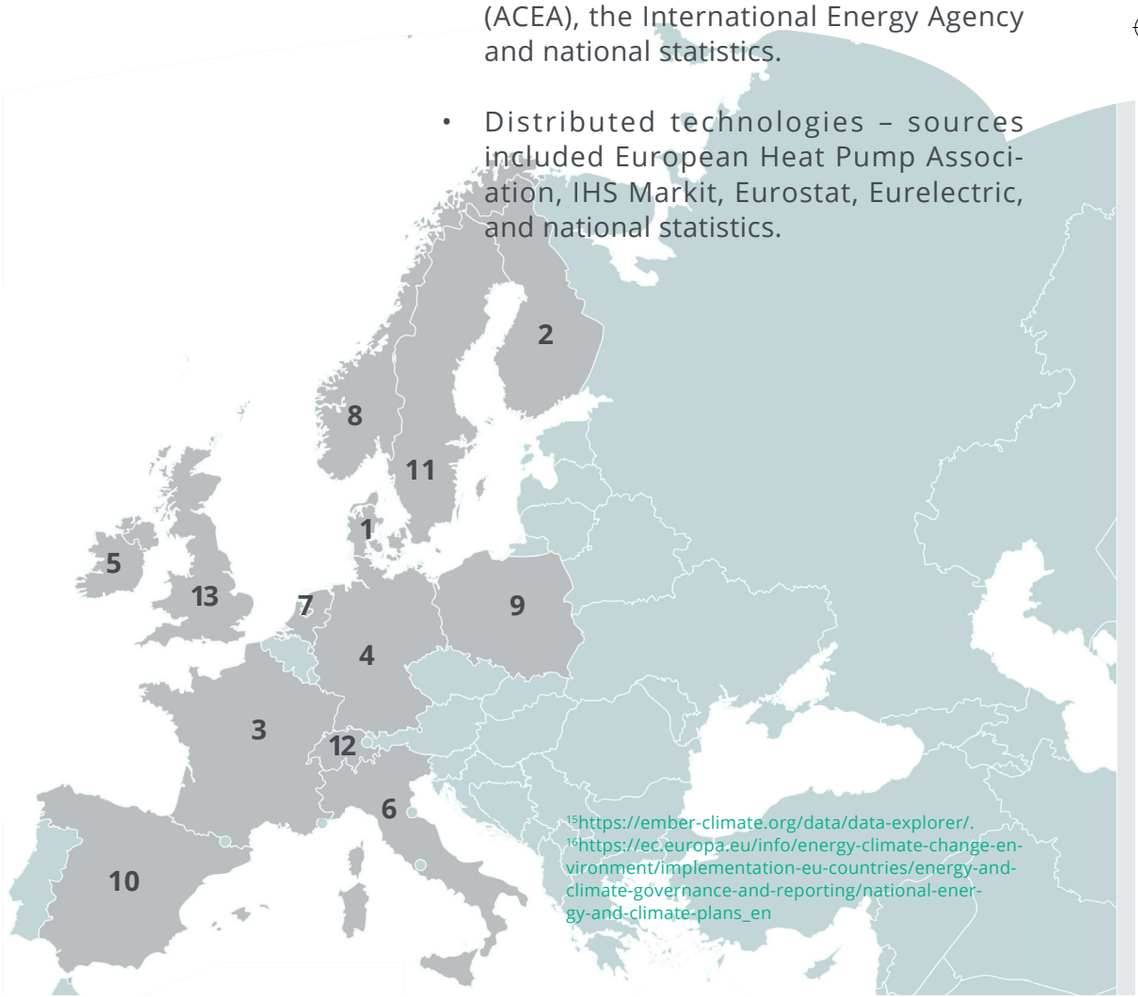
Country data was sourced from:

- **Electricity market data** – actual data for 2021 was obtained from Ember data and forecasts for 2030 were sourced from National Energy and Climate Plans for EU countries and national reports for non-EU countries.

  Annual electricity consumption forecasts for 2030 have been derived from published national forecasts. Where such information was not available, an increase of 7% between 2021 and 2030 was applied.

- **Distributed energy technologies** – The data for distributed energy products and enabling technologies has 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.



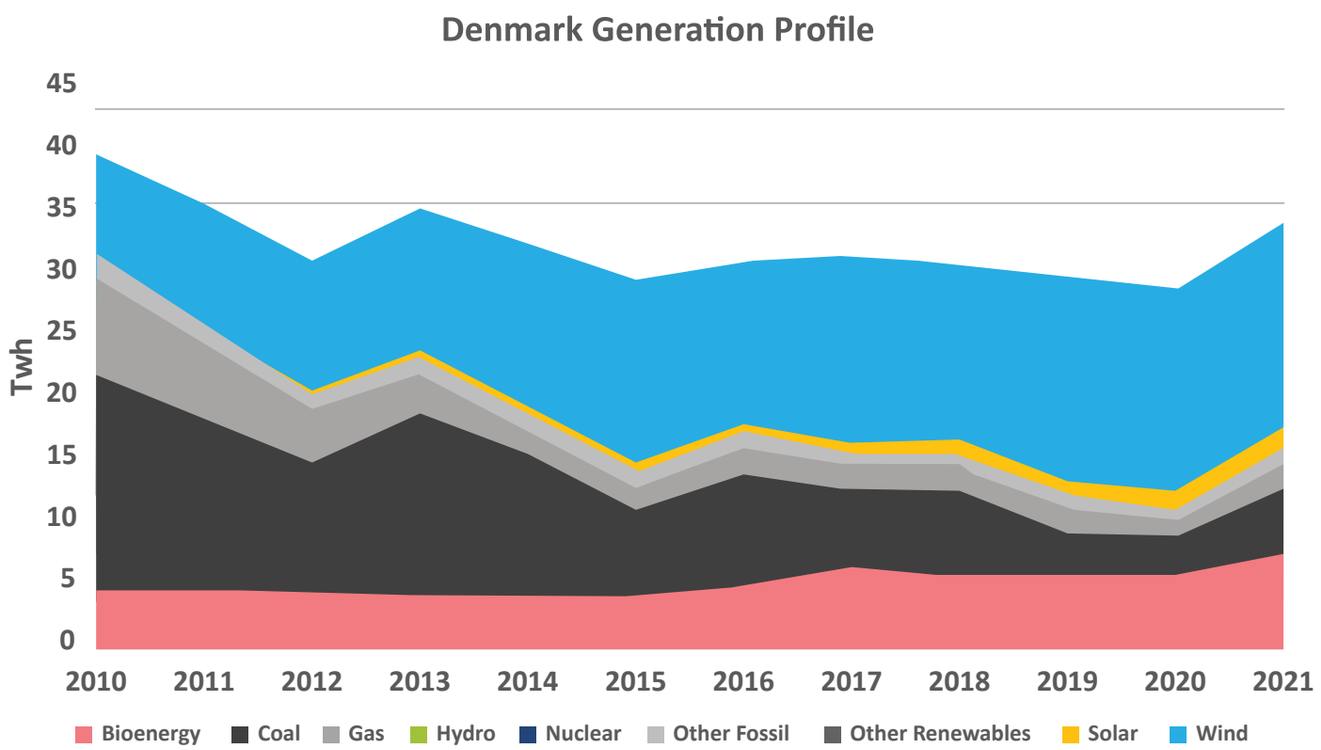
[15]https://ember-climate.org/data/data-explorer/.
[16]https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en

Denmark

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 8: DENMARK GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows that Denmark has significantly grown its wind generation capacity over the last decade and reduced its reliance on coal. High wind output will increase the need for other flexibility resources.

TABLE 5: DENMARK MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	38	41
Annual renewable production (TWh)	25	41
Renewable % of annual consumption	66%	100%
Annual solar and wind production (TWh)	17	33
Solar and wind % of annual consumption (TWh)	45%	81%

Flexible energy technologies	2021
Homes with electricity supply (million)	2.7
Domestic heat pumps ('000's)	590
Domestic heat pumps/1,000 homes	452
Heat pumps added/1,000 homes	25
Battery EV's (000's)	57
Total Battery EV's/1,000 homes	21
% EV registrations of all new registrations	13%

Enabling technologies	2021
Smart meter penetration	99%

Markets - In 2021, Danish annual renewable production (mainly wind) represented 66% of annual consumption. Denmark has targeted 100% renewables output for 2030, which could increase wind and solar output by an additional 16 TWh.

Flexibility resources - Denmark had a 2% penetration of electric vehicles in 2021, with electric vehicles representing about 13% of all new vehicle registrations. Heat pump penetration is around 20%. Smart meter penetration is high.

2. Survey results

The individual survey scores for Denmark are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
3	4	4	4

Market factors		
Regulations	Compensation structures	Transaction costs
4	3	3

Denmark is recognised as a leader in wind deployment with a strong supporting supply chain that benefits the overall economy. Overall, 2022 survey scores remain similar to the 2021 survey.

