ENERGY TRANSITION READINESS INDEX 2023

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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 fourth Energy Transition Readiness Index (ETRI) report, which covers the status of 14 leading countries across Europe on their path to achieving their ambitious 2030 decarbonisation goals. The countries covered within this report are all committed to Net Zero, and all recognise the centrality of decarbonising their electricity systems to reaching this goal.

Since its inception, the REA has advocated that renewable energy and clean technologies, delivered at all scales and rewarded through deep flexibility markets, are the means to achieving this ambition. However, progress varies between countries due to different government policy and regulations, the operation of local power markets, and the potential to capitalise on new technologies.

This survey sets out to understand these variations and assess the impact of them on national energy transition readiness. The outcome is the Energy Transition Readiness Index (ETRI).

In our first two reports, we examined the definition of what it means to be "ready" for the energy transition, not just from the stated ambitions of the countries studied, but through the perspective of investors and developers of renewable energy and clean technology projects.

Last year's report built upon this work while encompassing the energy price hikes associated with Russia's invasion of Ukraine. While the tragic war in Ukraine spurred action on decarbonising our energy systems and securing local supply chains, such as through the US Inflation Reduction Act and EU Green Deal Industrial Plan, there are still barriers to achieving the ambitious decarbonisation targets set by European countries.

To deepen our understanding of the energy transition across Europe, this year's survey has assessed Greece in addition to the countries covered in previous iterations of the report.

Our survey 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.

Assessing countries against these criteria reveals the 'flexibility gap' that exists between targets for variable renewable and low-carbon generation and the amount of associated flexibility required. While the gap varies between countries, the key recommendations of this year's report is for all countries to lead on demand-side reform and create an open market for flexible low-carbon assets, allowing these assets to compete fairly with carbon-intensive assets.

From the perspective of the UK, in which the REA operates, the report reveals that the UK, alongside Germany, faces the biggest 'flexibility gap'. However, Germany and the UK have also demonstrated the biggest 'investor attractiveness' since the annual survey started in 2019, making clear that countries can create the right policy environments to attract investment in the energy transition and flexibility resources. These findings reaffirm the REA Strategy, which demonstrates how a decarbonised power system could be realised as early as 2032.

We are pleased that both Eaton and Foresight Group have sponsored 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 throughout the development of this report.

The countries covered in this report have the potential to lead the energy transition and bridge the flexibility gap, delivering energy security and the benefits of renewables to all energy consumers. With increasing international competition, the time to realise this potential and reap the benefits of a flexible decarbonised energy system is now.

N. M. Skorupska

Dr Nina Skorupska CBE FEI
Chief Executive, REA

1. Executive summary

Countries across Europe have set ambitious renewable electricity targets for 2030 and beyond to meet decarbonisation goals. Following the energy crisis, renewables are becoming increasingly important for energy resilience as well as lowering energy costs for consumers and businesses.

Most renewable electricity growth will be met through rapid growth in new wind and solar. But this will need to be matched by growth in flexible low carbon electricity resources e.g., flexible demand or storage, to ensure security of supply when renewables are not available.

The growth needed in these new flexibility resources offers major new investment opportunities. The transition to a decarbonised energy system depends on successfully attracting investment to grow flexibility resources alongside renewables and is the focus of this report.

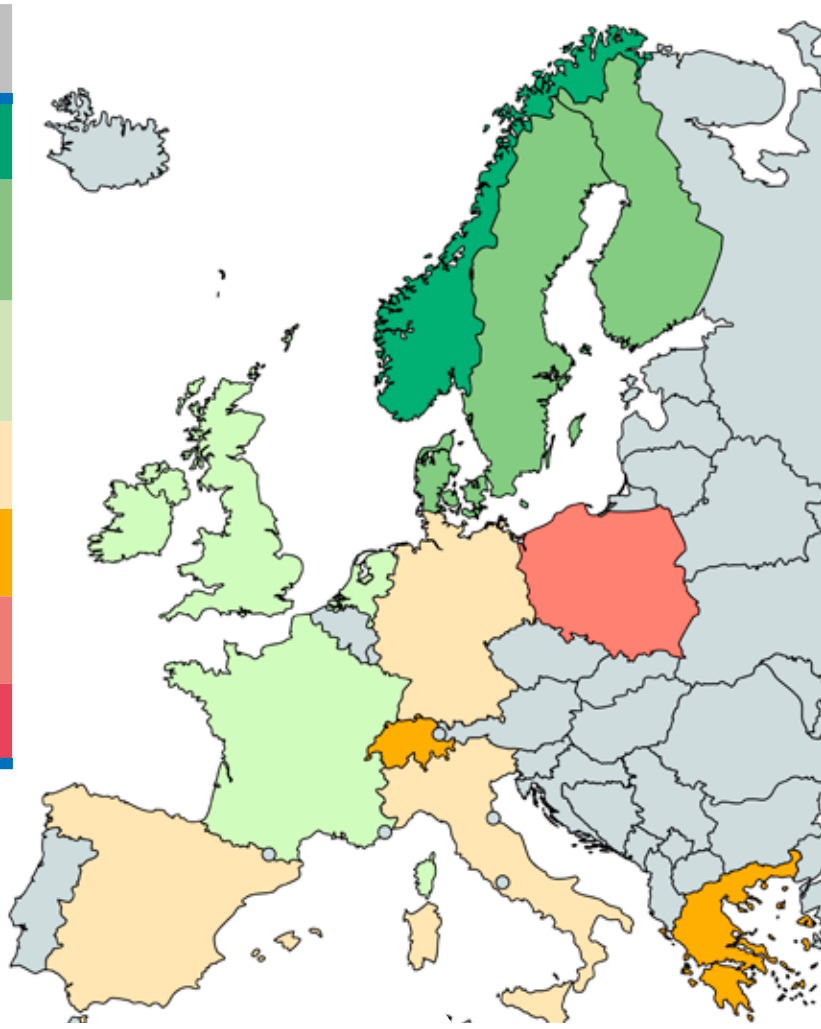
In this, our fourth Energy Transition Readiness Index report, we have ranked the progress of fourteen European countries according to progress against:

- 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 in these countries to assess and compare the energy transition in each country. Overall country rankings from this analysis are shown below.

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

Score	2023
5	
High 4	Norway
Low 4	Denmark, Finland, Sweden
High 3	France, Ireland, Netherlands, UK
Low 3	Germany, Italy, Spain
High 2	Greece, Switzerland
Low 2	Poland
1	



[1]https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en

participants. Nordic countries are leading the transition, but over the four years of our survey, the greatest improvement in investment attractiveness has been shown by Germany and the UK.

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.

Opportunities related to low carbon flexibility are growing, as are the numbers of participants and investment volumes. But many barriers to participation and investment remain, both in terms of technology enablers and accessibility to markets. These barriers must be urgently addressed. Many countries are facing a huge flexibility challenge and prompt action is needed to achieve energy transition targets.

Our previous ETRI reports have consistently recommended the introduction of strategies to address the flexibility challenge that will exist by 2030 and beyond. Our key recommendations that are applicable to all countries, particularly those that score lower in our index, continue to be:

1. **Identify future low carbon flexibility needs:** alongside renewable growth targets, forecasts for the related vast increase in future flexibility requirements should be quantified.
2. **Accelerate flexibility market reforms:** the delivery of policies and incentives to deliver fair, transparent, and easily accessible markets for new flexibility resources must speed up.
3. **Urgently address technology and process barriers:** particularly access to the grid for renewable and flexibility assets.

We welcome the European Commission's adoption of an energy storage strategy[1] in March 2023, with recommendations that are consistent with ours. The strategy recognises the importance of flexibility resources and includes recommendations for countries to identify flexibility needs, remove barriers to storage, and increase long-term visibility of revenues to facilitate access to finance.

However, we think these proposals neither go far enough, nor fast enough, and they do not apply to non-EU countries. Therefore, we recommend that the countries in our index also do the following:

- **Set clear flexibility targets for 2030** - national energy and climate plans should identify flexibility needs that show the expected proportions of flexibility likely to be available from grid-scale storage, demand-side flexibility, interconnectors, and other low carbon generation e.g., hydrogen, and residual fossil fuel generation.
- **Make co-ordinated plans to meet flexibility targets** - the relevant national authorities, including governments, regulators, and transmission and distribution system operators (TSOs and DSOs) should jointly prioritise the development of coordinated plans to meet flexibility targets. These coordinated plans should also identify how barriers to flexibility will be addressed.
- **Devise policy interventions to incentivise flexibility** - in countries with an urgent need for flexibility, incentives should be provided to attract investment into low carbon flexibility resources. Incentives could range from tax credits, to delivery incentives, to market prioritisation.

These additional initiatives should help to boost investor confidence and enhance competition in flexibility markets, delivering both economic and decarbonisation benefits.

2. Introduction

THE 2023 ETRI REPORT

Since 2019, the Association for Renewable Energy & Clean Technology (REA) has published its Energy Transition Readiness Index (ETRI). The report assesses the readiness of selected European electricity markets for the energy transition, from the perspective of private investors in the flexibility services and technologies that support the deployment of renewable power and decarbonisation.

Last year's report examined 13 countries. This latest ETRI study updates the ranking of those countries and includes a first assessment of Greece, making a study total of 14 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, followed up by one-to-one interviews to understand the underlying reasons for their responses. Survey respondents were also invited to comment upon how the current energy crisis had impacted their confidence in Europe's ability to achieve the energy transition.

The Europe-wide growth in renewable energy generation makes grid stabilisation and flexibility resources increasingly critical to support the further deployment of renewable power. This report includes specific recommendations that could help to 'level-up' all countries to best practices.

WHAT ARE FLEXIBILITY RESOURCES?

The requirement for flexibility resources is increasing as vast new sources of variable renewable energy are added to electricity systems to replace the large fossil-fuel generators. This is because electricity systems must be able to operate in circumstances where renewable energy generation and customer demand may vary significantly from minute to minute.

Flexibility (or 'dispatchability') is the ability of electricity generation or customer demand to increase or decrease supply and demand. Flexibility resources are needed on a continuous basis to stabilise the electricity system within operational limits, especially when unexpected changes occur.

The energy transition has meant that new providers of flexibility services are emerging, offering resources including distributed generation, energy storage, demand response, and interconnection. These new providers can face challenges to investment and deployment if barriers prevent them from accessing flexibility markets. These barriers may be technical e.g., equipment certifications, metering limitations, grid connection constraints, or they may be commercial e.g., high trading costs, restrictive market access, or a lack of supportive market framework to enable investment.

Approach to evaluation

This report sets out the results of a review of 14 European electricity markets. In the report, we have presented an index that ranks these markets in terms of their relative attractiveness for new investors in flexible electricity services. The study is based on publicly available information, supplemented by 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; Denmark has significant wind generation capacity; 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 how new investors might perceive the attractiveness of each 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?
- Does the socio-political background support or impede investment?
- Are measures in place to help develop and deploy flexibility enabling 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

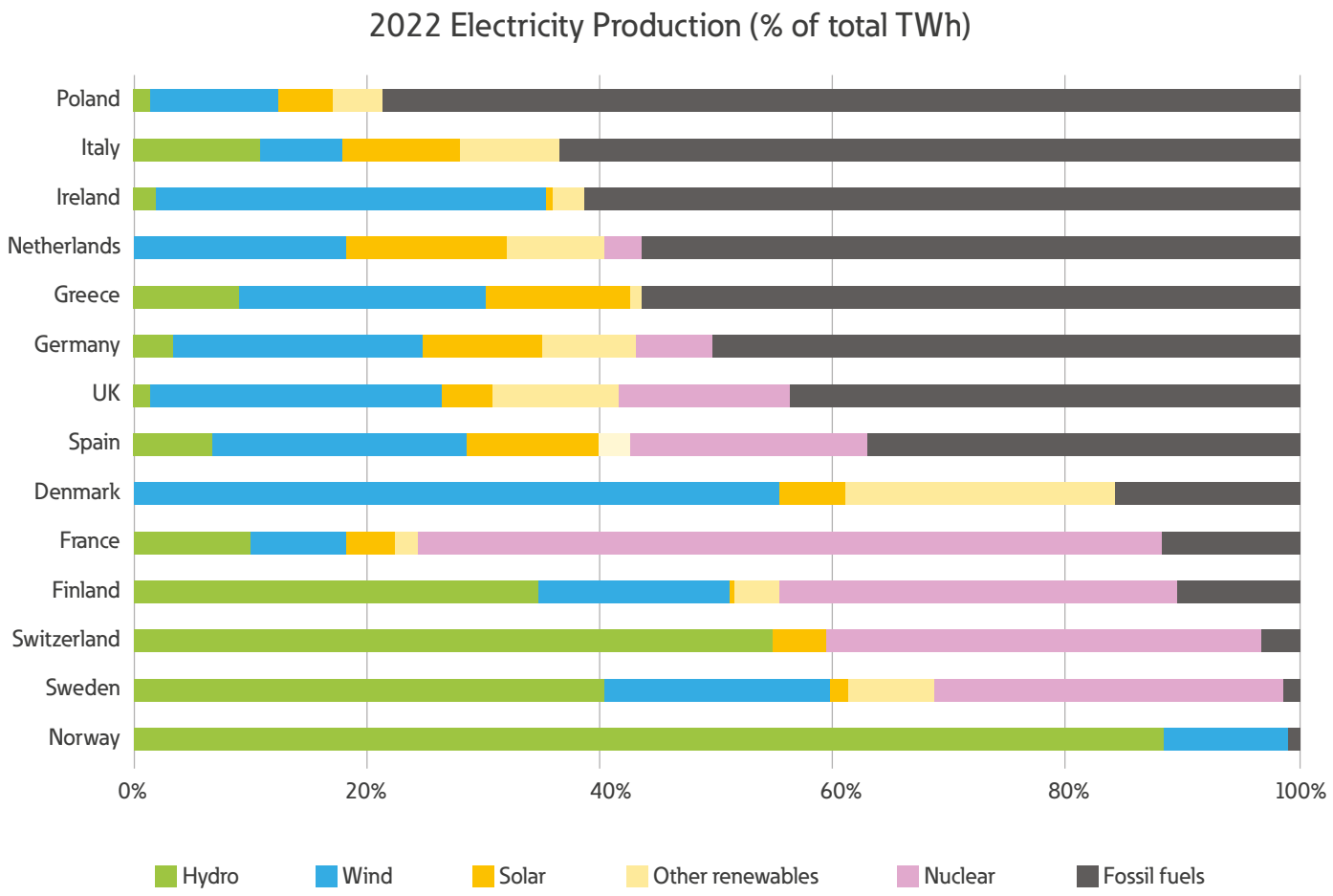
2022 - the year in context

During 2022, wholesale prices for electricity and gas increased significantly across Europe as energy and supply costs were impacted by Russian military aggression in Ukraine. Governments introduced various subsidies and allowances, together with energy efficiency measures to mitigate the impact of these price increases. Some windfall taxes were also introduced. In May 2022, the European Commission launched the longer term 'REPowerEU' and 'Green Deal' plan[2] to save energy, produce clean energy and diversify energy supply.