Key points raised by survey participants were:

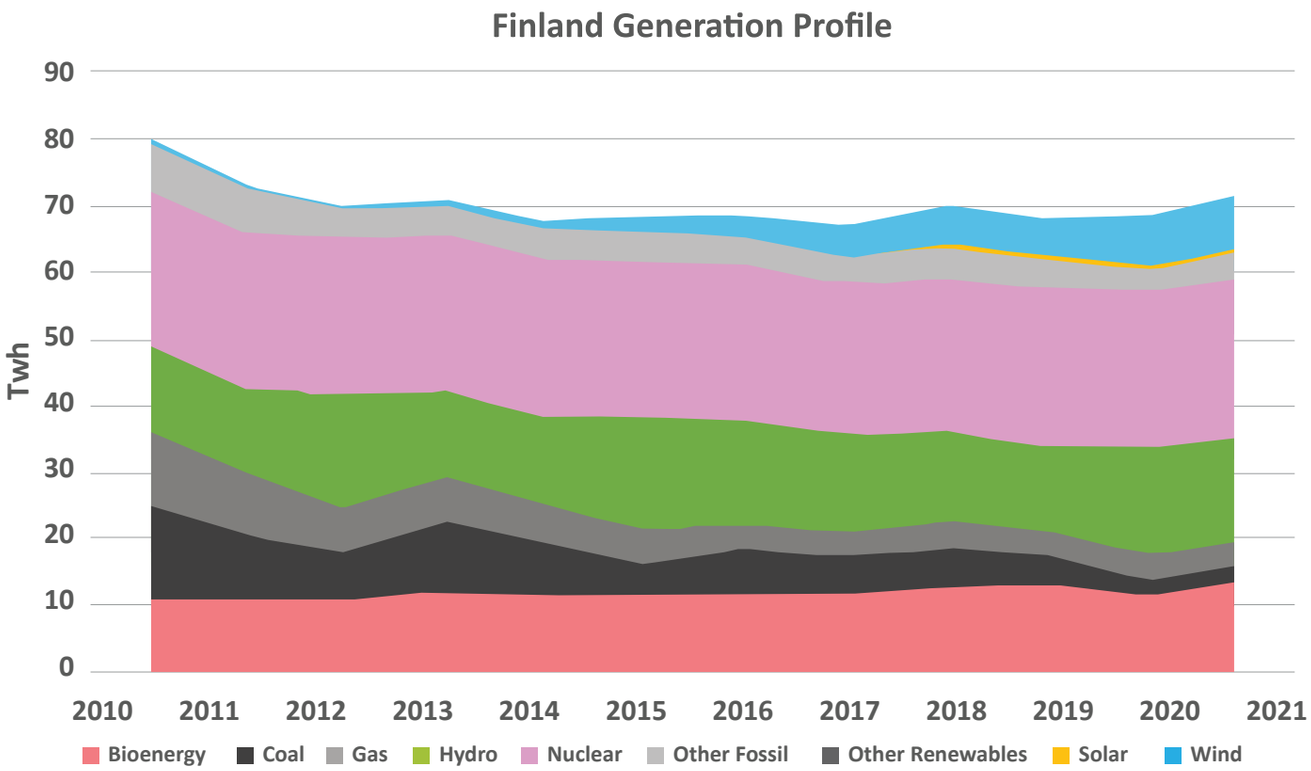
- The current energy crisis and high prices have led to an acceleration in customer investment in lower cost renewable energy, and associated flexibility resources.
- There is a strong political and public consensus about the energy transition, but affordability is becoming a priority due to the energy crisis. While policy aims and regulatory frameworks are clear, implementation may be delayed due to affordability concerns.
- Grid availability and investment are good, but significant additional investment is needed. Bidirectional flexibility needs are under-developed, especially vehicle to grid.
- Market design and availability of market information enable 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

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 9: FINLAND GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the significant contribution from hydro, nuclear and bioenergy. Finland has grown its wind generation output over the last few years, but it still represents a small proportion overall.

TABLE 6: FINLAND MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	90	96
Annual renewable production (TWh)	38	51
Renewable % of annual consumption	42%	53%
Annual solar and wind production (TWh)	8	22
Solar and wind % of annual consumption (TWh)	9%	23%

Flexible energy technologies	2021
Homes with electricity supply (million)	3.1
Domestic heat pumps ('000's)	1388
Domestic heat pumps/1,000 homes	124
Heat pumps added/1,000 homes	44
Battery EV's (000's)	20
Total Battery EV's/1,000 homes	7
% EV registrations of all new registrations	10%

Enabling technologies	2021
Smart meter penetration	97%

Markets - In 2021, Finnish annual renewable production represented 42% of annual consumption. Most renewables were hydro, with around 9% derived from solar and wind. Finland has targeted 53% renewables output for 2030, which could increase wind and solar output by 14 TWh.

Flexibility resources - Finland had less than 1% penetration of electric vehicles in 2021, with electric vehicles representing about 10% of all new vehicle registrations. Heat pump penetration is around 45%. Smart meter penetration is high.

2. Survey

The individual survey scores for Finland are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
5	4	5	4

Market factors		
Regulations	Compensation structures	Transaction costs
5	5	5

Finland has clear policy goals and implementation plans for delivering the energy transition. Given the dominance of low carbon energy production, Finland has fewer challenges to achieving energy transition compared to other countries. Overall, scores remain similar to the 2021 survey.

Key points raised by survey participants were:

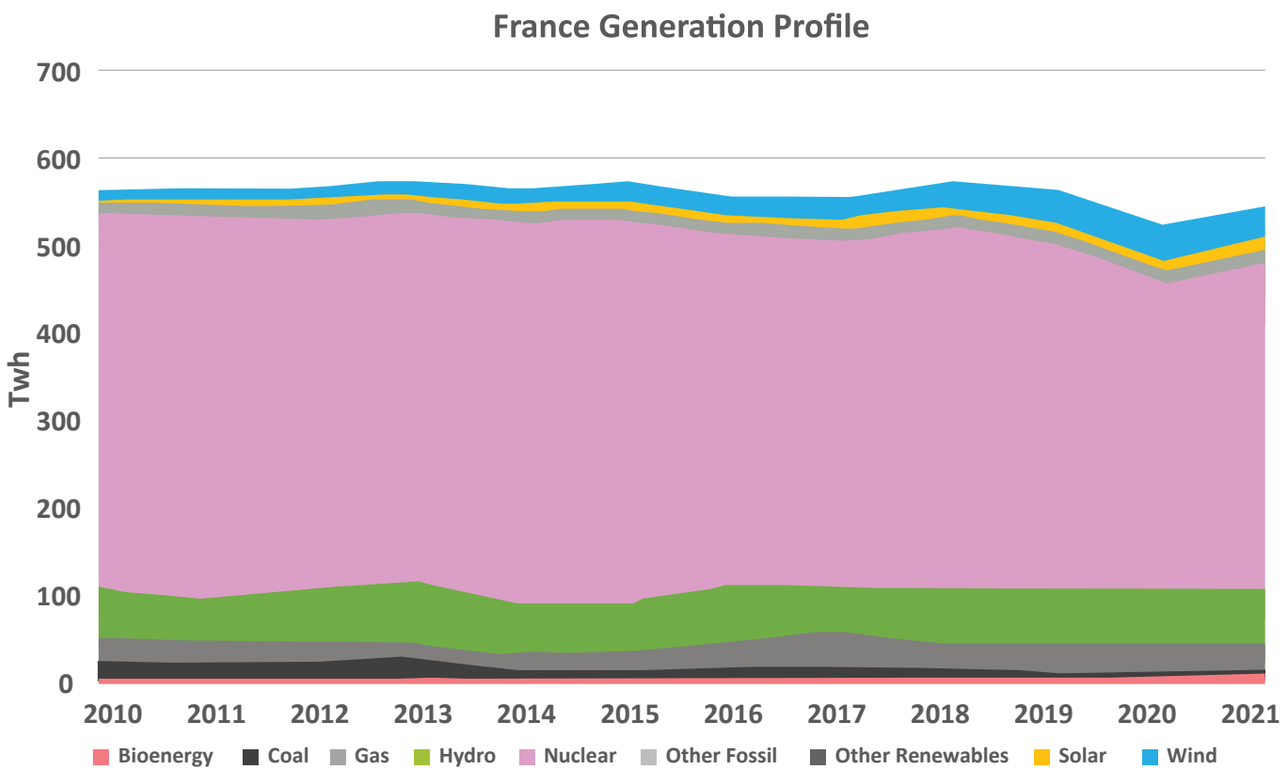
- The current energy crisis and high prices have led to an acceleration in the energy transition with increased investment in lower cost renewable energy, and associated flexibility resources.
- Support for decarbonisation and the energy transition is generally strong, but there are some concerns about 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. Support for electric vehicles is insufficient to incentivise faster take up.
- Market rules are fair and allow access by new distributed energy technologies. Flexibility markets generally work well and allow access to all technologies and market participants.

France

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 10: FRANCE GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It illustrates the dominant position of nuclear for French electricity production. While wind and solar have increased the last few years, they still represent a small proportion of the energy mix.

TABLE 7: FRANCE MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	504	533
Annual renewable production (TWh)	120	213
Renewable % of annual consumption	24%	40%
Annual solar and wind production (TWh)	51	144
Solar and wind % of annual consumption (TWh)	10%	27%

Flexible energy technologies	2021
Homes with electricity supply (million)	37.0
Domestic heat pumps ('000's)	4599
Domestic heat pumps/1,000 homes	124
Heat pumps added/1,000 homes	17
Battery EV's (000's)	407
Total Battery EV's/1,000 homes	11
% EV registrations of all new registrations	10%

Enabling technologies	2021
Smart meter penetration	85%

Markets - In 2021, 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 93 TWh.

Flexibility resources - France has a 1% penetration of electric vehicles in 2021, with electric vehicles representing around 10% of all new vehicle registrations. Heat pump penetration is around 12%. Smart meter penetration is high.