Historic electricity data used in this report has been obtained from the Ember climate and energy database.[3] The following chart shows the proportions of electricity production by technology in 2022 for each of the 14 countries discussed in this report. Renewable technologies include hydro, solar, wind and biomass. Renewables plus nuclear show the total clean electricity output.

The chart shows the countries e.g., Poland, Italy, Ireland, that generated a significant proportion of their electricity from fossil fuels (gas, coal), and those with minimal fossil-fuel output e.g., Norway, Sweden, Switzerland. Denmark generated over half its output from wind, and France generated more than 60% from nuclear.

CHART 1: PERCENTAGE OF ELECTRICITY PRODUCTION BY TECHNOLOGY (2022)



[2]https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en.

[3]Data derived from the Ember climate and energy database https://ember-climate.org/data/data-explorer/. Further details of data sources used for this report are described in Appendix A.

TABLE 1: CHANGE IN RENEWABLE OUTPUT FROM 2021 TO 2022

Country	% change
Denmark	15%
Finland	6%
France	-4%
Germany	8%
Greece	3%
Ireland	10%
Italy	-12%
Netherlands	20%
Norway	0%
Poland	27%
Spain	-3%
Sweden	2%
Switzerland	-8%
UK	10%
Overall	3%

Overall, output from renewable energy, especially wind and solar, continues to grow. In 2022, across the EU[4], wind and solar output reached 22% of EU generation output, and all renewable output totalled nearly 40%. The following table shows the change in all renewable output between 2021 and 2022 for the countries in our survey.

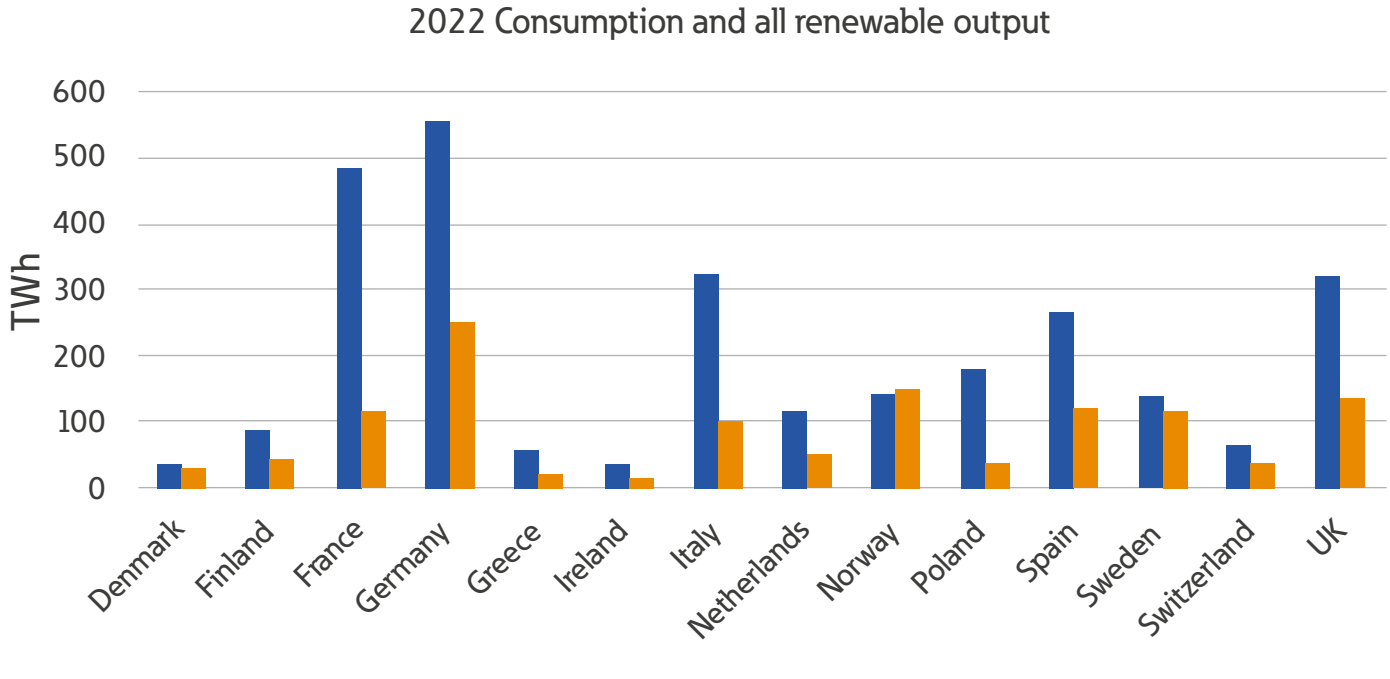
The overall growth in renewables across these countries was 3%. This overall growth was reduced by lower hydro output in several countries due to drought conditions. Also, growth in clean electricity output was impacted by unexpected outages impacting the French nuclear fleet.

Poland had the highest growth rate of 27%, in both wind and solar, but this growth was from a relatively low base. The Netherlands had a growth of 20%, mainly attributable to solar expansion.

European renewable electricity - 2022

The chart below compares the TWh of total electricity consumption for each country generated by all renewable resources during 2022. This excludes nuclear output.

CHART 2: PERCENTAGE OF ELECTRICITY PRODUCTION BY TECHNOLOGY (2022)

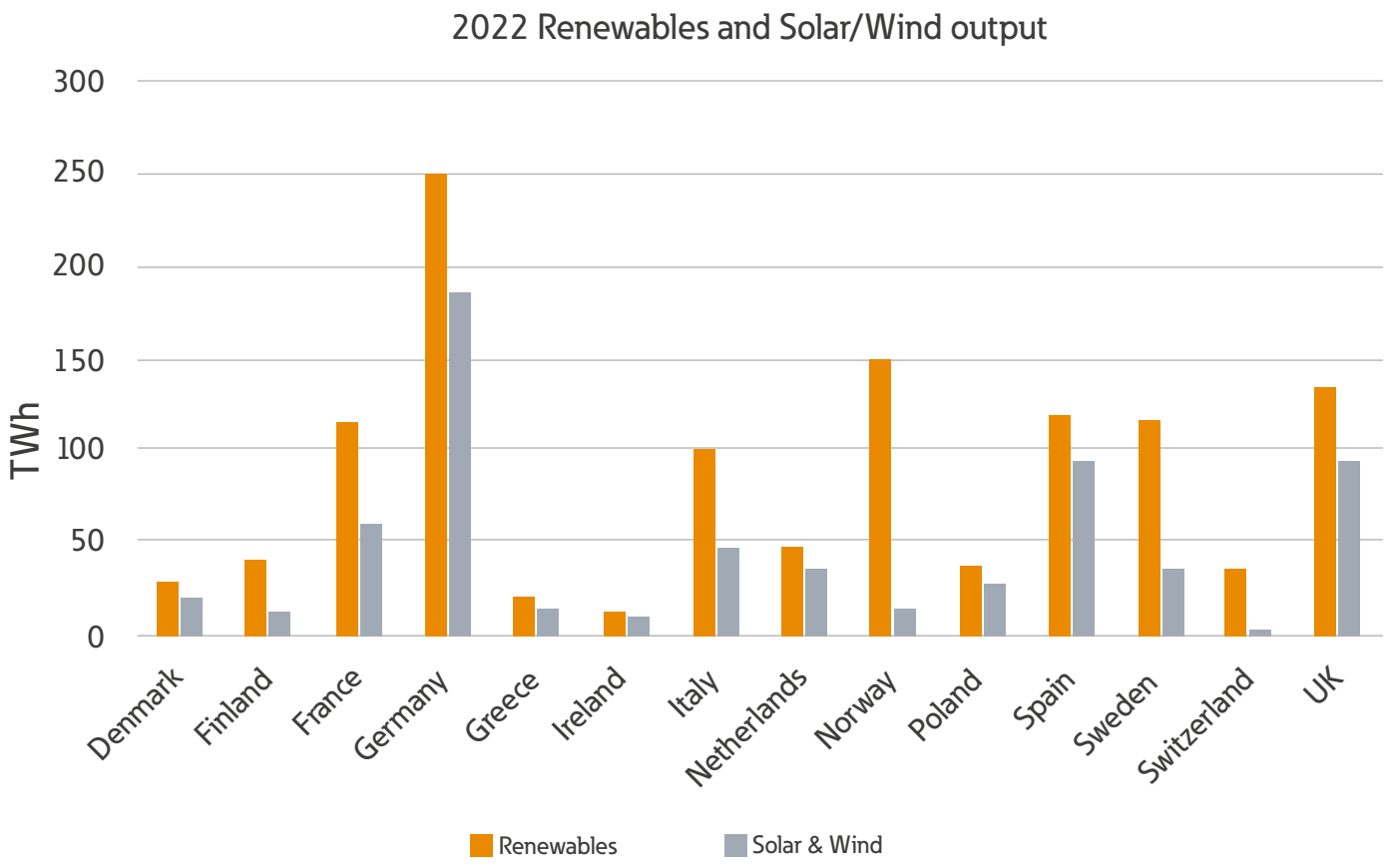


[4]https://www.energymonitor.ai/renewables/europe-renewables-in-2022-in-five-charts-and-what-to-expect-in-2023/?cf-view

Most countries show significant proportions of renewable electricity production. Denmark, Norway, and Sweden generated over 80% of their electricity consumption from renewable resources, reflecting their high hydro capacity, or wind in the case of Denmark. The largest renewable output by volume was in Germany with 250TWh of renewable output (45% of consumption),

Renewable resources such as hydro and biomass can normally provide flexibility services, whereas solar and wind will be less flexible, increasing the need for new low carbon flexibility resources. To illustrate this, the following chart compares the TWh of electricity provided in 2022 by solar and wind renewables with total renewable output. It highlights that Germany, Spain and the UK had the greatest TWh volume of solar and wind, requiring support from flexible resources.

CHART 3: TOTAL RENEWABLE AND SOLAR/WIND ELECTRICITY PRODUCTION (2022)



To illustrate this flexibility need further, the following table shows the percentage of electricity consumption in 2022 provided by solar and wind renewables in each country.

TABLE 2: 2022 RENEWABLES AS A PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION

Country	All renewables %	Solar & Wind %
Denmark	81%	58%
Finland	47%	15%
France	24%	12%
Germany	45%	33%
Greece	41%	31%
Ireland	38%	33%
Italy	32%	15%
Netherlands	41%	33%
Norway	108%	11%
Poland	21%	16%
Spain	45%	36%
Sweden	85%	26%
Switzerland	57%	4%
UK	42%	29%

This analysis illustrates that, in 2022, many countries increased their solar and wind output and overall volumes of renewables. Denmark had the highest proportion (58%) of solar and wind generation as a percentage of total electricity consumption. Several countries - Germany, Greece, Ireland, Netherlands, Spain, and UK generated around one third of their electricity consumption from solar and wind. Other flexible resources (mainly flexible gas generation) were needed alongside this renewable output to maintain continuous security of supply.

EUROPEAN DEMAND-SIDE FLEXIBILITY - 2022

Flexible electricity resources are increasingly being located 'behind the meter' (BTM) with energy prosumers (those who both produce and consume electricity) who need to be able to engage with wholesale electricity and flexibility markets. These distributed energy resources can be many and varied. But they all 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 assessed the following for 2022:

- Battery electric vehicle (BEV) penetration - the total number of BEVs, the percentage of BEVs in total passenger car and light commercial vehicle fleets, and the percentage of BEVs in new vehicle registrations.
- Heat pump (HP) penetration - the total number of heat pumps, the number of HPs per 1000 households, and the number of new HPs during 2022.
- Smart meter penetration - the total number of smart meters as a percentage of households.

The following table presents a comparison across the 14 countries. Data sources are provided in Appendix A.