2. Survey

The individual survey scores for France are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
4	4	4	3

Market factors		
Regulations	Compensation structures	Transaction costs
3	3	3

Overall, there is a clear policy goal towards decarbonisation, but high nuclear capacity means there is less urgency to decarbonise than in other countries. Nevertheless, progress is being made in the policy and regulatory development to enable growth of renewables and distributed flexibility resources. Overall, scores have increased from the 2021 survey.

Key points raised by survey participants were:

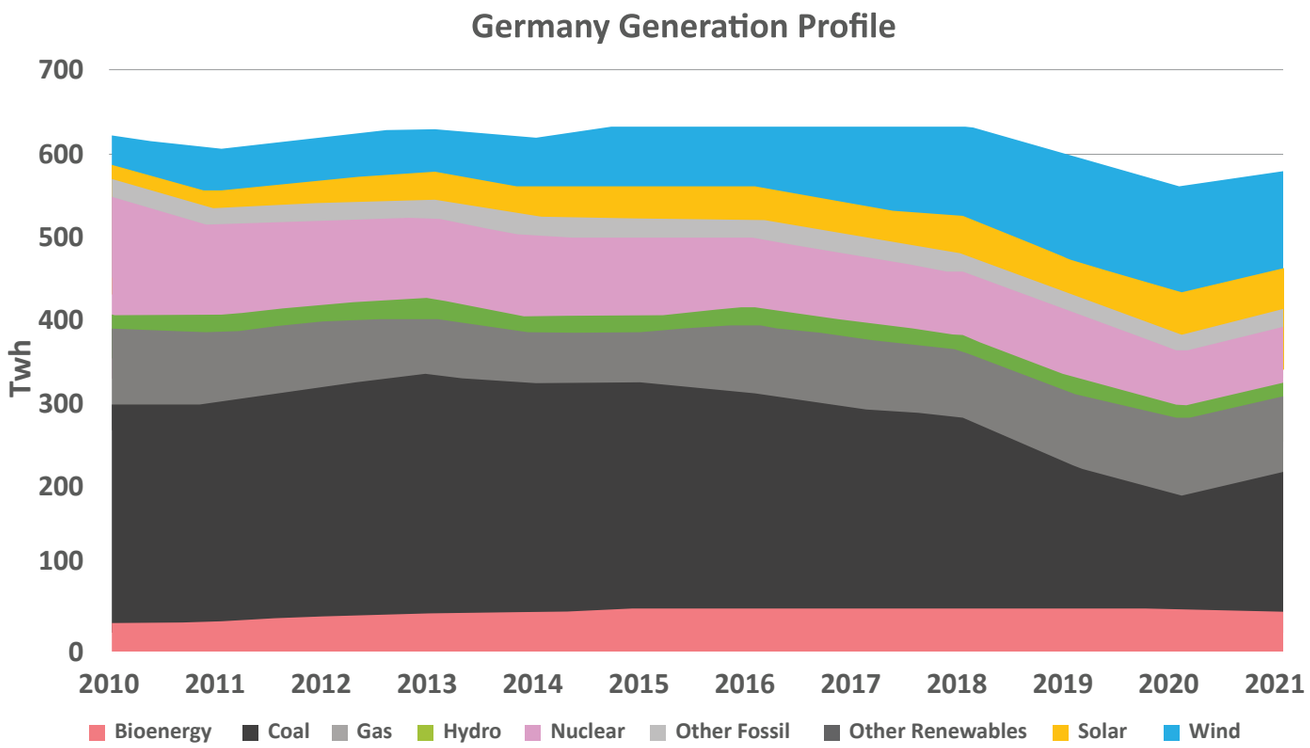
- The current energy crisis and high prices have led to an acceleration in the energy transition with increased investment in lower cost renewable energy, and associated flexibility resources.
- High level policy goals are in place for the energy transition. Decision making is centralised with a priority on nuclear policy for energy independence and decarbonisation. Affordability of energy has increased in importance.
- Grid access and investment are generally good. However, opportunities for flexibility resources are limited and standards are unclear. Vehicle-to-grid flexibility is not yet available.
- There is limited potential for distributed energy technologies to access flexibility markets. This is mainly due to the dominance of low cost nuclear and hydro capacity in these markets.

Germany

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 11: GERMANY GENERATION PROFILE



Germany is the largest electricity market in Europe. The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal.

TABLE 8: GERMANY MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	563	658
Annual renewable production (TWh)	232	526
Renewable % of annual consumption	41%	80%
Annual solar and wind production (TWh)	166	460
Solar and wind % of annual consumption (TWh)	29%	70%

Flexible energy technologies	2021
Homes with electricity supply (million)	43.0
Domestic heat pumps ('000's)	1518
Domestic heat pumps/1,000 homes	35
Heat pumps added/1,000 homes	4
Battery EV's (000's)	666
Total Battery EV's/1,000 homes	15
% EV registrations of all new registrations	14%

Enabling technologies	2021
Smart meter penetration	17%

Markets - In 2021, German annual renewable production represented 41% of annual consumption, with solar and wind comprising 29% of annual consumption. Germany has recently increased 2030 targets for renewable output to 80% (from 65%), and a consumption increase of 17% is forecast. This would require a 294 TWh increase in renewable output, from the 166 TWh produced in 2021.

Flexibility resources - Germany had 1.5% penetration of electric vehicles in 2021, with electric vehicles representing around 14% of all new vehicle registrations. Heat pump penetration was around 4%. Smart meter penetration remains low, with concerns over cybersecurity impacting rollout.

2. Survey

The individual survey scores for Germany are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
2	3	2	3

Market factors		
Regulations	Compensation structures	Transaction costs
2	2	2

Germany has significantly increased its decarbonisation target for 2030, demonstrating a strong commitment to decarbonisation of Europe's largest electricity market. This increases the challenge of replacing brown coal and gas with renewables at a time when energy costs have increased. While policy direction is clear, delivery of policy and regulatory change is uncertain. Overall, scores have decreased from the 2021 survey.

Key points raised by survey participants were:

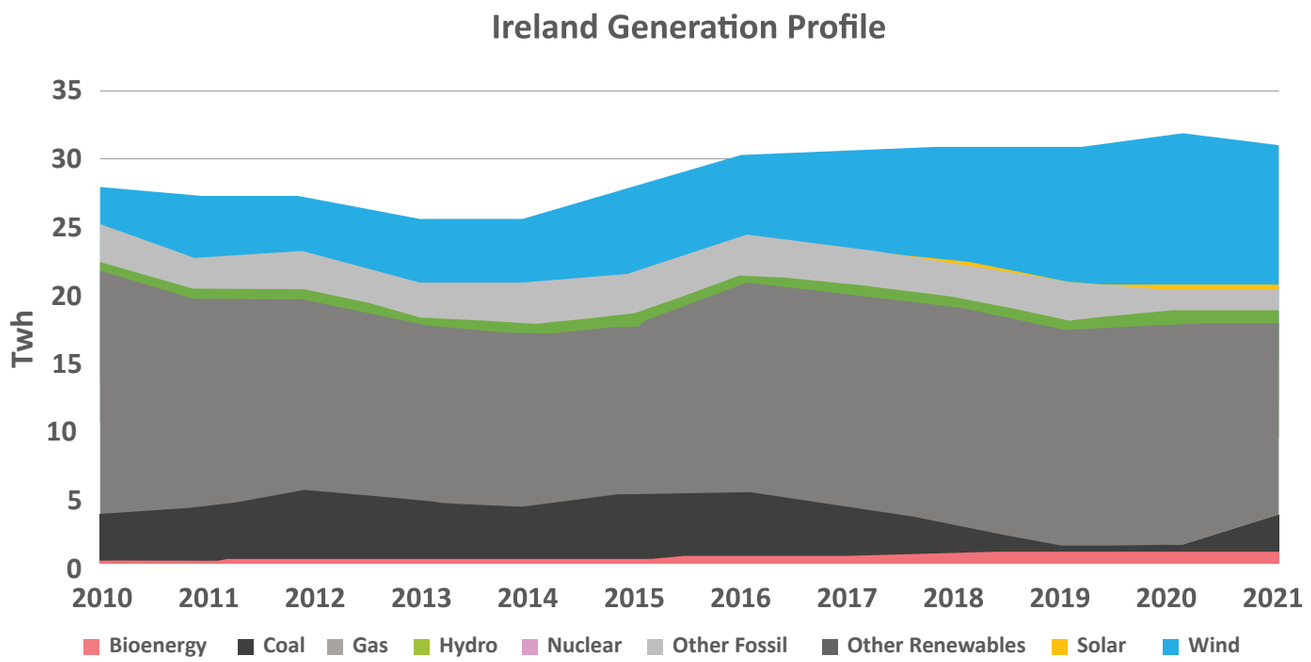
- Energy security has become a priority issue in Germany due to the energy crisis – it has highlighted the potential value for flexibility from reducing demand.
- Decision making about the energy transition has been blurred by concerns about the current high energy prices, resulting in a lack of alignment about delivery actions. Delivery of the energy transition policies may be delayed as a result.
- Grid access is effective but access to flexibility opportunities is limited. There is strong policy support for 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. Cybersecurity concerns about smart meters are driving up costs and delaying deployment.
- There is only a very limited flexibility market. These markets are generally closed to new smaller entrants. There are restrictions on revenue stacking, making it difficult for new technologies to enter and compete.