TABLE 3: 2022 DEMAND-SIDE FLEXIBILITY RESOURCES AND ENABLERS

Country	Electric Vehicles			Heat Pumps			Smart Meter penetration
	BEV Total ('000's)	BEV % of total fleet	BEV % of new registrations in 2022	Total ('000's)	No./1,000 homes	Number added in 2022 per 1,000 homes	
Denmark	100	3.2%	28%	611	224	33	99%
Finland	49	1.2%	30%	1,345	438	64	97%
France	761	1.7%	14%	3,986	108	17	85%
Germany	1,035	2.0%	16%	1,652	38	6	1%
Greece	6	0.1%	5%	N/A	N/A	N/A	1%
Ireland	38	1.4%	15%	62	30	10	55%
Italy	185	0.4%	4%	3,199	122	20	99%
Netherlands	342	3.4%	26%	426	53	16	85%
Norway	534	14.9%	75%	1,631	625	58	98%
Poland	28	0.1%	4%	563	35	13	12%
Spain	118	0.4%	5%	1,264	49	6	100%
Sweden	224	4%	35%	2,403	503	45	100%
Switzerland	128	2.5%	18%	435	95	9	20%
UK	664	1.8%	14%	381	14	2	55%

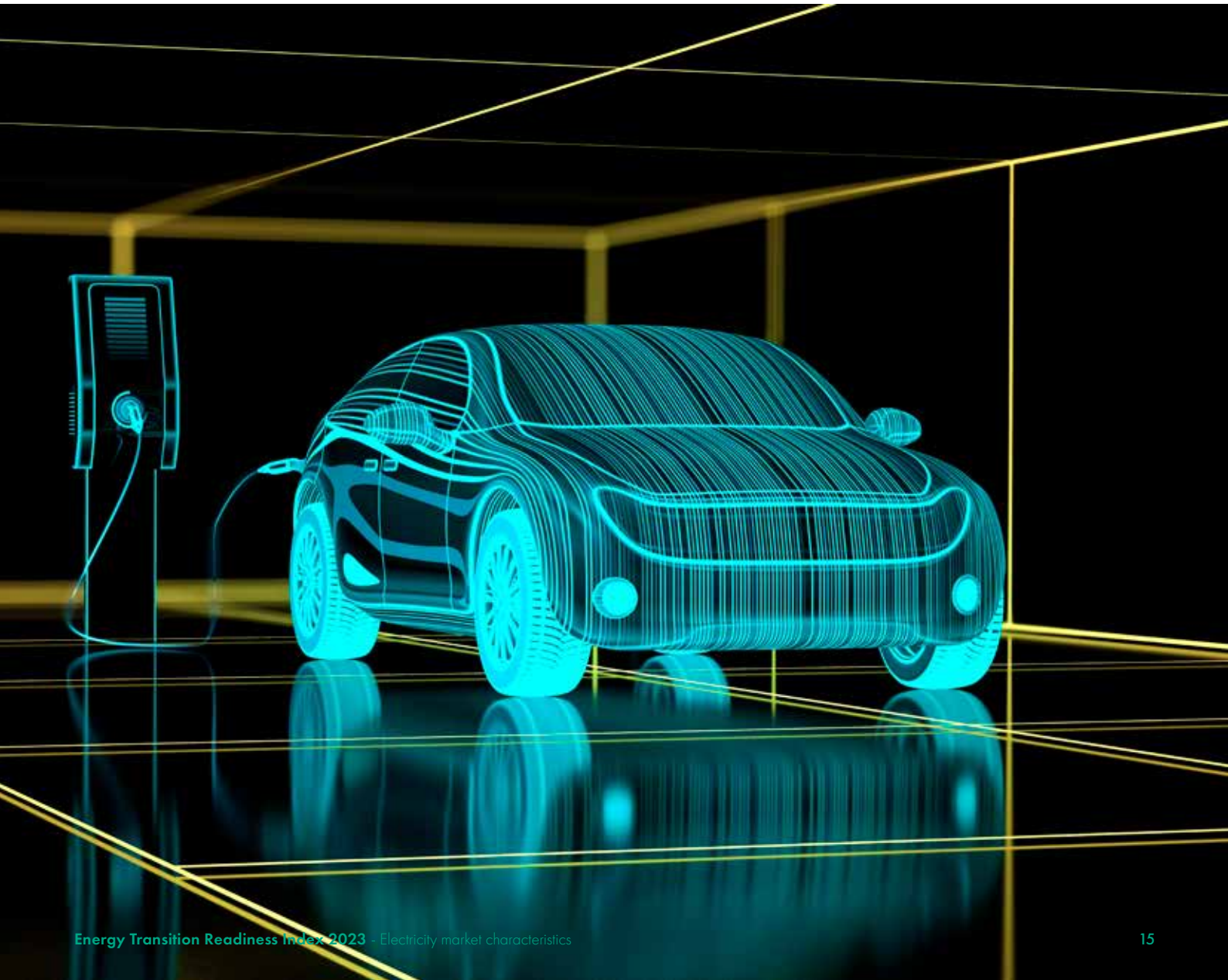
The analysis shows:

- ***Electric vehicles -*** Norway is leading on electric vehicle uptake with both a high level of market penetration and a high proportion of new registrations. While rollout is increasing across most other countries, Greece, Poland, Spain, and Italy show both the lowest fleet numbers and new registrations.
- ***Heat pumps -*** Norway, Sweden and Finland continue to lead 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.

The future net zero energy system will have large volumes of variable renewables, as well as large volumes of electric heating and transport. Demand-side, or distributed flexibility, is essential. Without it, renewable energy will be wasted, electric vehicles and heat pumps will increase peak demand, resulting in a more expensive energy system than necessary.

Demand-side flexibility is hugely valuable: electric vehicles and heat pumps can provide significant future volumes of flexible demand at a distributed system level. But they will need to participate in flexibility markets and receive price signals to deliver these benefits when needed.

Smart meters and associated communications systems are expected to be a key component for the monitoring and settlement of distributed flexibility service provision in electricity systems. Smart meter rollout has reached high levels in many countries, but Germany and Greece have relatively low levels of penetration, with mandatory rollouts yet to take effect. Numbers in Ireland and the UK are increasing as smart meter rollout programmes are being implemented.



ELECTRICITY STORAGE

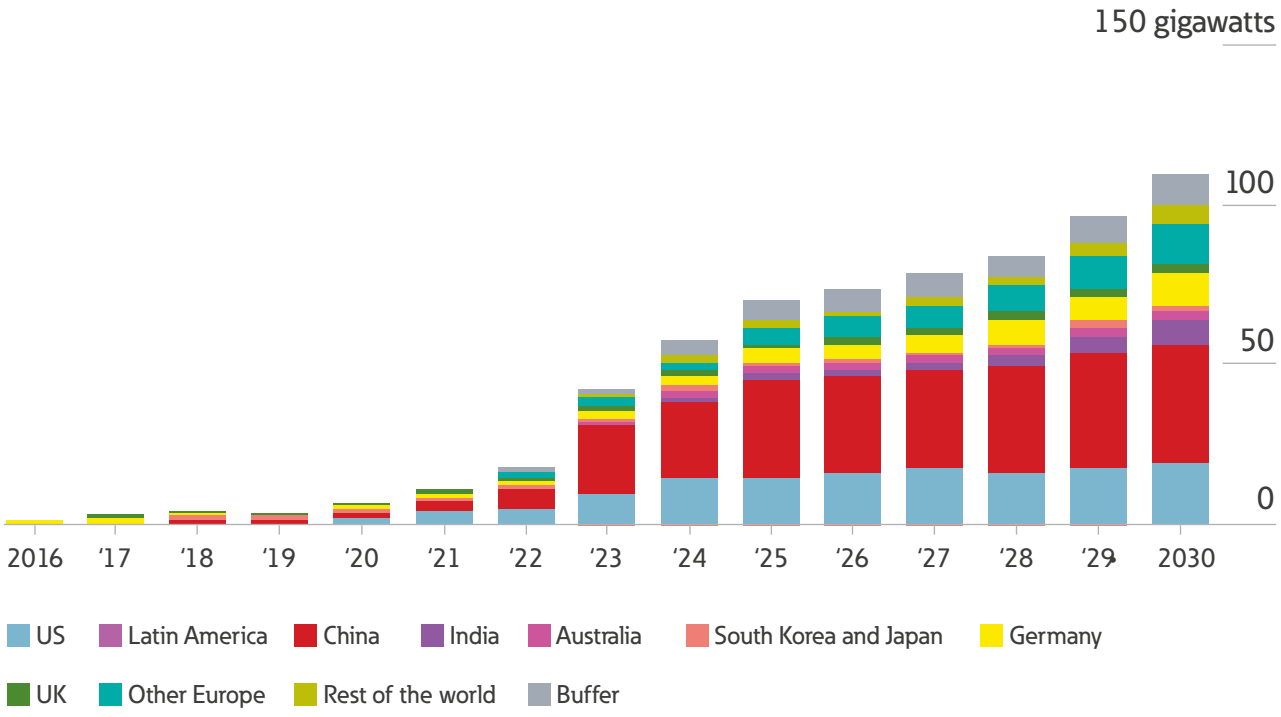
Alongside the development of demand-side flexibility technologies, electricity storage is increasingly used to support the necessary flexibility, stability, and reliability of the whole energy system. It contributes to decarbonisation goals by supporting the integration of renewable energy, improving energy efficiency, and enabling the electrification and decarbonisation of transport and heating. Installation times are short, and lithium-ion batteries are increasingly being installed at grid-scale and in BTM applications.

Flexibility from battery storage is rapidly expanding worldwide. The Global Storage Market Outlook[5] published by market analyst Bloomberg New Energy Finance (BNEF) reports that a further 16GW (35GWh) of energy storage was added during 2022, up 68% from 2021.

As illustrated in the following chart, BNEF forecast annual compound growth of 27% per year to 2030 to some 650GW (1,877TWh) of global energy storage capacity, with growth dominated by the US and China.

Separate studies used by the European Commission suggest that European storage capacity may need to grow to between 200 and 400GW by 2030.[6]

CHART 4: GLOBAL GROSS ENERGY STORAGE CAPACITY ADDITIONS BY KEY MARKET (BNEF)



Source: Bloomberg NEF.
Note: Buffer = headroom not explicitly allocated to an application.

[5]https://about.bnef.com/blog/2h-2023-energy-storage-market-outlook/

[6]https://energy.ec.europa.eu/topics/research-and-technology/energy-storage/recommendations-energy-storage_en#:~:text=Many%20European%20energy%2Dstorage%20markets,of%20more%20than%209%20GWh.

Examples of battery storage growth in the UK and Germany are provided below.

UK - grid scale battery storage deployment

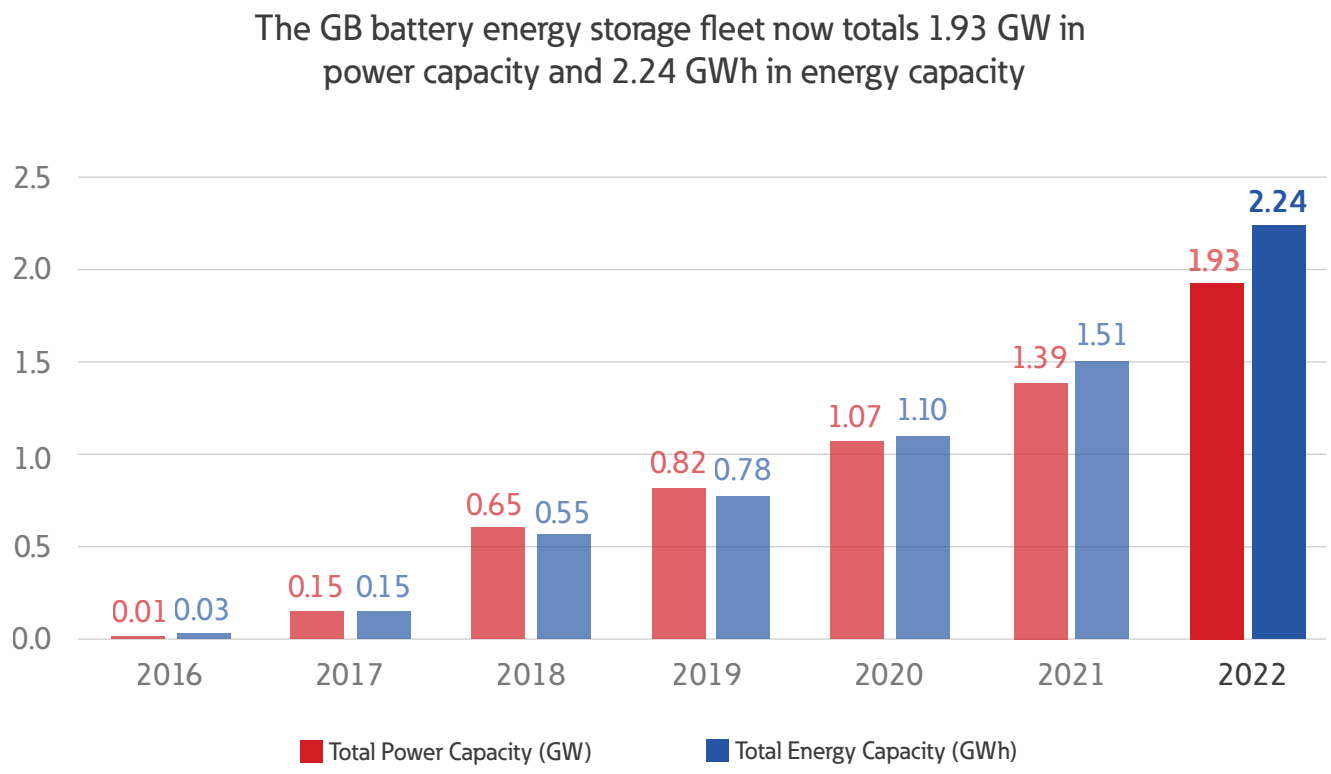
The UK is one of the leading markets in Europe for grid-scale battery deployment. The following chart shows the growth in grid scale battery deployment over recent years. Significant future growth is expected to 2030 and beyond.

While the early UK battery fleet has output durations of around one-hour, newer installations are targeting durations of 2-4 hours, allowing them to provide additional services and gain additional revenues from electricity markets.

Germany - residential battery storage deployment

Germany is one of the leading European markets for residential battery energy storage. Installations in Germany totalled 1.2GW/1.9GWh in 2022, a year-on-year increase of 52%. As of 2022, the accumulated installed capacity of residential battery energy storage systems reached 7.0GWh[8].

CHART 5: UK BATTERY STORAGE GROWTH TO END 2022[7]



[7]https://modoenergy.com/research/7326

[8]https://interactanalysis.com/insight/analysis-of-energy-storage-policies-in-key-countries-germany/#:~:text=Industry%20data%20shows%20installed%20capacity,to%200.43GW%2F0.47GWh.

EUROPEAN ELECTRICITY FLEXIBILITY NEEDS IN 2030

Each of the countries in our survey has set emission reductions targets for 2030, together with associated targets for renewable electricity. We have included here the targets stated in the latest draft National Energy Climate Plans for EU countries (where available) , or other national plans. Annual electricity consumption forecasts for 2030 have been derived from national forecasts. Sources are detailed in Appendix A, Country Summaries.

Table 4 shows Norway and Denmark aiming to reach 100% or more in renewable electricity by 2030. Most countries show major increases over 2022 levels. Many have increased their renewable targets, diversifying energy supplies in response to the energy crisis.

By 2030, this diversification is mainly expected to be achieved by growth in solar and wind capacity. While other low carbon technologies e.g., nuclear, hydrogen, are under development, their contribution by 2030 is likely to be limited due to long development and construction timescales.

The following chart shows actual solar and wind output in 2022 and illustrates the potential forecast growth in wind and solar resources between 2022 and 2030 to meet national renewable targets, assuming all growth is delivered by these technologies.