Ireland

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 12: IRELAND GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the growth of wind generation over the last decade, accompanied by a reduction in coal. Gas generation remains a significant proportion of the overall generation mix.

TABLE 9: IRELAND MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	32	41
Annual renewable production (TWh)	12	23
Renewable % of annual consumption	36%	55%
Annual solar and wind production (TWh)	10	21
Solar and wind % of annual consumption (TWh)	31%	51%

Flexible energy technologies	2021
Homes with electricity supply (million)	2.1
Domestic heat pumps ('000's)	74
Domestic heat pumps/1,000 homes	36
Heat pumps added/1,000 homes	13
Battery EV's (000's)	21
Total Battery EV's/1,000 homes	10
% EV registrations of all new registrations	8%

Enabling technologies	2021
Smart meter penetration	34%

Markets - In 2021, Irish annual renewable production (mainly wind) represented 36% of annual consumption. Ireland has targeted 55% renewables output for 2030, which would increase wind and solar output by 11 TWh. Ireland expects a 27% increase in consumption by 2030, driven by data centre demand.

Flexibility resources - Ireland had 1% penetration of electric vehicles in 2021, with electric vehicles representing about 5% of all new vehicle registrations. Heat pump penetration is around 4%. Smart meter penetration is increasing as a national rollout is underway.

2. Survey

The individual survey scores for Ireland are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
3	2	4	3

Market factors		
Regulations	Compensation structures	Transaction costs
4	3	5

Ireland has an ambitious plan to decarbonise electricity though the deployment of renewables and the access to flexibility markets. Good progress has been made, but the policy and delivery plans are coming under pressure from the current energy crisis. Overall, the survey scores have decreased since the 2021 survey.

Key points raised by survey participants were:

- The current energy crisis has exposed delays in deployment of renewable generation and energy security gaps. Short-term crisis management may delay transition plans such as further development of flexibility markets. It is hoped that the crisis will demonstrate the need to speed up the transition to renewable and flexibility resources.

- The political and public consensus for the energy transition has been weakened by affordability and energy security issues arising from the current energy crisis. Confidence in the policies and governance to implement the transition has reduced.

- Grid access is of increasing concern – there are some critical areas of grid congestion. Electric vehicle and charging infrastructure rollout is slow and V2G is limited. Flexibility service standards are reasonably well defined. Smart meter rollout is underway, but benefits are not yet emerging.

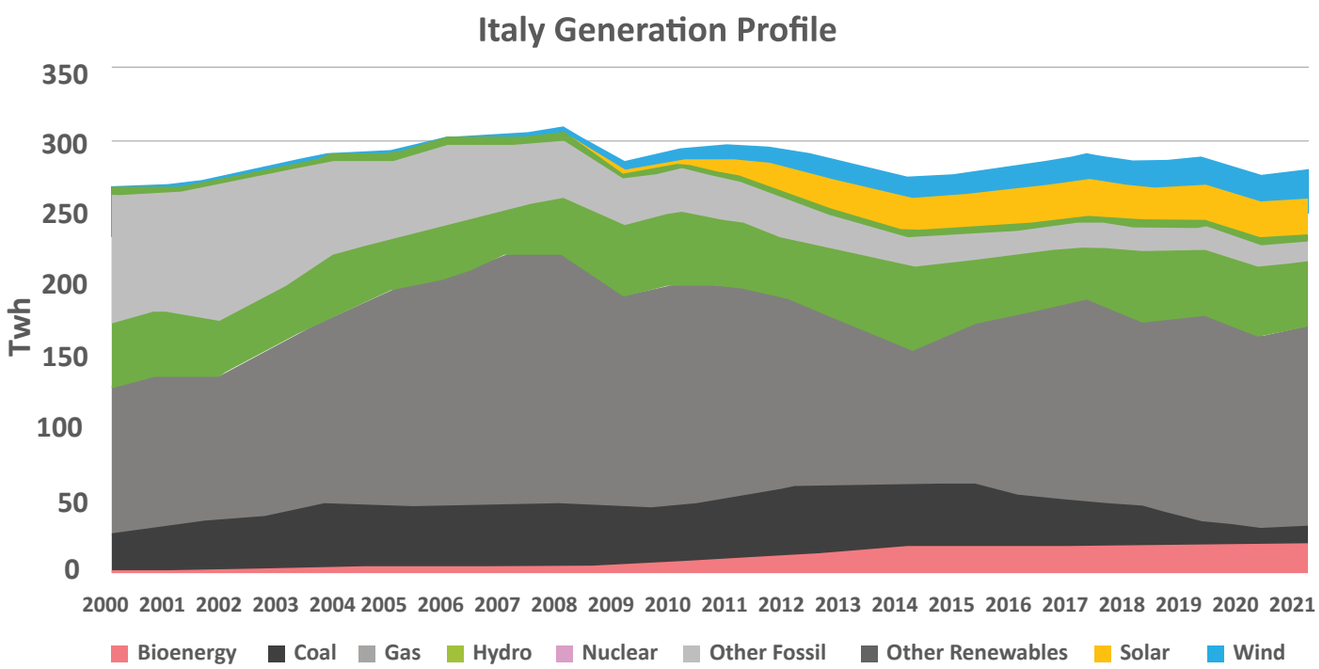
- There is an open and transparent flexibility market design. There are few commercial barriers. The market design encourages the use of aggregators for participation.

Italy

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 13: ITALY GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal. Gas generation remains a significant proportion of the overall generation mix.

TABLE 10: ITALY MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	326	366
Annual renewable production (TWh)	116	201
Renewable % of annual consumption	36%	55%
Annual solar and wind production (TWh)	45	131
Solar and wind % of annual consumption (TWh)	14%	36%

Flexible energy technologies	2021
Homes with electricity supply (million)	26.2
Domestic heat pumps ('000's)	2773
Domestic heat pumps/1,000 homes	106
Heat pumps added/1,000 homes	15
Battery EV's (000's)	120
Total Battery EV's/1,000 homes	5
% EV registrations of all new registrations	5%

Enabling technologies	2021
Smart meter penetration	99%

Markets - In 2021, Italian annual renewable production represented 36% of annual consumption, with solar and wind comprising 14% of annual consumption. Italy has targeted 55% renewables output for 2030, which could increase wind and solar output by 85TWh.

Flexibility resources - Italy had less than 1% penetration of electric vehicles in 2021, with electric vehicles representing around 5% of all new vehicle registrations. Heat pump penetration is around 10%. Smart meter penetration is high.

2. Survey

The individual survey scores for Italy are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
3	3	3	4

Market factors		
Regulations	Compensation structures	Transaction costs
3	3	4

Overall, there is a clear policy ambition and pathway towards decarbonisation and phasing out of fossil fuels for electricity generation. Progress is being made in policy and regulatory development to enable growth of renewables and distributed flexibility resources. Overall, the survey scores have increased since the 2021 survey.

Key points raised by survey participants were:

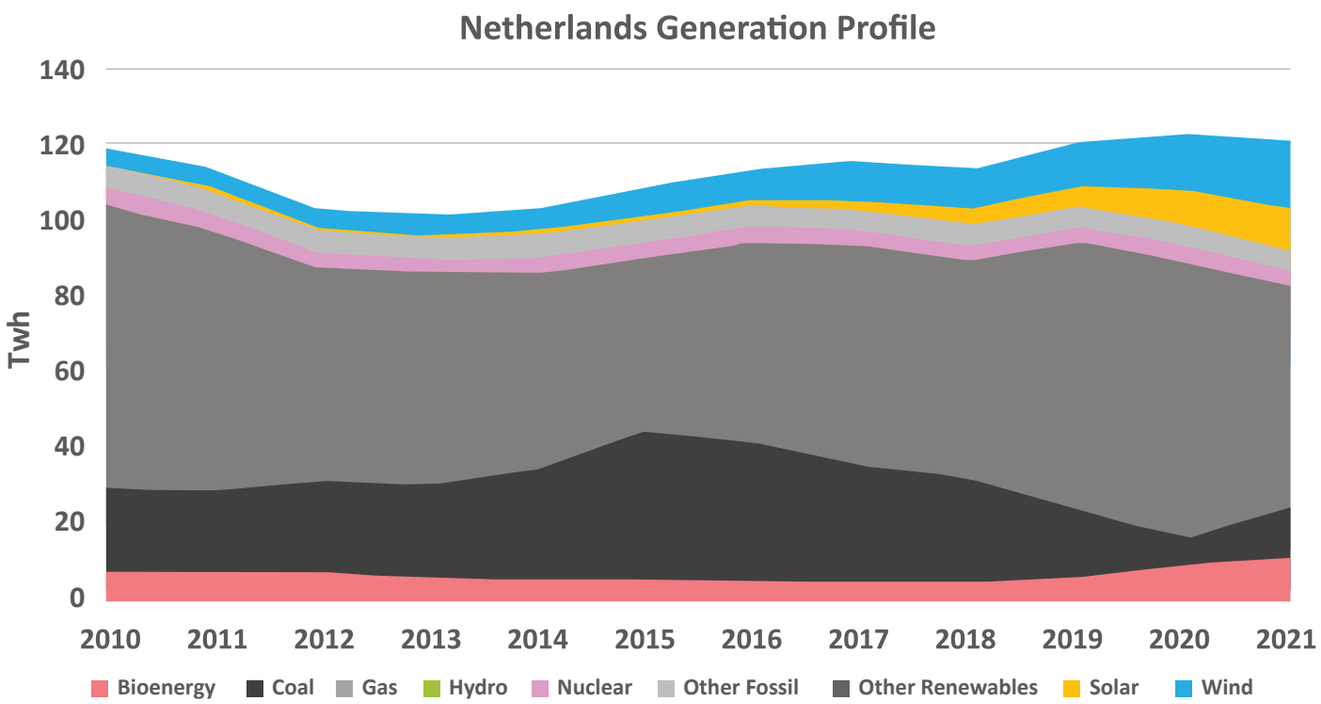
- The energy crisis has made investment in renewables and other energy transition assets more affordable, and an accelerated growth is anticipated. However, the economic crisis means that only wealthier individuals and businesses are likely to be able to afford these investments, meaning this may be a short-term acceleration, followed by a slowdown.
- The energy crisis has increased public support for the energy transition. Policy and action plans are clear with considerable detail to give confidence. However, the governance and regulatory certainty to achieve planned delivery are less certain. Regulatory uncertainty presents a difficult environment for new market entrants to invest.
- Grid accessibility is generally good, but potential problems are anticipated about the future grid needs. Incentives for EV uptake are limited and V2G is not currently possible. Metering standards and access to data may present barriers to flexibility markets.
- Market designs for flexibility resources are under development, with limited access by flexibility resources to date. There do not appear to be any other discriminatory restrictions in place, but technical compliance requirements add additional cost.