TABLE 4: 2030 TARGET PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION SUPPLIED BY RENEWABLE ELECTRICITY

Country	2022	2030
Denmark	81%	120%
Finland	47%	57%
France	24%	40%
Germany	41%	80%
Greece	41%	79%
Ireland	38%	80%
Italy	32%	49%
Netherlands	41%	86%
Norway	108%	108%
Poland	21%	32%
Spain	45%	81%
Sweden	85%	88%
Switzerland	57%	60%
UK	42%	82%

CHART 6: POTENTIAL FORECAST FOR 2030 WIND AND SOLAR ELECTRICITY PRODUCTION

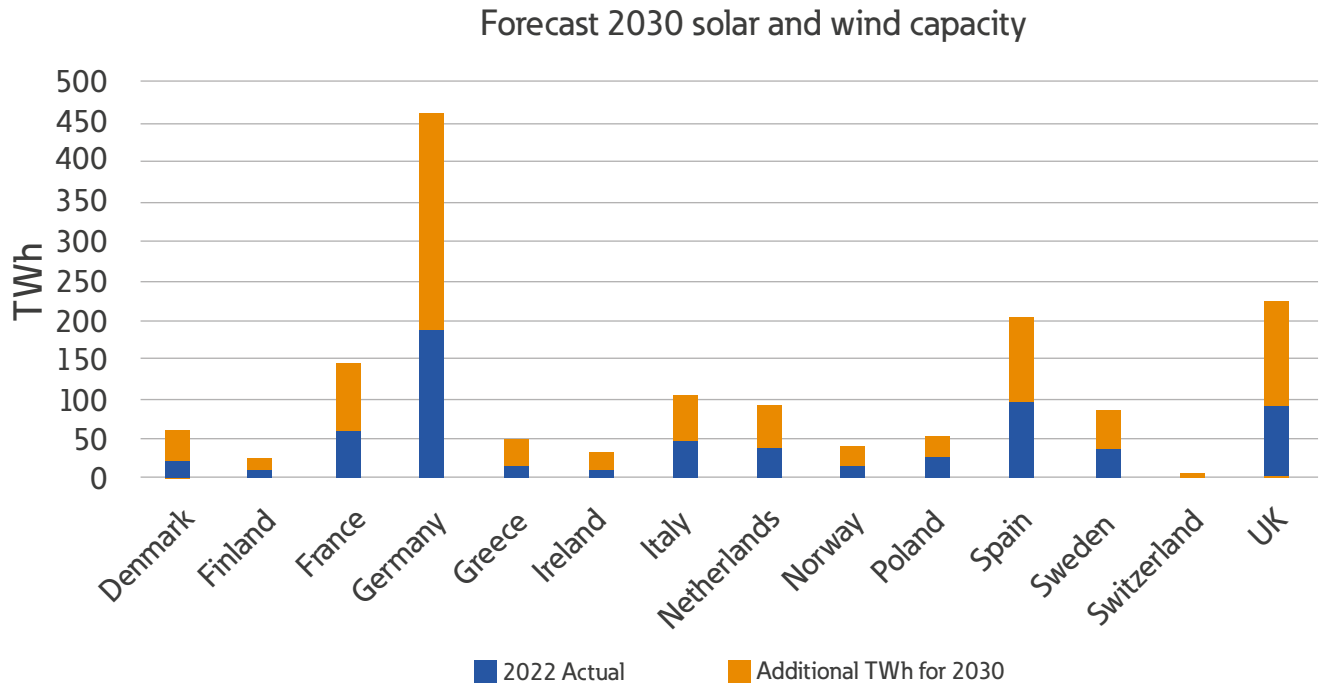


Table 5 shows the potential TWh increase over 2022 levels of solar and wind combined for each country, and the growth needed to achieve 2030 renewable electricity targets with just solar and wind resources.

TABLE 5: POTENTIAL ADDITIONAL SOLAR AND WIND TO MEET 2030 TARGETS

Country	2022 RENEWABLES (TWh)	2030 RENEWABLES (TWh)	NEW SOLAR & WIND (TWh)	GROWTH 2022 TO 2030
Denmark	29	72	46	159%
Finland	40	55	13	32%
France	115	204	89	77%
Germany	250	526	276	111%
Greece	23	54	31	136%
Ireland	13	36	23	178%
Italy	102	160	49	48%
Netherlands	48	102	54	112%
Norway	151	177	26	17%
Poland	38	64	26	69%
Spain	120	228	96	80%
Sweden	117	167	45	38%
Switzerland	37	42	5	14%
UK	135	267	132	98%

Most countries are assuming very high growth for solar and wind output by 2030 compared to 2022 levels. However, the TWh volume growth targets for Germany, the UK and Spain are significantly higher than other countries. Germany faces the greatest challenge in reaching its 2030 targets, with an additional 276TWh of solar and wind renewable resources being required. The UK could need an additional 132TWh of solar and wind output, and Spain an additional 96TWh.

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

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.

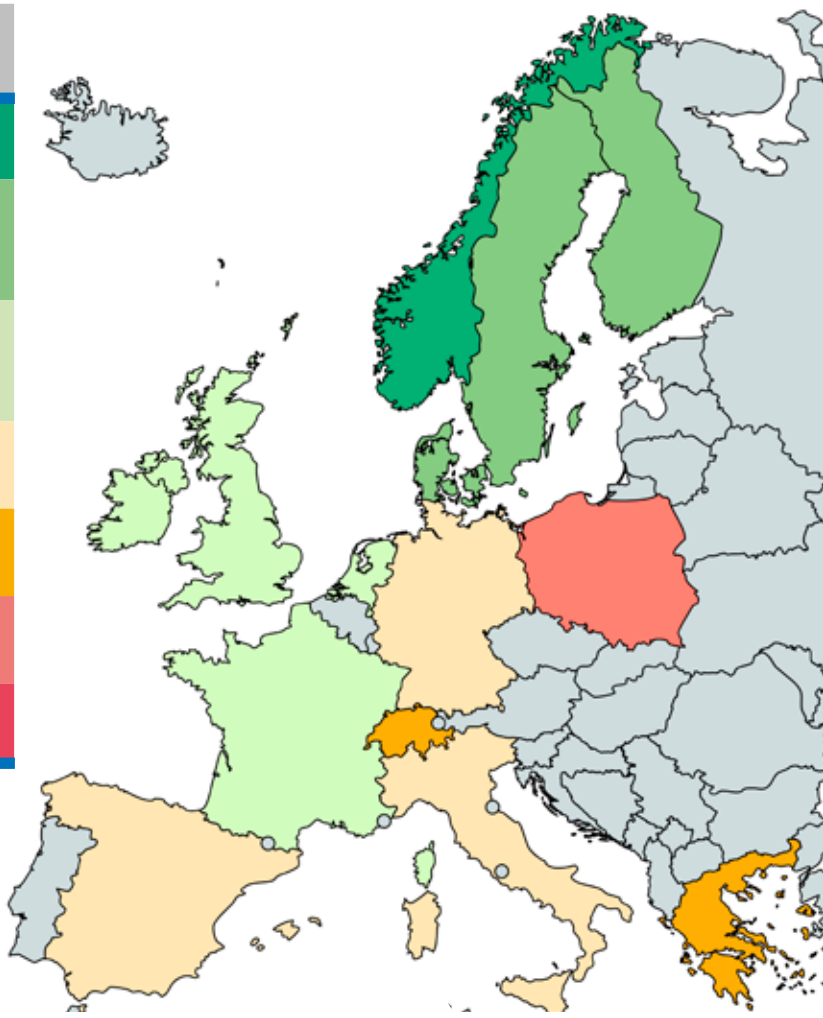
The supporting analysis for each country, as summarised in Appendix A, and Appendix B, shows the full scorecard with responses for each assessment area.

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

OVERALL READINESS RANKINGS

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

Score	2023
5	
High 4	Norway
Low 4	Denmark, Finland, Sweden
High 3	France, Ireland, Netherlands, UK
Low 3	Germany, Italy, Spain
High 2	Greece, Switzerland
Low 2	Poland
1	



There has been little change since our last survey, with Nordic countries continuing to lead. Germany and the UK have shown small overall improvements while Spain, Italy and Poland have deteriorated slightly. Looking back over the four years of our survey, overall investment attractiveness scores for Germany and the UK have shown the greatest improvement, with each of their overall scores for 2023 being around 15% higher than their historic averages since the survey started.

The higher-ranking countries are primarily differentiated by having effective energy transition policies which enable electricity markets that flexibility technologies can access fairly and easily, as well as encourage investment by new flexibility providers through clear price signals i.e., short and long-term market prices which incentivise flexibility providers to increase or decrease output.

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. But barriers for renewable and flexibility growth include factors such as difficulties in obtaining grid connections and planning consents. Flexibility assets also may have difficulties in accessing electricity markets. While much progress has been made, a key ongoing barrier to the energy transition is the effective implementation of open flexibility markets.

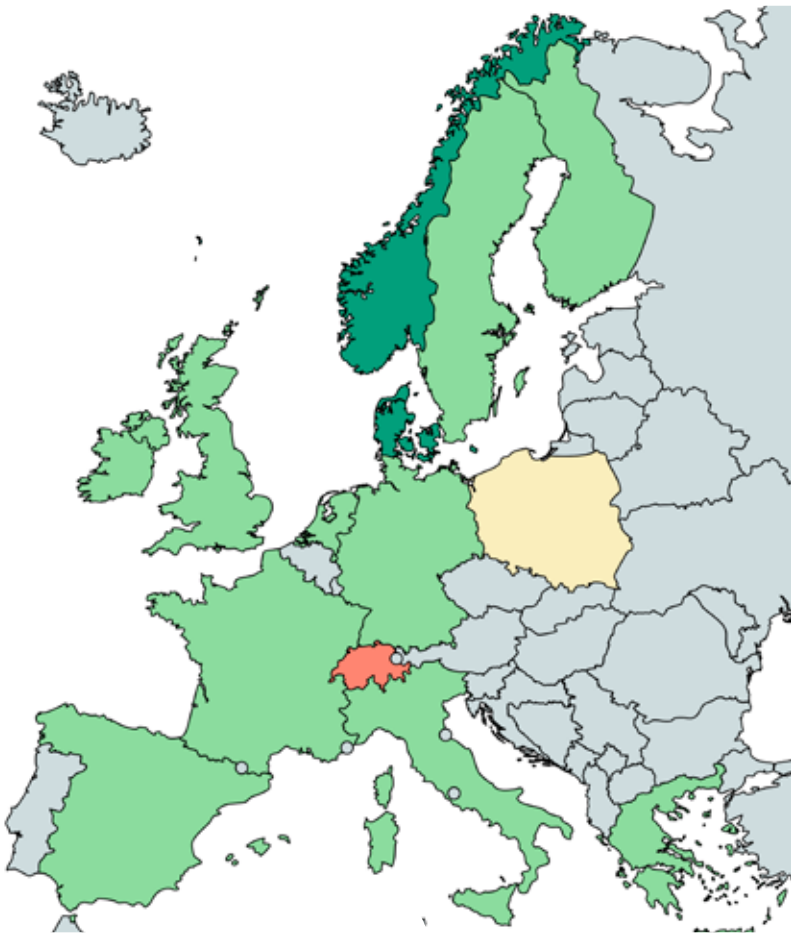
The ability to unlock new flexible decentralised electricity resources in energy systems with high variable renewables is mostly falling short, and risks undermining the energy transition.

The individual assessment categories are described in more detail below.

1. SOCIO-ECONOMIC RANKING

This section assessed whether the socio-political background supports or impedes investment.

Socio-economic ranking	
Rank	**2023**
5	**Denmark, Norway**
4	**Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Spain, Sweden, UK**
3	**Poland**
2	**Switzerland**
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. Norway 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. Denmark and Finland scored highest in this category, while Poland and Switzerland scored lowest.

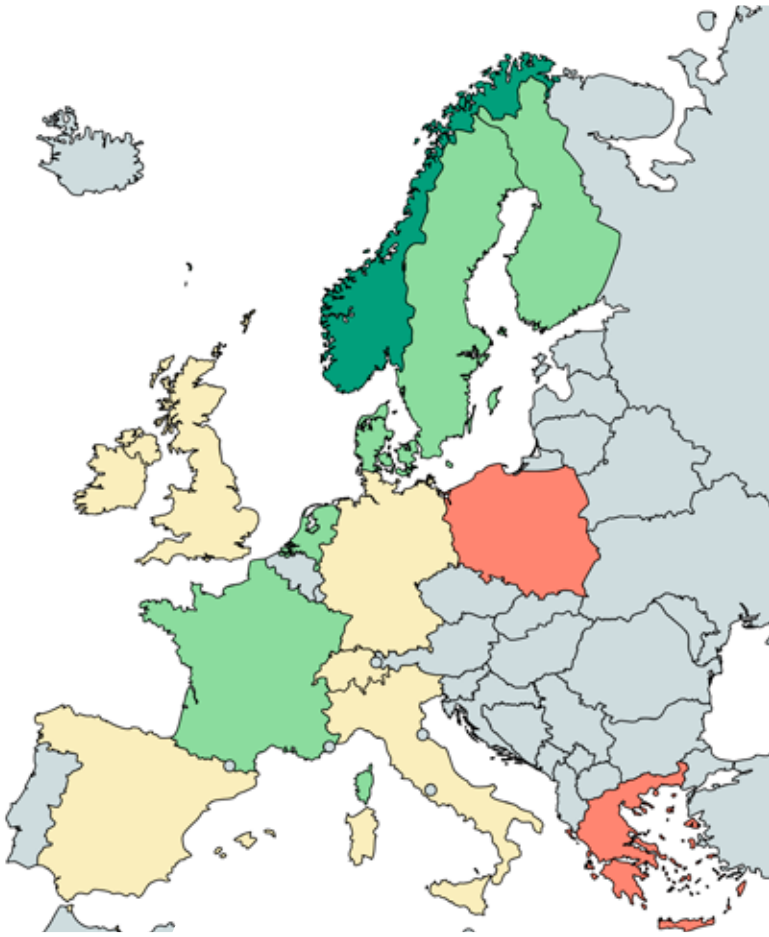
Regulation and delivery **-** in high scoring countries, there is a strong political commitment to a zero-carbon economy, and this is translated into a strong and 'fit-for-purpose' regulatory framework that will deliver the objectives particularly around flexibility. The lower scoring countries have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

Overall comments **-** Looking back to last year's (2022) report on socio-economic factors, we highlighted that there was an overall decline in confidence (around a 10% reduction in average scores) from the previous year (2021) about delivery of the energy transition. This decline mainly resulted from concerns about the energy crisis. Overall, the scores in this year's report have improved on last year suggesting that participant confidence may have recovered to pre-energy crisis levels.

2. TECHNOLOGY ENABLER RANKING

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

Technology Enablers	
Rank	**2023**
5	**Norway**
4	**Denmark, Finland, France, Netherlands, Sweden**
3	**Germany, Ireland, Italy, Spain, Switzerland, UK**
2	**Greece, 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 have technical or operational barriers that inhibit the application of distributed flexibility services. Finland scored highest in this area. Germany, Greece, the Netherlands, Poland, Spain, Switzerland, and the UK all scored below average, mainly because of increasing market barriers due to grid accessibility constraints.