Netherlands

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 14: NETHERLANDS GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal. Gas generation remains a significant proportion of the overall generation mix.

TABLE 11: NETHERLANDS MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	121	129
Annual renewable production (TWh)	40	91
Renewable % of annual consumption	33%	70%
Annual solar and wind production (TWh)	29	80
Solar and wind % of annual consumption (TWh)	24%	62%

Flexible energy technologies	2021
Homes with electricity supply (million)	8.0
Domestic heat pumps ('000's)	290
Domestic heat pumps/1,000 homes	37
Heat pumps added/1,000 homes	9
Battery EV's (000's)	238
Total Battery EV's/1,000 homes	30
% EV registrations of all new registrations	20%

Enabling technologies	2021
Smart meter penetration	85%

Markets - In 2021, the Netherlands annual renewable production (mainly wind and solar) represented 33% of annual consumption. The Netherlands has targeted 70% renewables output for 2030, which could increase wind and solar output by 51 TWh.

Flexibility resources - the Netherlands had a 2% penetration of electric vehicles in 2021, with electric vehicles representing around 20% of all new vehicle registrations. Heat pump penetration is around 4%. Smart meter penetration is high.

2. Survey

The individual survey scores for Netherlands are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
3	5	5	3

Market factors		
Regulations	Compensation structures	Transaction costs
4	4	5

The overall policy goal is clear but there is not a clear consensus on delivery and how barriers should be addressed. The latest scoring shows that public and political support for the energy transition has weakened as other issues have taken priority. Overall, survey scores are similar to the 2021 survey.

Key points raised by survey participants were:

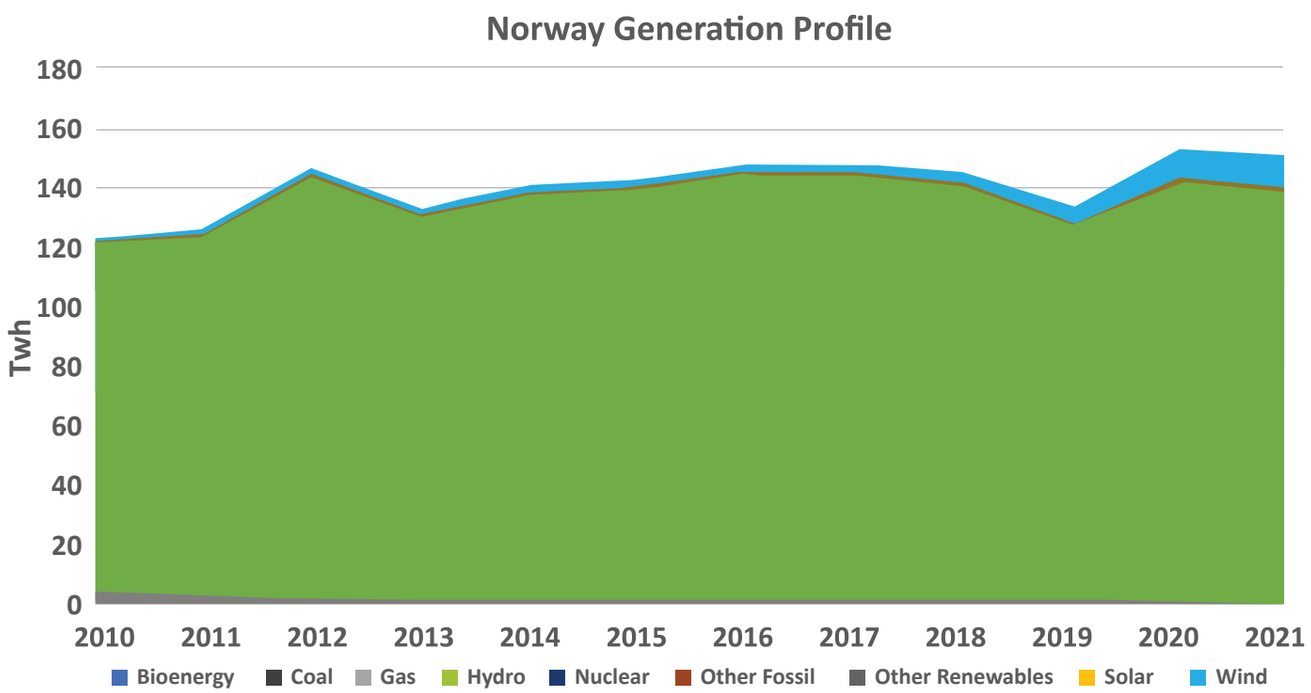
- The energy crisis may slow down the energy transition in the short term as there is a greater focus on affordability. But in the long term the effect of the crisis may support Net Zero goals by encouraging a move to greater energy security through growth in renewables and flexibility resources.
- The energy transition currently sits below other public and 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 infrastructure investment and access delays are of increasing concern. They present a potentially growing barrier to the integration of flexibility resources. Electric vehicle deployment is increasing and V2G trials are underway.
- Flexibility markets are fair and open. Smaller flexibility resources access the markets through aggregation. Some concerns that technical requirements may impose additional costs on smaller market participants.

Norway

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 15: NORWAY GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the dominance of hydro with some growth in wind over the last few years.

TABLE 12: NORWAY MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	134	143
Annual renewable production (TWh)	150	164
Renewable % of annual consumption	113%	115%
Annual solar and wind production (TWh)	11	25
Solar and wind % of annual consumption (TWh)	8%	18%

Flexible energy technologies	2021
Homes with electricity supply (million)	2.6
Domestic heat pumps ('000's)	1706
Domestic heat pumps/1,000 homes	654
Heat pumps added/1,000 homes	50
Battery EV's (000's)	457
Total Battery EV's/1,000 homes	175
% EV registrations of all new registrations	65%

Enabling technologies	2021
Smart meter penetration	98%

Markets - In 2021, 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 8% derived from solar and wind. Similar renewable output levels are assumed in 2030.

Flexibility resources - Norway has a high level of penetration of electric vehicles, reaching 18% in 2021, and electric vehicles represent some 65% of all new vehicle registrations. Heat pump penetration is 65%. Smart meter penetration is high.

2. Survey

The individual survey scores for Norway are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
4	4	5	5

Market factors		
Regulations	Compensation structures	Transaction costs
5	3	4

Overall, there is a strong and clear policy ambition in support of the energy transition but increasing concerns about the costs and methods of delivery. The average survey score has decreased compared to the 2021 survey.

Key points raised by survey participants were:

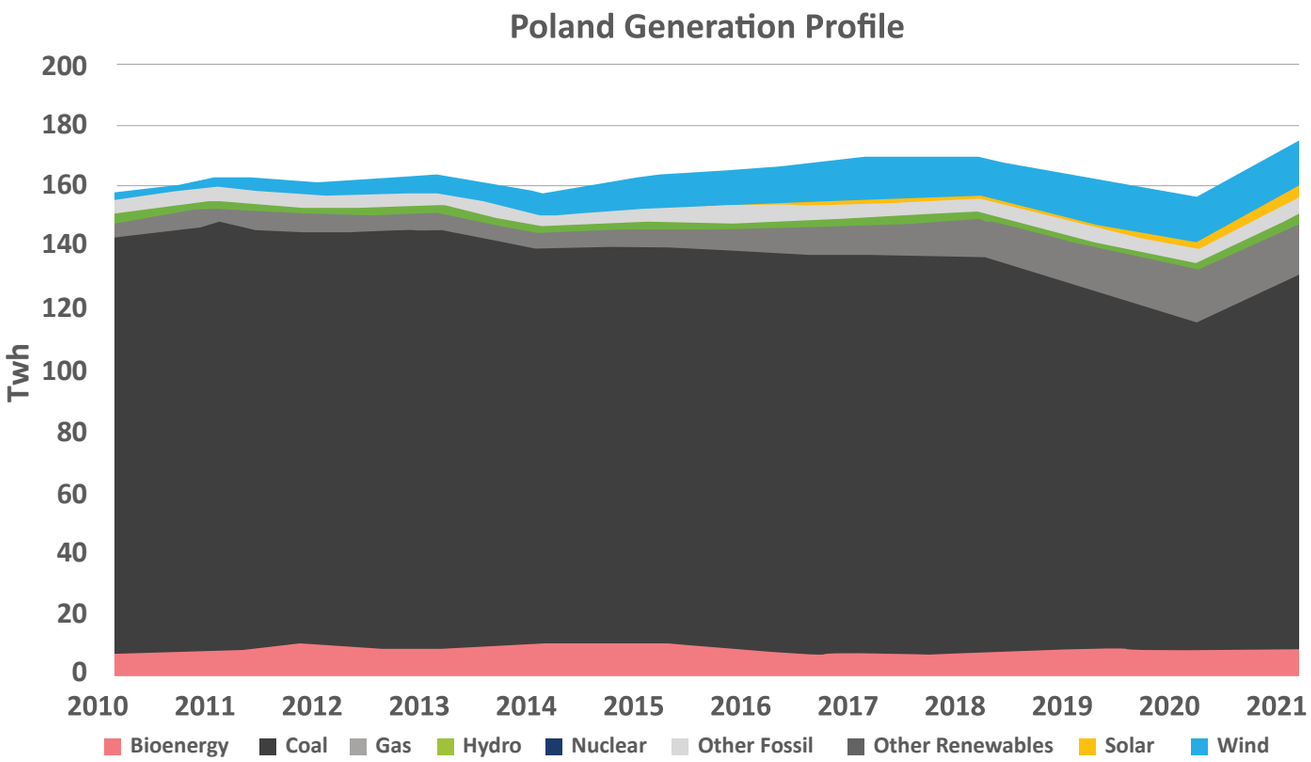
- The energy crisis is seen as a positive opportunity for investment in additional renewable and flexibility resources, and acceleration of the energy transition.
- There is a common public and political goal to achieve the energy transition but different views on how to achieve it. Costs of the transition are of increasing concern. Onshore wind has been difficult to develop but attitudes may change due to the energy crisis. There is strong political and regulatory alignment.
- Grid accessibility is good. Policies and incentives for EVs and EV charging are highly successful. There are no policy barriers to V2G and this market is growing.
- Market rules are fair and allow access by new distributed energy technologies. Flexibility markets generally work well and allow access to all technologies and market participants. However, the dominance of flexible hydro limits the market opportunities.

Poland

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 16: POLAND GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the dominance of coal with gradual growth in wind and gas over the last decade.

TABLE 13: POLAND MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	177	200
Annual renewable production (TWh)	30	46
Renewable % of annual consumption	17%	23%
Annual solar and wind production (TWh)	20	36
Solar and wind % of annual consumption (TWh)	11%	18%

Flexible energy technologies	2021
Homes with electricity supply (million)	16.3
Domestic heat pumps ('000's)	395
Domestic heat pumps/1,000 homes	24
Heat pumps added/1,000 homes	7
Battery EV's (000's)	17
Total Battery EV's/1,000 homes	1
% EV registrations of all new registrations	2%

Enabling technologies	2021
Smart meter penetration	12%

Markets - In 2021, Poland's annual renewable electricity production was 17% of annual consumption, with 11% derived from wind and solar. Poland's target is for 23% of consumption to be derived from renewables by 2030, an increase of 16 TWh.

Flexibility resources - Poland has low level penetration of electric vehicles, reaching 2% in 2021, and electric vehicles represent just 2% of all new vehicle registrations. Heat pump penetration is 2%. Smart meter penetration is low, although is expected to increase through a national rollout.

2. Survey

The individual survey scores for Poland are shown below.

Socio-political factors		
Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment
2	2	2

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
2	2	2	2

Market factors		
Regulations	Compensation structures	Transaction costs
5	4	4

This is the first year that Poland has been included in the survey. Overall, the scores appear to reflect that Poland is at the early stages of transitioning from a fossil-fuel dominated electricity sector. The investment environment is considered higher risk as transition policies and regulation are at early stages of development and implementation.

Key points raised by survey participants were:

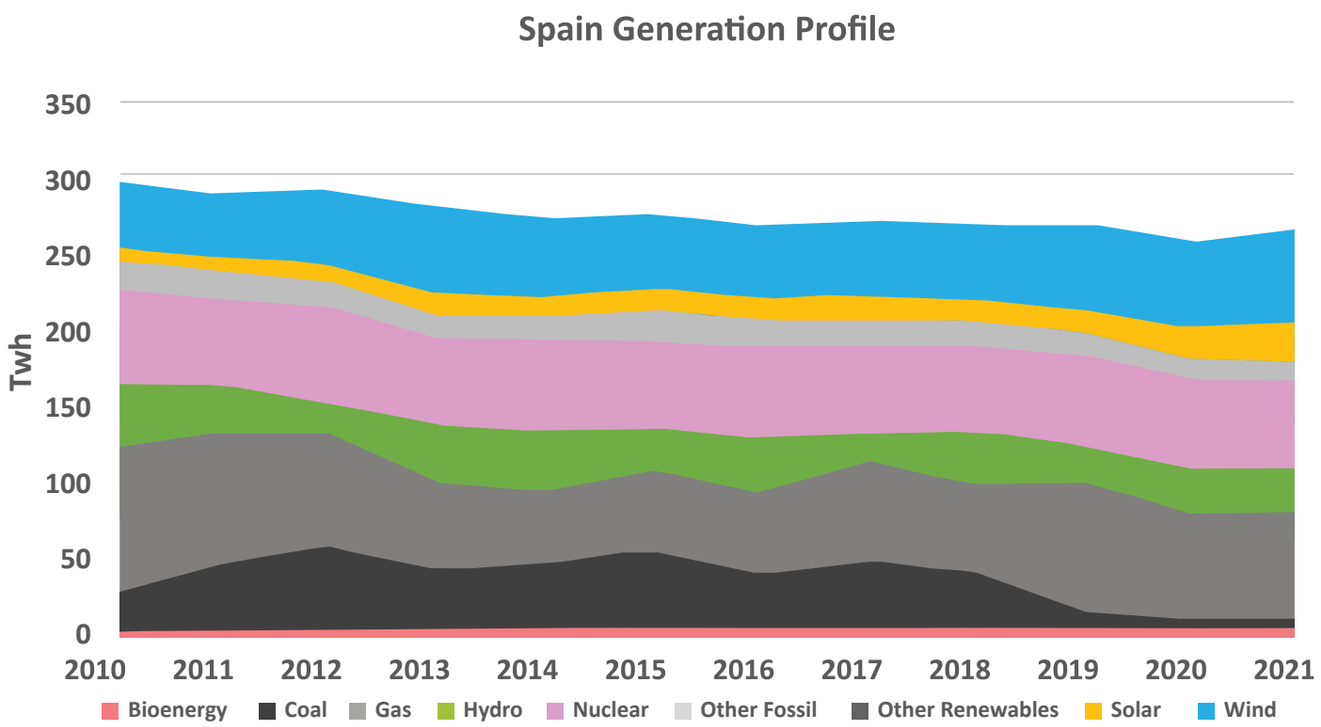
- The energy crisis is demonstrating the need for renewables as a way of achieving energy security. But it is difficult to see how this energy security can be realised without a clear transition delivery plan.
- While Poland has agreed renewable targets with the EU, there appears to be limited political and public ambition for achievement of Net Zero targets. Net Zero is not yet seen as a priority for Poland and actions to deliver transition reforms are limited.
- Grid accessibility is a significant barrier, with projects unable to gain grid access pre-construction. Policies and incentives for EVs and EV charging are limited, leading to slow EV rollout. EV uptake appears to be a lifestyle choice rather than an energy transition policy.
- Market rules have been developed to meet EU requirements and should be effective. Centralised government decision making means that market arrangements have been quickly established. But this gives rise to uncertainty about the ongoing stability of market arrangements for investment in renewable flexibility resources. Flexibility resources will also face competition from incumbent fossil-fuel generation.

Spain

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 17: SPAIN GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal.

TABLE 14: SPAIN MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	269	288
Annual renewable production (TWh)	124	158
Renewable % of annual consumption	46%	55%
Annual solar and wind production (TWh)	88	122
Solar and wind % of annual consumption (TWh)	33%	43%

Flexible energy technologies	2021
Homes with electricity supply (million)	25.8
Domestic heat pumps ('000's)	1545
Domestic heat pumps/1,000 homes	60
Heat pumps added/1,000 homes	8
Battery EV's (000's)	81
Total Battery EV's/1,000 homes	3
% EV registrations of all new registrations	3%

Enabling technologies	2021
Smart meter penetration	100%

Markets - In 2021, Spanish annual renewable production represented 46% of annual consumption, with solar and wind comprising 33% of annual consumption. Spain has targeted 55% renewables output for 2030, which could increase wind and solar output by 34TWh.

Flexibility resources - Spain had less than 1% penetration of electric vehicles in 2021, with electric vehicles representing around 3% of all new vehicle registrations. Heat pump penetration is around 6%. Smart meter penetration is high.

2. Survey

The individual survey scores for Spain are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
4	3	4	4

Market factors		
Regulations	Compensation structures	Transaction costs
3	3	3

Overall, there is a clear ambition in support of the energy transition but increasing concerns about the energy crisis and how this will impact the policies for delivery. The average survey score has increased compared to the 2021 survey because of increased confidence in the market frameworks.