Electric vehicles (EVs) **-** high scoring countries may be expected to have a clear roadmap for growth in the number of EVs on their roads, providing bi-directional charging infrastructure to enable EVs to participate in flexibility markets. However, progress remains relatively slow in 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, Greece, and Poland score lowest in this area.

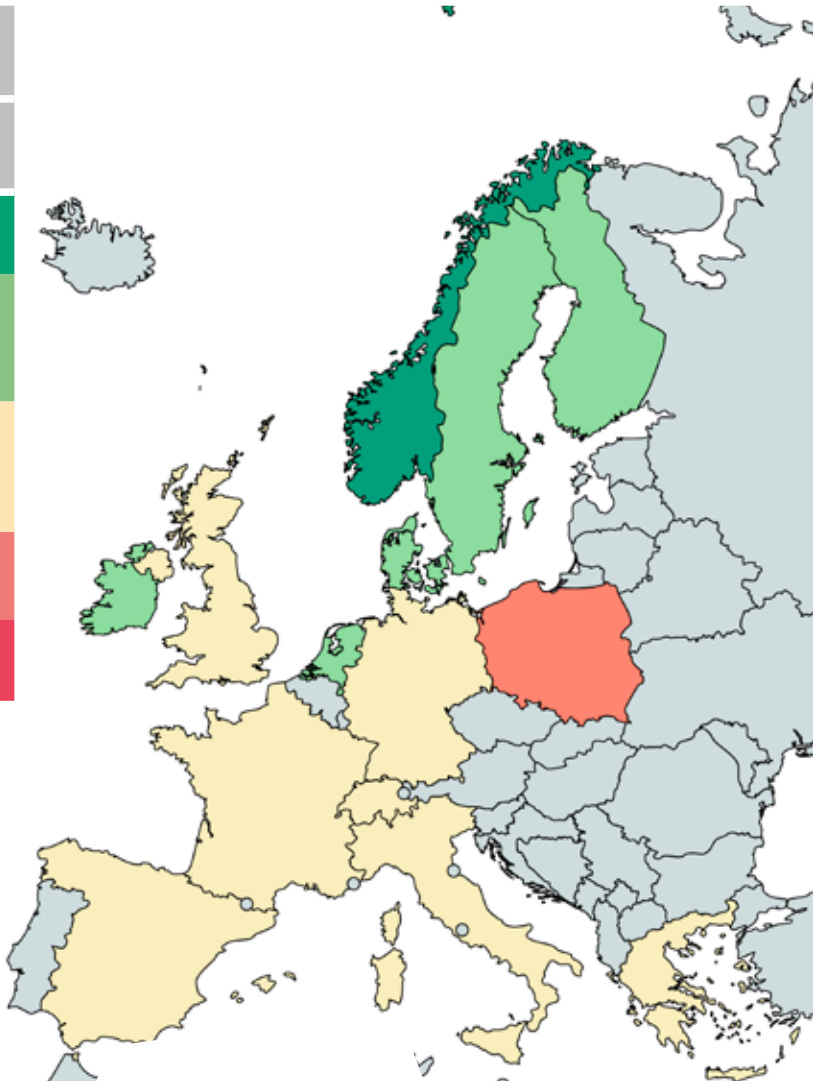
Innovation **-** high performing countries have a clear route for enabling technology innovation through opportunities to participate in flexibility markets perhaps using regulatory sandboxes, whereas in lower performing countries there are often barriers to the connection of new technologies to the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

Overall comments **-** Scores in this area have remained constant in our index since 2019, demonstrating that technology enablers are contributing to the energy transition. But little improvement is evident suggesting more progress needs to be made by several countries. Norway continually scores highest because of its leadership role in EV adoption and the associated use of EVs for flexibility services. Denmark, Finland, and Sweden are also consistently strong performers.

3. MARKET ACCESSIBILITY RANKING

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

Market Access	
Rank	**2023**
5	**Norway**
4	**Denmark, Finland, Ireland, Netherlands, Sweden**
3	**France, Germany, Greece, Italy, Spain, Switzerland, UK**
2	**Poland**
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. Denmark scored highest in this category, while Poland and Switzerland scored lowest.

Market trading arrangements - in high scoring countries, market trading arrangements provide transparent markets that allow different contract terms, this delivers trading volumes (including aggregation) that enable effective flexibility trading. In lower scoring countries, trading of flexibility is limited. Denmark and Norway scored highest in this category, while Poland and Italy 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. Norway and Ireland scored highest in this category, while Poland and Spain scored lowest.

Overall comments - Over our last three reports, scores in this area have generally been constant,

illustrating that most countries have accessible market arrangements. But little improvement is evident, suggesting that more progress is needed to address market barriers to make trading flexibility resources easier to do, and therefore make investment in such resources more attractive.

Significant differences remain in how flexibility resources participate in electricity markets. In some countries e.g., in the Nordics, there are few market access barriers, but flexibility resources there compete with flexible hydro. In countries including Germany, Italy, and the UK, which have large electricity markets and significant fossil-fuel generation to displace, there is much greater market potential for flexibility resources, but growth in take-up is slow.

THE IMPACT OF GLOBAL INVESTMENT INCENTIVES ON THE ENERGY TRANSITION

The US Inflation Reduction Act and the European Green Deal

During 2022, the United States introduced the Inflation Reduction Act (IRA), releasing an unprecedented level of federal funding to subsidise clean energy generation, storage, and related technologies. Overall, the IRA is considered to have had a major positive economic impact in the US, driving increased investment in green technology supply chains and applications. It is based on a broad tax credit system which rewards both supply chain and renewable investment.

The European Commission responded with the European Green Deal Industrial Plan which has, amongst other things, sought to boost renewable energy production in Europe.

Survey respondents were also asked about how these initiatives impacted the investment landscape in their country over the past year.

Key points that were highlighted included the following:

- The IRA had clearly accelerated investment in the US, including investment in supply chains as additional incentives were given to domestic manufacturing. There was some evidence that supply chain investment e.g., battery plants, had moved to the US rather than Europe.
- The European Green Deal policy initiative was welcome, but the impact of these policies has not yet been seen in EU countries. In non-EU countries, there were few specific policies to address the impact of the IRA or Green Deal.

This year's ETRI survey suggests that investor confidence in the energy transition and opportunities for the deployment of green technologies has improved slightly since last year, but it would likely have improved further if Green Deal policies had been implemented faster in European countries.

5. Looking forward - the energy transition implementation challenge

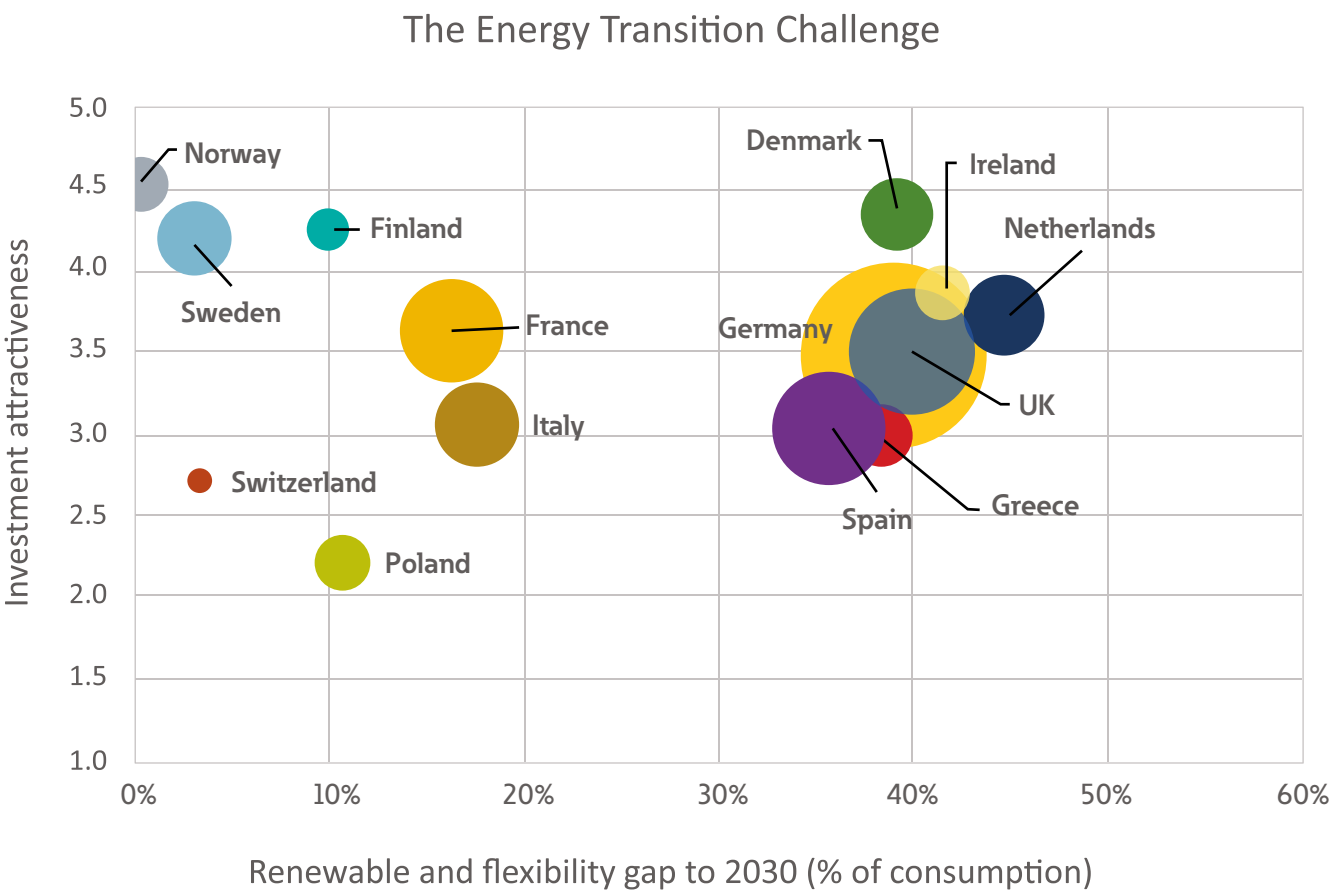
The scale of the flexibility challenge

The evaluation data allows us to assess each country's overall level of ambition for delivering the energy transition against the progress they are making. The chart plots investment attractiveness, as measured by the average of survey results for each country - against the percentage increase in renewable energy targets between 2022 and 2030.

The chart shows the renewable electricity increases (as a percentage of consumption) expected by 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. Alongside the challenge of delivering new renewable capacity, there will be a similar challenge to deliver flexibility growth.

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

CHART 7: 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 are indicating 'below average' investor attractiveness. This suggests that the lower scoring countries - Poland and Switzerland - have greater market barriers to investment.

Bridging the gap to 2030

The seven countries on the right of the chart (Denmark, Germany, Greece, Ireland, the Netherlands, Spain, and the UK) have set the most ambitious renewable electricity targets for 2030. These targets appear to be the most challenging to achieve in the time available. These countries forecast an increase their renewable electricity output (as a percentage of electricity consumption) by around 40% from 2022 levels. The Netherlands has the most ambitious percentage growth target, increasing renewable output from 41% of consumption in 2022, to 86% in 2030., an increase of 45%.

With regard to volumes of renewable output, Germany (with a target of 276TWh growth in electricity from renewables by 2030), the UK (with growth of 132 TWh), and Spain (with growth of 107TWh) face the greatest challenges.

This growth in renewables will need to be accompanied by comparable growth in flexibility resources, including storage, demand-side flexibility, interconnectors, and other low carbon generation. As well as some of the challenges to growth highlighted in this report, rapid growth in both renewable assets 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.

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 these resources and technologies, together with the opening of markets in which they can operate. Across Europe, there are some good examples of how markets and demand-side flexibility are beginning to emerge.

The case studies here illustrate the roles of integrated demand-side flexibility services; flexibility markets; and the use of hydrogen production as a flexibility resource.

Example 1: Florian Hotel, Amsterdam

Access to grid capacity is becoming more challenging in many countries across Europe as investment in renewables and distributed energy resources grows. Grid reinforcements to add capacity can take time to construct, resulting in long connection delays, and capacity limits. Many customers and businesses are seeking alternative solutions and technologies to overcome these issues. Amongst the options is Eaton's Buildings as a Grid approach which provides the infrastructure to combine local solar generation, energy storage, and intelligent digital control for managing electricity flows in real-time.

This approach has been implemented in the Netherlands, where additional import capacity was needed to transform what was a former office building into a hotel called The Florian. After receiving an inadequate grid connection offer, the hotel owner worked with Eaton to design an energy strategy that balanced on-site solar power generation, the hotel's demand for energy, electric vehicle charging, and an energy storage system within the limits of its existing grid connection.

Overall energy consumption is maintained well within the pre-agreed limits set by the distribution system operator, through a system of 'peak shaving', which ensures that electricity from the batteries is used when demand for power in the hotel is at its highest. This approach is scalable, too, with an expandable network of EV chargers installed in the hotel's parking garage and integrated into the building energy management system.

In addition, the Buildings Energy Management Software (BEMS) analyses the hotel's current and past energy use trends and monitors weather forecasts to ensure that the energy from solar panels is used to maximum effect. By using an algorithm, available power can be directed to where it is most needed for EV charging and other electrical requirements in the hotel, while at the same time keeping the battery storage device charged to substitute power from the grid when necessary.

The result is that, during periods of high energy prices, the hotel can control energy costs while reducing carbon emissions.

Example 2: Norway Flexibility Markets (NODES)

In last year's ETRI report, we provided an overview of a project called NorFlex, which involved the NODES marketplace for trading energy flexibility working with the DSO, and the Agder Energi Nett, and Glitre Energi Nett grids in southern Norway to alleviate pressure on the distribution grids by establishing a pilot flexibility market.

The pilot opened in autumn 2020 and closed in April 2023, with 1394 MW of flexibility, at a value of 12m NOK (approximately 1.1m Euro) traded in total. The flexibility products and results of the pilot are described below.

ShortFlex and LongFlex Products

ShortFlex was a NODES product for the physical delivery of flexibility. The ShortFlex market opened for trading seven days ahead of physical delivery, closed two hours before physical delivery and had a duration of one hour while also supporting products with shorter duration, including 30 minutes and 15 minutes.

LongFlex was a product for the reservation of flexibility over two different durations: LongFlex season and LongFlex week. Seasonal contracts spanned multiple weeks, whereas the weekly contract lasted a single week. 96% of the contracted hours under LongFlex contracts were delivered according to the terms of the LongFlex contracts but had a relatively low income.

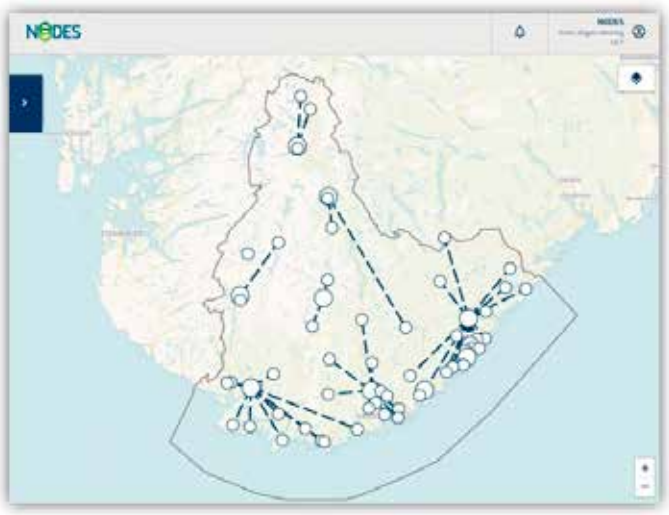
Pilot findings

Flexibility service providers (FSPs) offered flexibility across several different asset types in the pilot, which could be broadly categorised together as households (EVs), commercial buildings, batteries, and industry. During the pilot, EVs were the largest flexibility source by traded volume, where they derive their flexibility by shifting their time of charging based on trades in the market. This shows how vehicle-to-grid connections will offer huge flexibility potential once they are commercially available.

A barrier to unleashing the flexibility potential in commercial buildings is the price of installing hardware for the aggregator to tap into this flexibility, as individual loads are relatively small. The potential for cost-cutting is huge if already existing control systems could be used to manage loads.

Batteries can be an excellent source of flexibility when activated, but their limited storage capacity means that they can only deliver flexibility for limited periods before needing to re-charge. Market actors indicated that this is still a relatively expensive technology, and therefore needs other revenue streams in addition to make a profit.

While industrial assets are often large, and have potential as a flexibility source, the pilot found that industrial assets did not want to be activated frequently. This is likely because flexibility activations have a direct impact on the production line of industrial assets, and therefore came at a large cost.



White Paper: Trading in NorFlex 2020-23 (updated): https://nodesmarket.com/publications/

TABLE 6: FINDINGS OF NORFLEX FLEXIBILITY MARKETPLACE PILOT (2023)

Source	Frequent activations	Cost	Suited for ShortFlex?	Suited for LongFlex?	Flexibility potential
Households	Yes	Low	Too some degree. Prefer product without baseline	No. Majority of income comes from frequent ShortFlex activations	Large
Commercial buildings	Yes	Medium	Too some degree. Prefer product without baseline	No. Majority of income comes from frequent ShortFlex activations	Large
Batteries	Too some degree	Medium	Yes	Too some degree. Have limitations on duration and rest time	Medium
Industry	No	High	Yes, but few activations	Yes	Large, but cannot be activated often

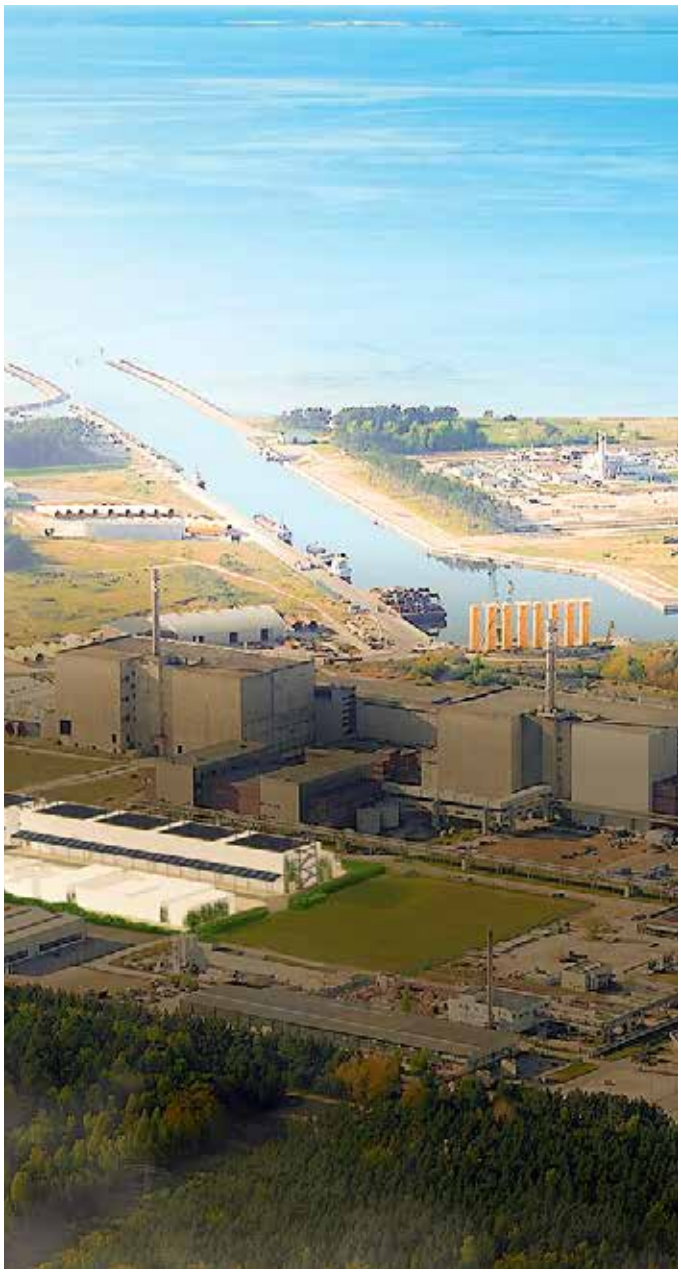
Example 3: Green Hydrogen production and electrolyser demand

The HH2E Lubmin project, located on the German Baltic coast in the state of Mecklenburg-Vorpommern, is a large-scale green hydrogen production plant that encompasses high-capacity battery and heat storage to maximise green hydrogen production.

The project is expected to become operational by mid-2025 and will be capable of producing approximately 6,000 tonnes (over 200,000 MWh) of green hydrogen per annum during the first 100 MW phase. By 2030, it is expected to increase capacity to over 1 GW, with annual production exceeding 60,000 tonnes of green hydrogen.

The plant will serve green hydrogen customers and off-takers, including large-scale energy and industrial consumers such as the chemical industry, and commercial air and road transport operators. A collaboration is in place with MET Group, an integrated European energy company, with activities in natural gas and power, to facilitate the sale of green hydrogen produced by HH2E Lubmin.

The HH2E Lubmin plant is in a highly congested area of the German electricity grid, where capacity is fully utilised by imports from large offshore windfarms in the Baltic Sea. Due to its electricity import requirements, the plant was able to obtain an early grid connection and has the potential to provide important grid flexibility services and gain associated revenues in the future.



7. Conclusions

In this report, we have reviewed energy transition readiness in 14 European countries. We have:

- listened to the opinions of experts in each country about the readiness of that country for the energy transition, taking into consideration the socio- political environment, the state of 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 key electricity market characteristics in each country and looked ahead to 2030, to consider the implications for that country involved in meeting increased renewable energy targets.

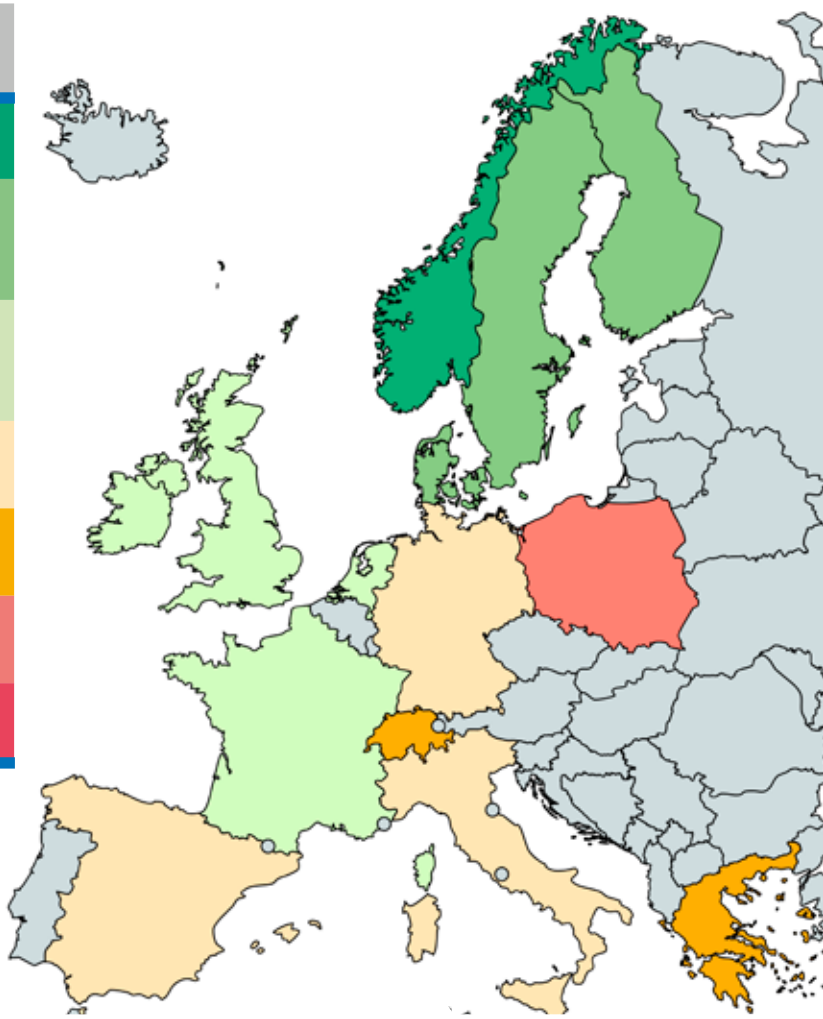
The key findings of this report are discussed below:

1. 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. Given the increased number of countries in the report, our overall scoring has been enhanced from last year to show high and low scores within each scoring range, adding greater granularity to aid comparison.

The results of the survey are shown in the diagram below, with Norway showing the greatest degree of readiness and Poland showing the least. Since our 2022 survey, the scores for Norway, Germany and the UK have strengthened, and the score for Poland has weakened. Looking back over the four years of our survey, the scores for Germany and the UK have shown the greatest improvement.

Score	2023
5	
High 4	Norway
Low 4	Denmark, Finland, Sweden
High 3	France, Ireland, Netherlands, UK
Low 3	Germany, Italy, Spain
High 2	Greece, Switzerland
Low 2	Poland
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.

2. Political and public support

Political and public support for the energy transition appears to have strengthened slightly since our last report. In some countries, this was attributed to greater apparent evidence of the impact of climate change on society making the perceived need for action more urgent. The aftermath of the energy crisis continues to affect the affordability of the energy transition, but also reinforces the benefits of renewables in terms of energy resilience and reduced reliance on volatile international gas markets.

More ambitious targets for renewable deployment are being set, but concerns remain that policy and regulatory implementation can be complex, uncoordinated, and slow. The costs of the transition may not be well understood or communicated, risking delivery.

3. Technology

Technology enablers, such as grid access, remain a significant barrier, particularly in Germany, Greece, the Netherlands, Poland, Spain, Switzerland, and the UK. Planning consents for renewables and grid reinforcement are becoming more difficult to obtain in some countries due to local opposition. Policies to incentivise EV charging and bi-directional operation remain patchy and underdeveloped.

4. Markets

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 report noted the views of participants that the US subsidy regime (IRA) has not been matched by similar incentives in Europe, potentially reducing the attractiveness of investing in the energy transition in Europe.

The report continues to show that the energy transition to decarbonised electricity markets, including technology enablers and flexibility markets, is well underway, but the pace of change varies. The scale and potential of flexibility needs are becoming better understood, and many new participants are emerging, bringing new skills, solutions, technologies, and investment capital.

5. US Inflation Reduction Act (IRA) subsidy regime and European Green Deal

Survey respondents noted that the IRA had clearly accelerated renewable and storage investment in the US, including investment in supply chains as incentives were given to domestic manufacturing. The EU Green Deal policy initiative was welcome, but the potential impact remains uncertain, and non-EU countries would not benefit.

Overall, survey respondents considered that progress towards the energy transition in Europe would accelerate faster if equivalent measures to the IRA had been introduced.

6. Market data

The market data analysed in this report highlights the following:

- Renewable energy - There was a 3% overall increase in renewable electricity output across the survey countries in 2022. This figure would have been higher except for a reduction in hydro output in some countries due to drought conditions.
- Demand side flexibility - BEV and heat pump installations are continuing across survey countries, but a wide differential in the number of installations remains between countries.
- Electricity storage - 2022 saw significant growth in electricity storage installations, both grid scale and behind the meter.