Key points raised by survey participants were:

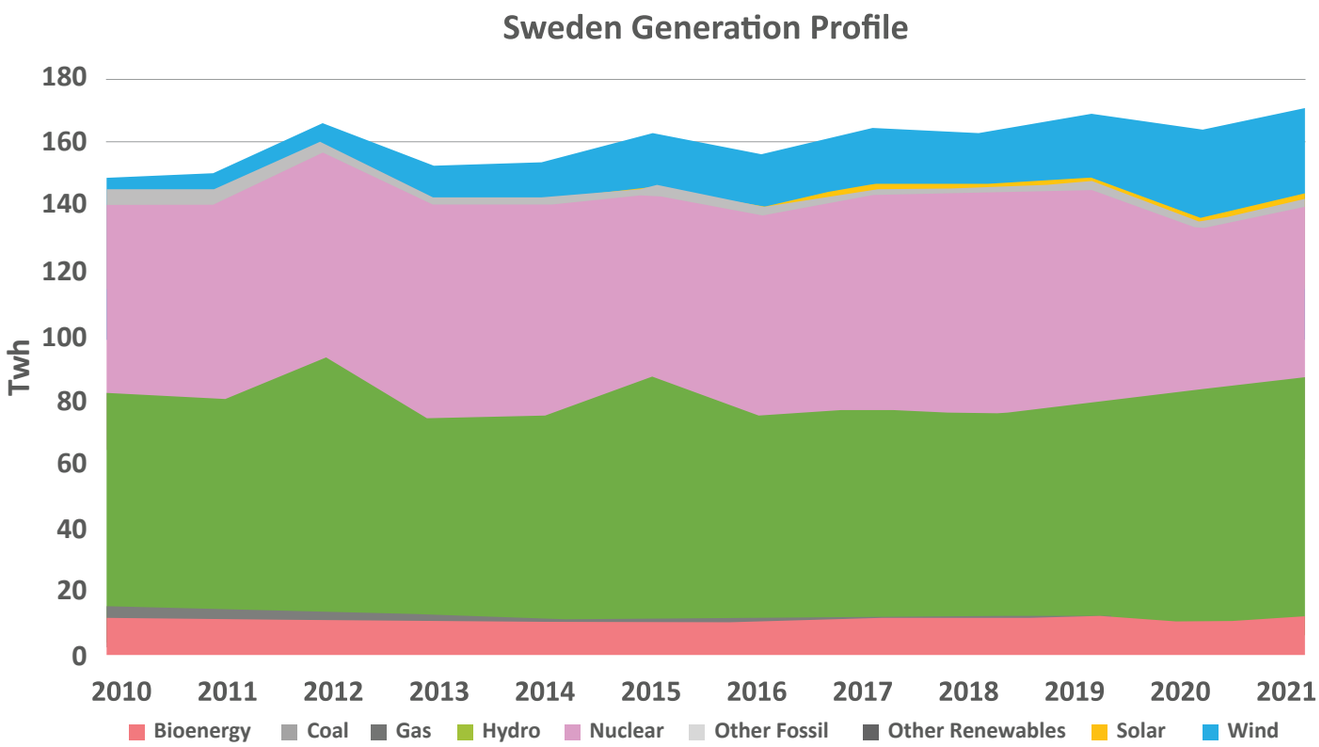
- The energy crisis and importance of energy security are seen as a positive opportunity for investment in additional renewable and flexibility resources, and acceleration of the energy transition.
- There are differing views on the policy actions needed to address the energy transition and the implementation pathway is unclear.
- Grid accessibility and investment is considered good but additional investment is needed to enable access by flexibility resources. Policies to encourage EV rollout are having limited effect, with EV growth remaining slow.
- Market rules are fair and allow access by new distributed energy technologies. Flexibility markets generally work well and allow access to all technologies and market participants.

Sweden

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 18: SWEDEN GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the dominance of hydro and nuclear, together with growth in wind over the last decade.

TABLE 15: SWEDEN MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	146	156
Annual renewable production (TWh)	115	129
Renewable % of annual consumption	79%	83%
Annual solar and wind production (TWh)	28	42
Solar and wind % of annual consumption (TWh)	19%	27%

Flexible energy technologies	2021
Homes with electricity supply (million)	4.8
Domestic heat pumps ('000's)	2156
Domestic heat pumps/1,000 homes	451
Heat pumps added/1,000 homes	24
Battery EV's (000's)	113
Total Battery EV's/1,000 homes	24
% EV registrations of all new registrations	19%

Enabling technologies	2021
Smart meter penetration	100%

Markets - In 2021, Swedish annual renewable production represented 79% of annual consumption. Most renewables were hydro, with around 19% derived from solar and wind. Sweden has targeted 83% renewables output for 2030, which could increase wind and solar output by 14TWh.

Flexibility resources - Sweden had around 2% penetration of electric vehicles in 2021, with electric vehicles representing some 19% of all new vehicle registrations. Heat pump penetration is around 45%. Smart meter penetration is high.

2. Survey

The individual survey scores for Sweden are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
4	4	5	4

Market factors		
Regulations	Compensation structures	Transaction costs
5	4	4

Sweden has clear policy goals and implementation plans for delivering the energy transition. Given the dominance of low carbon energy production, Sweden has fewer challenges to achieving the energy transition compared to other countries. Overall, scores remain similar to the 2021 survey.

Key points raised by survey participants were:

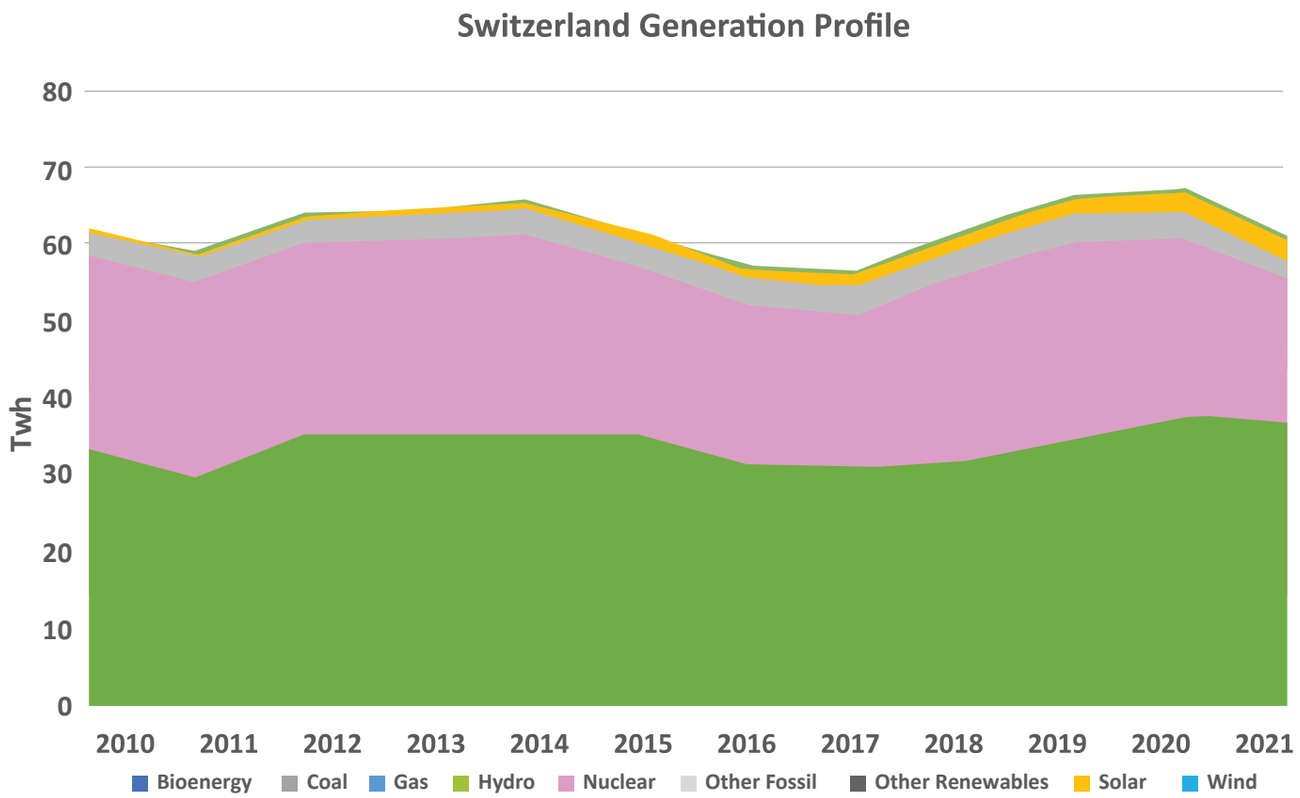
- The energy crisis and importance of energy security are seen as a positive opportunity for investment in additional renewable and flexibility resources, and acceleration of the energy transition. But the economic effects of the energy crisis mean that not everyone can afford to invest.
- Support for decarbonisation and the energy transition is generally strong, but there are some concerns about cost impacts. Political and regulatory alignment is good.
- A lack of grid capacity is beginning to become a barrier to investment in renewables and distributed energy. Digital enablers are in place, enabling flexibility markets through aggregators. EV penetration is growing but V2G accessibility is limited.
- Market rules are fair and allow access by new distributed energy technologies. Flexibility markets generally work well and allow access to all technologies and market participants.

Switzerland

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 19: SWITZERLAND GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the dominance of hydro and nuclear, accompanied by limited growth in solar over the last few years.