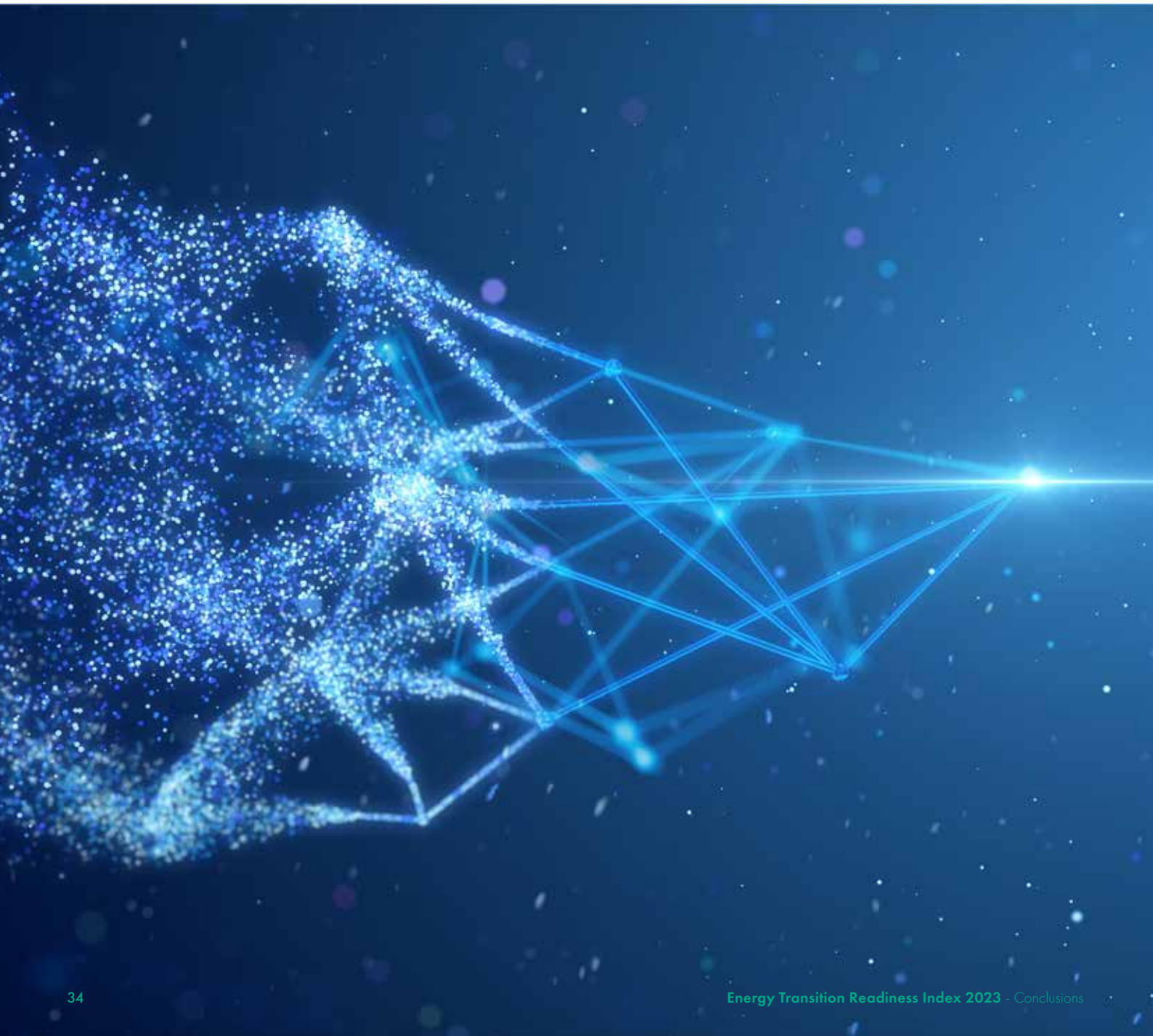
7. The 2030 renewable and flexibility challenge

Our assessment illustrated the high volumes of new renewable and flexibility resources that will be needed if 2030 decarbonisation targets are to be met. Alongside the rapid growth expected in grid scale storage, demand-side flexibility technologies will have an increasingly important role to play, and the amount of electric vehicles, heat pumps, and storage, will need to be increased significantly.

We estimate that, in aggregate, the 14 countries we assessed in this survey will require almost 1000 TWh additional renewable capacity by 2030, together with the new flexibility resources needed to enable this capacity.

Our analysis shows that Denmark, Germany, Greece, Ireland, the Netherlands, Spain, and the UK have the most ambitious targets for 2030. Germany (with a target of an additional 276TWh of electricity from renewables by 2030) and the UK (with aa additional 132TWh clean energy ambition by 2030) face the greatest challenges.

Battery storage resources are growing but, alongside demand side flexibility resources, growth will need to accelerate much faster to reach the levels needed for 2030. If this growth is not realised, them renewable output targets are unlikely to be reached, also resulting in higher costs for customers as renewable output is increasingly curtailed.



8. Recommendations

This report highlights the importance that the low carbon flexibility resources needed to enable renewable capacity will play in achieving the energy transition. The benefits are significant, delivering cost savings, decarbonisation and enhancing security of supply. The energy crisis has shown the importance of renewables for energy resilience and lower costs, as well as decarbonisation.

Key recommendations

Our previous ETRI reports have consistently recommended that countries introduce strategies to address the flexibility challenge for 2030 and beyond. Our key recommendations continue to be:

1. **Identify future low carbon flexibility needs and make 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 deliver coordinated low carbon flexibility planning and ensure effective delivery.

2. **Accelerate flexibility market reforms:** Policies and supporting incentives to deliver fair, transparent, and easily accessible markets for new flexibility resources must be introduced much faster to avoid putting the energy transition at risk. Market reforms should unlock and realise the potential of distributed energy resources.

   To attract investment, flexibility markets must be open so that grid scale and demand-side flexibility resources can compete fairly. Investors want predictability to allow investments with long payback periods to be funded. Long-term price signals are needed to guide them.

3. **Urgently address technology and process 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 action and investment are needed to remove these barriers to low carbon flexibility investment.

More low carbon flexibility is needed. 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.

EU Storage strategy

We welcome that the European Commission adopted an energy storage strategy[9] in March 2023. It recognised the importance of flexibility resources and included recommendations for countries to:

- Remove barriers to storage, including avoiding double taxation and facilitating permitting procedures.

[9]https://energy.ec.europa.eu/topics/research-and-technology/energy-storage_en

- Identify flexibility needs across different timescales and ensure that system operators assess these needs when planning network developments.
- Increase the long-term visibility and predictability of revenues to facilitate access to finance.
- Consider instruments, such as competitive bidding procedures (within capacity mechanisms) to achieve the necessary flexibility.

Accelerating the transition

These EU recommendations are consistent with our proposals. However, we do not think they go far enough or fast enough, nor are they applicable in non-EU countries. We recommend:

- Clear flexibility targets should be set for 2030 - National energy and climate plans for 2030 should clearly identify flexibility needs, showing the expected proportions of flexibility from:
  - Grid-scale storage
  - Demand-side flexibility (including electric vehicles, heat pumps and storage)
  - Interconnectors
  - Other low carbon generation e.g., hydrogen
  - Fossil fuel generation
- Co-ordinated plans to meet flexibility targets - the relevant national authorities, including government, regulator, and transmission and distribution system operators (TSOs and DSOs) should jointly prioritise the development of coordinated plans to meet flexibility targets.
- Identify and remove barriers to flexibility - these coordinated plans should also identify barriers to flexibility delivery and how these will be addressed. Barriers to flexibility resources include delays to accessing grid capacity, market access constraints, and unduly onerous technical standards.
- Policy interventions to incentivise flexibility - in countries with an urgent need for flexibility, incentives could be provided to accelerate the development and application of low carbon flexibility resources. Such incentives could include:
  - Tax credits - similar to those offered under the US IRA - to directly encourage supply chain investment and development
  - Incentives targeting delivery of low carbon distributed flexibility resources, e.g., heat pumps, electric vehicles
  - Prioritisation of low carbon flexibility output in existing electricity markets

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 key electricity market, distributed energy resources (DER) and enabling technologies for each of the survey countries. Survey results are provided together with a summary of comments from experts.

Survey countries

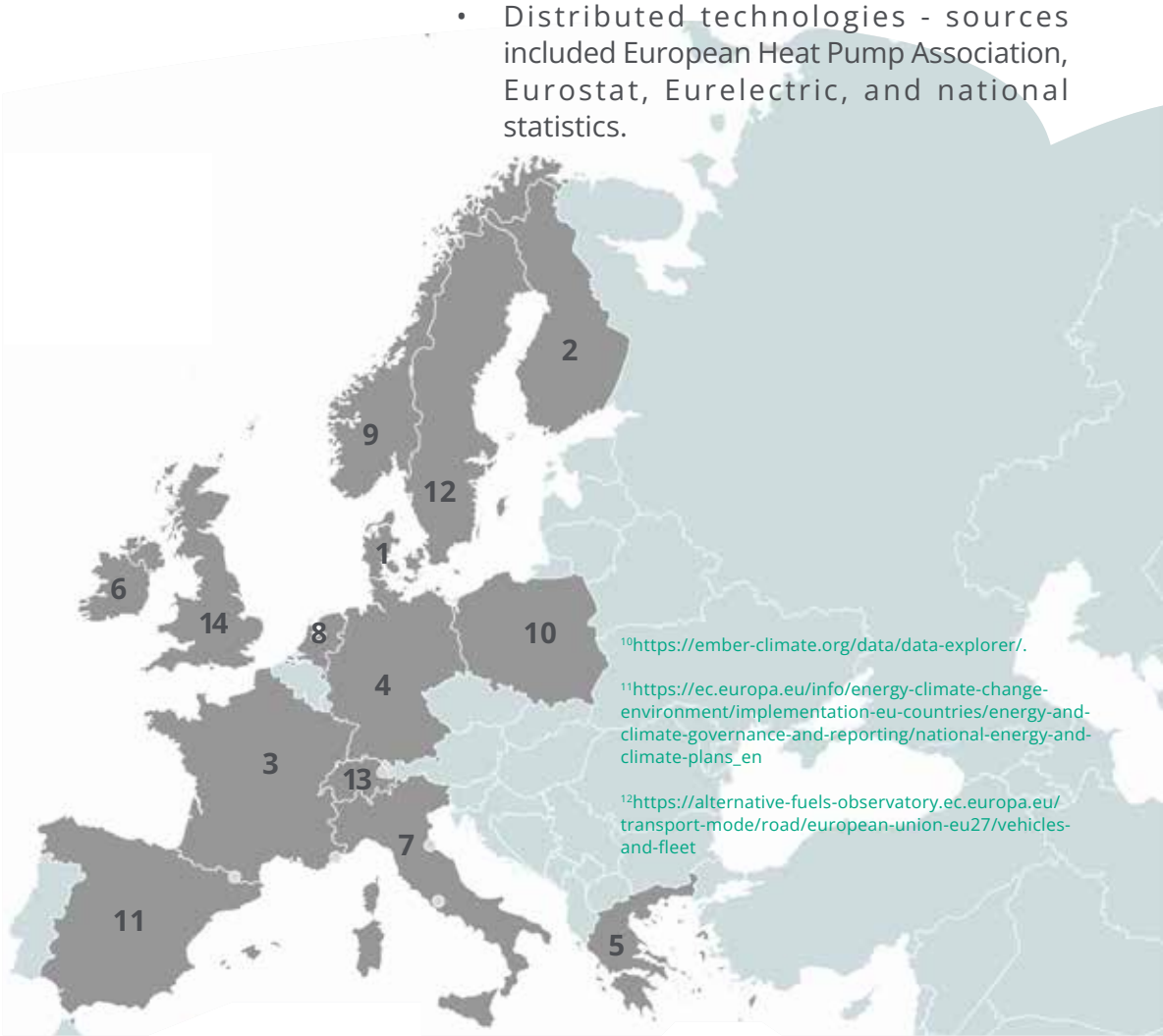
Summary information is provided in this appendix for the following countries:

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

Data sources

Country data was sourced from:

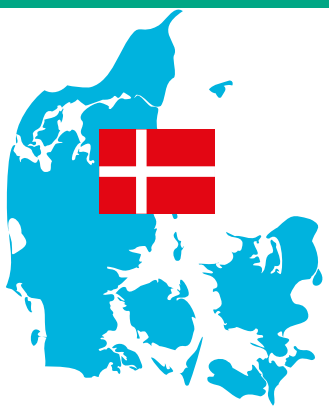
- **Electricity market data -** actual data for 2022 was obtained from Ember data.[10] Forecasts for 2030 were sourced from the latest National Energy and Climate Plans (NECPs)[11] for EU countries (where available) and national reports for non-EU countries. For EU countries where updated NECP's were not available, electricity consumption and renewable generation forecasts for 2030 have been derived from published national forecasts.
- **Distributed energy technologies -** The data for distributed energy products and enabling technologies has been derived from:
  - Transport data - from the EU Alternative Fuels Observatory[12], European Automobile Manufacturers Association (ACEA), the International Energy Agency and national statistics.
  - Distributed technologies - sources included European Heat Pump Association, Eurostat, Eurelectric, and national statistics.



[10]https://ember-climate.org/data/data-explorer/.

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

[12]https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27/vehicles-and-fleet

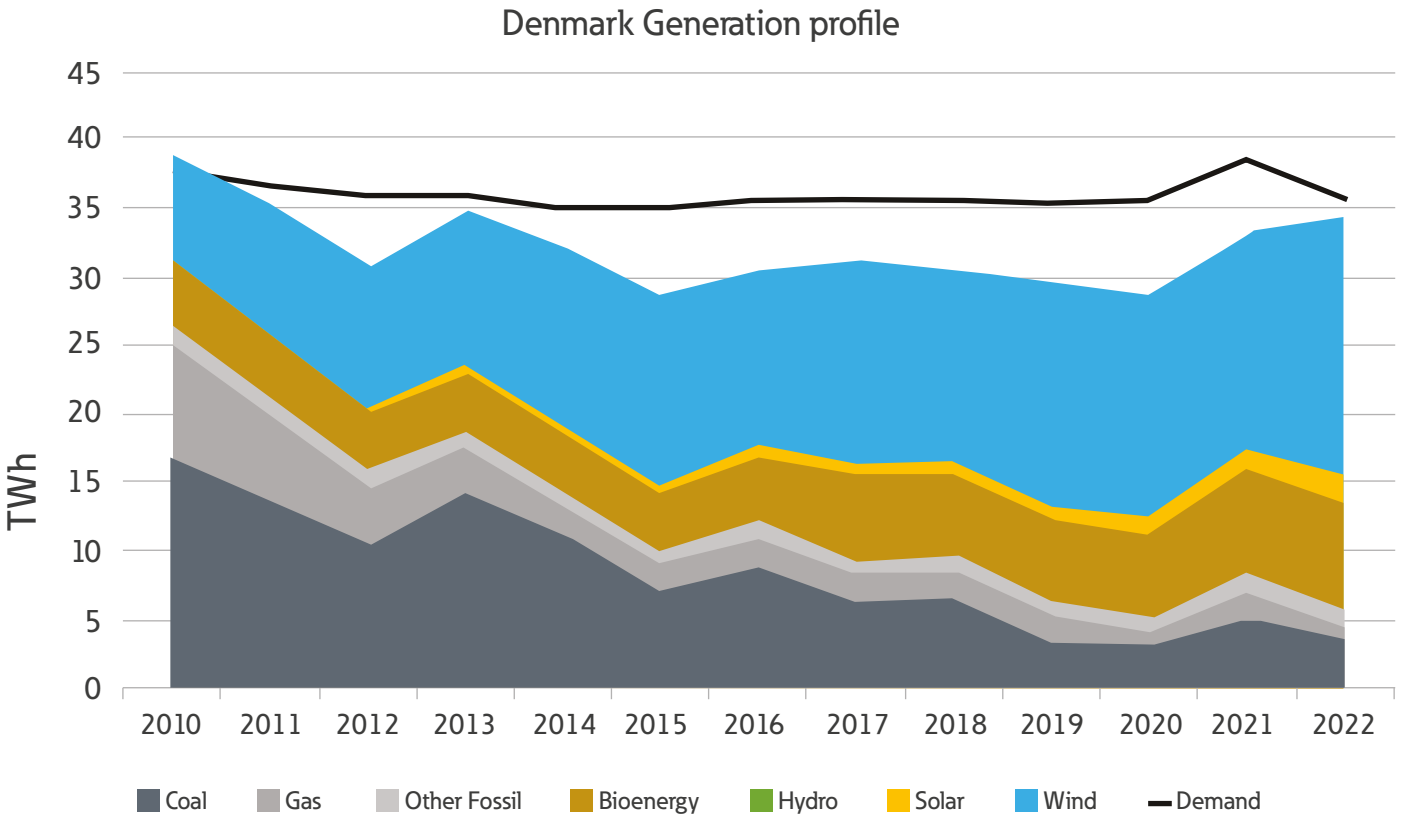


Denmark

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 8: DENMARK GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows Denmark has significantly grown its wind generation capacity over the last decade and reduced reliance on coal. Denmark is recognised as a leader in wind deployment with the strong supporting supply chain bringing wider economic benefits. In 2022, Denmark's generation output increased and moved closer to meeting consumption, reducing the historic level of imports.