TABLE 16: SWITZERLAND MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	63	68
Annual renewable production (TWh)	40	68
Renewable % of annual consumption	63%	100%
Annual solar and wind production (TWh)	3	31
Solar and wind % of annual consumption (TWh)	5%	45%

Flexible energy technologies	2021
Homes with electricity supply (million)	4.6
Domestic heat pumps ('000's)	603
Domestic heat pumps/1,000 homes	132
Heat pumps added/1,000 homes	11
Battery EV's (000's)	75
Total Battery EV's/1,000 homes	16
% EV registrations of all new registrations	13%

Enabling technologies	2021
Smart meter penetration	17%

Markets - In 2019, Swiss annual renewable production (mainly hydro and solar) represented 74% of annual consumption. Switzerland has targeted 100% renewables output for 2030, which would increase wind and solar output by 28TWh.

Flexibility resources - Switzerland had 2% penetration of electric vehicles in 2021, with electric vehicles representing around 13% of all new vehicle registrations. Heat pump penetration is 13%. Smart meter penetration is low.

2. Survey

The individual survey scores for Switzerland are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
4	3	3	3

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. Overall, scores remain similar to the 2021 survey.

Key points raised by survey participants were:

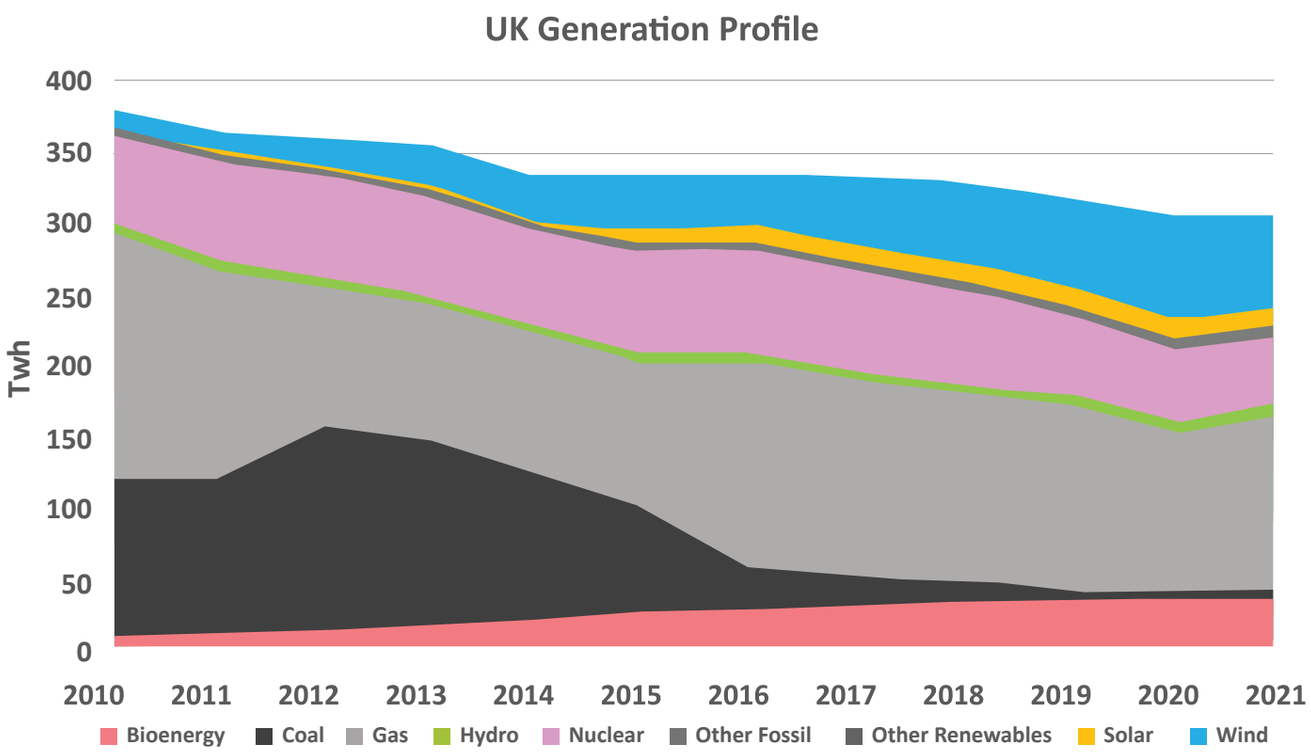
- The energy crisis and importance of energy security are seen as a positive opportunity for investment in additional renewable and flexibility resources. But shorter-term solutions may not be the most economical in the long-term.
- The clarity of transition goals and policy has improved but the regional governance structure of Switzerland means there is less co-ordination of policy delivery. 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 considered strong, and can accommodate bidirectional flows. V2G is in its infancy, waiting for industry to demonstrate the concept. Digital enablers are limited by low smart meter penetration. Metering and communications standards are difficult and complex to adapt.
- Market access for new flexibility technologies or services is limited, without a clear regulatory framework to allow fair access for all technologies. Market opportunities for flexibility services are limited by the high levels of flexible hydro.

UK

1. Energy characteristics

The following chart and table summarise the key electricity sector characteristics.

CHART 20: UK GENERATION PROFILE



The above chart shows the historic profile of generation output by fuel type between 2010 and 2021. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal.

TABLE 17: UK MARKET CHARACTERISTICS

Electricity markets	2021 actual	2030 estimate
Annual consumption (TWh)	331	355
Annual renewable production (TWh)	122	177
Renewable % of annual consumption	37%	50%
Annual solar and wind production (TWh)	77	133
Solar and wind % of annual consumption (TWh)	23%	37%

Flexible energy technologies	2021
Homes with electricity supply (million)	28.0
Domestic heat pumps ('000's)	318
Domestic heat pumps/1,000 homes	11
Heat pumps added/1,000 homes	1
Battery EV's (000's)	392
Total Battery EV's/1,000 homes	14
% EV registrations of all new registrations	12%

Enabling technologies	2021
Smart meter penetration	45%

Markets - In 2021, UK annual renewable production represented 37% of annual consumption, with solar and wind representing 23% of annual consumption. The UK has targeted 50% renewables output for 2030, which could increase wind and solar output by 55 TWh.

Flexibility resources - The UK had about 1% penetration of electric vehicles in 2021, and electric vehicles represent around 12% of all new vehicle registrations. Heat pump penetration is 1%. Smart meter rollout is 45% complete.

2. Survey

The individual survey scores for UK are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
3	3	3	3

Market factors		
Regulations	Compensation structures	Transaction costs
2	3	3

Overall, scores remain similar to the 2021 survey. The UK has set ambitious long-term goals, but the current policy priorities appear more focused on the short-term rather than long-term, leading to increased investment uncertainty.

A major consultation on reform of market arrangements (REMA) was recently launched, focusing on the need for future markets to incentivise development of both renewable and flexibility resources. While an important initiative, it risks adding to uncertainty that policy decisions for future markets may be delayed or changed. It is notable that this review is also happening in parallel to the implementation of the UK's Smart Systems Flexibility Plan (SSFP), published in 2021. It is so far yet unclear how the SSFP and REMA are set to interact.

Key points raised by survey participants were:

- Energy crisis - there is evidence of a short-term growth in renewable and flexibility resources driven by high prices, but there appears to be a decline in public and political confidence about the acceptability of the costs involved in the energy transition. The energy crisis offers an opportunity to drive increased renewable investment, but this pathway is uncertain.

- Energy transition governance and regulation do not currently provide the long-term visibility needed to encourage investment in renewable or flexibility resources.

- Grid access delays are becoming an increasingly critical issue. But there is some growth in demand-side flexibility resources used to alleviate grid congestion and as an alternative to long-term network investment needs. Electric vehicle policies are encouraging rollout.

- 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.

Appendix B – detailed scorecards

SOCIO-POLITICAL FACTORS

	Transparency on system needs and policy direction	Socio-economic impact	Political and regulatory alignment	Average
Denmark	4	3	4	4
Finland	5	5	5	5
France	4	5	4	4
Germany	3	3	3	3
Ireland	3	4	3	3
Italy	4	4	3	4
Netherlands	3	4	3	3
Norway	4	3	4	4
Poland	2	2	2	2
Spain	2	4	4	3
Sweden	4	4	5	4
Switzerland	3	4	3	3
UK	3	3	3	3

TECHNOLOGY FACTORS

	Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation	Average
Denmark	3	4	4	4	4
Finland	5	4	5	4	4
France	4	4	4	3	4
Germany	2	3	2	3	3
Ireland	3	2	4	3	3
Italy	3	3	3	4	4
Netherlands	3	5	5	3	4
Norway	4	4	5	5	4
Poland	2	2	2		2
Spain	4	3	4	4	4
Sweden	4	4	5	4	4
Switzerland	4	3	3	3	3
UK	3	3	3	3	3

MARKET FACTORS

	Regulations	Compensation structures	Transaction costs	Average
Denmark	4	3	3	4
Finland	5	5	5	5
France	3	3	3	3
Germany	2	2	2	2
Ireland	4	3	5	4
Italy	3	3	4	3
Netherlands	4	4	5	4
Norway	5	3	4	4
Poland	5	4	4	4
Spain	3	3	3	3
Sweden	5	4	4	4
Switzerland	3	3	3	3
UK	2	3	3	3

Notes

Notes

Special thanks are due to those who provided content, advice and feedback during the development of the **Energy Transition Readiness Index.**

These include:

ABUNDANCE INVESTMENT LTD

ELECTRON

ENERSENSE INTERNATIONAL

NATURAL POWER

NRG MANAGEMENT CONSULTANCY LTD

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