TABLE 7: DENMARK MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	36	60
Annual renewable production (TWh)	29	72
Renewable % of annual consumption	81%	120%
Annual solar and wind production (TWh)	21	67
Solar and wind % of annual consumption (TWh)	58%	112%

Flexible energy technologies	2022
Homes with electricity supply (million)	2.7
Domestic heat pumps ('000's)	611
Domestic heat pumps/1000 homes	224
Heat pumps added/1000 homes	33
Total Battery EV's (000's)	101
Total Battery EV's (% of total fleet)	3.2%
% EV registrations of all new registrations	28%

Enabling technologies	2022
Smart meter penetration	99%

Markets - In 2022, Danish annual renewable production (mainly wind) represented 81% of annual consumption, up from 66% in 2021. In its draft 2023 National Energy and Climate Plan update, which it is required to produce as an EU member, Denmark has forecast significantly increased electricity consumption by 2030 (driven by growth in electrolysis capacity for hydrogen production), together with major growth in renewables output for 2030, targeting 120% of consumption by 2030. Overall, this requires an additional 46 TWh of solar and wind output by 2030.

Flexibility resources - Denmark had a 3.2% penetration of battery electric vehicles in 2022, with electric vehicles representing 28% of all new vehicle registrations, up from 13% in 2021. Heat pump penetration is around 22%. Smart meter penetration is high.

2. Survey results

The 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	5	5

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	5	3

Overall, 2022 scores were slightly higher than in last year's survey.

Key points raised by survey participants were:

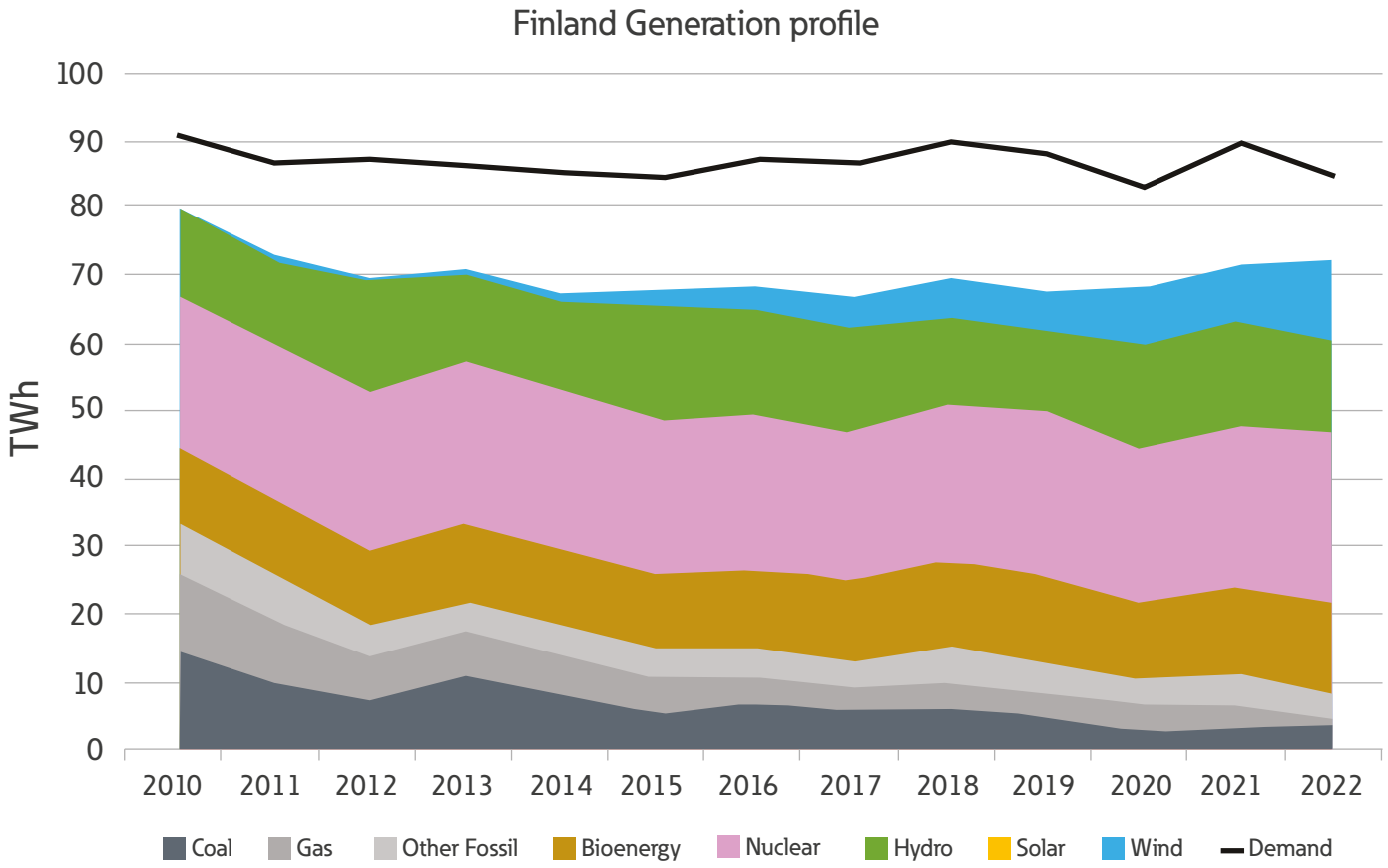
- The energy crisis has strengthened Denmark's prioritisation of growth in renewables and the transition from fossil-fuels for transport and heating.
- There is strong political and public consensus about the energy transition, but there is some uncertainty about how policy measures will be implemented.
- Grid availability and investment are generally good, but there is evidence of congestion and connection delays on distribution networks. Bi-directional flexibility needs are under-developed, especially vehicle-to-grid (V2G) capabilities.
- Market design and the availability of market information to enable access for flexibility resources are good, 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 chart and table summarise the key electricity sector characteristics.

CHART 9: FINLAND GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the significant contribution from hydro, nuclear and bioenergy. Wind output continues to grow and is replacing fossil fuels. In 2022, Finland's consumption exceeded total generation output, continuing the trend of the country being a net importer of electricity.

TABLE 8: FINLAND MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	86	97
Annual renewable production (TWh)	40	55
Renewable % of annual consumption	47%	57%
Annual solar and wind production (TWh)	12	25
Solar and wind % of annual consumption (TWh)	15%	26%

Flexible energy technologies	2022
Homes with electricity supply (million)	3.1
Domestic heat pumps ('000's)	1345
Domestic heat pumps/1000 homes	438
Heat pumps added/1000 homes	64
Total Battery EV's (000's)	49
Total Battery EV's (% of total fleet)	1.2%
% EV registrations of all new registrations	30%

Enabling technologies	2022
Smart meter penetration	97%

Markets - In 2022, Finnish annual renewable production represented 47% of annual consumption, up from 42% in 2021. Most renewables were hydro, with around 15% derived from solar and wind. In its draft 2023 National Energy and Climate Plan update, Finland has targeted 55TWh of renewable electricity. This represents 57% of annual electricity consumption in 2030, which would require an increase in wind and solar output of 13 TWh.

Flexibility resources - Finland had just over 1% penetration of electric vehicles in 2022, with electric vehicles representing about 30% of all new vehicle registrations, up from 10% in 2021. Heat pump penetration is around 44%. Smart meter penetration is high.

2. Survey

The survey scores for Finland are shown below.

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

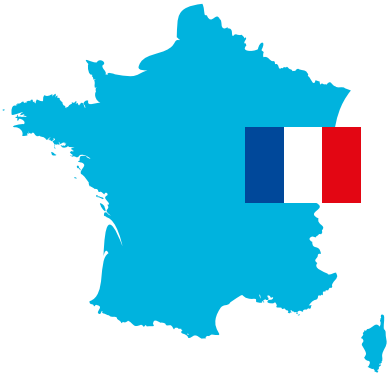
Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
4	4	5	3

Market factors		
Regulations	Compensation structures	Transaction costs
4	4	4

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 are similar to last year's survey.

Key points raised by survey participants were:

- The energy crisis has strengthened Finland's resolve to deliver on its priority of energy independence from Russia, resulting in growth in renewables and increased pace in the transition away from fossil-fuels for transport and heating.
- Support for decarbonisation and the energy transition is strong. Political and regulatory alignment is good.
- There is a strong grid network, offering good access for renewables and distributed energy. Digital enablers are in place, enabling flexibility markets through aggregators. Incumbents appear to dominate innovation projects and funding, however, leading to a lower score for innovation.
- 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 hydro is limiting the market capacity for flexibility resources.

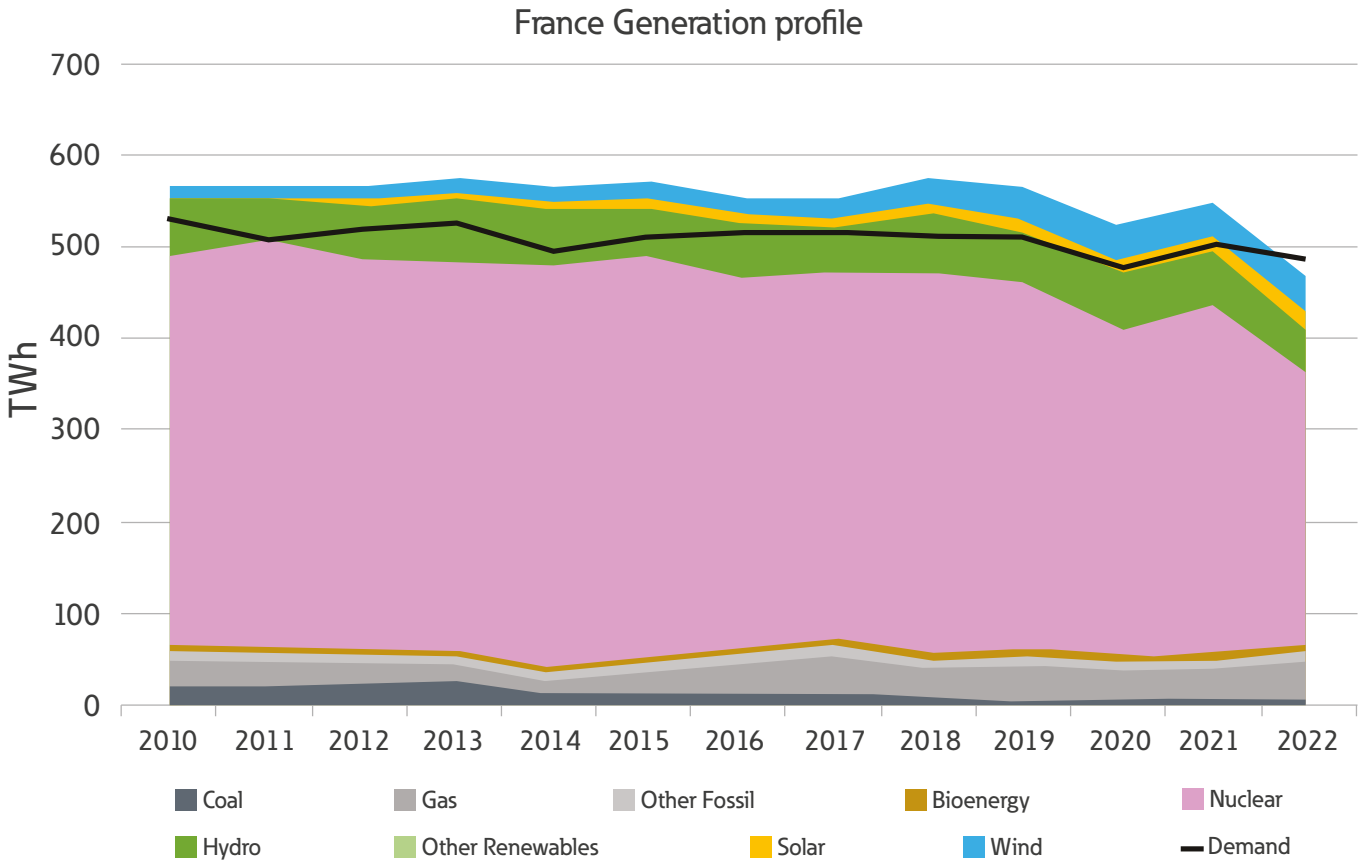


France

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 10: FRANCE GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It illustrates the dominant position of nuclear for French electricity production. However, nuclear output fell in 2022 due to unexpected outages, and France became a net importer of electricity. While wind and solar output have increased over recent years, they still represent a small proportion of the energy mix.

TABLE 9: FRANCE MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	485	510
Annual renewable production (TWh)	115	204
Renewable % of annual consumption	24%	40%
Annual solar and wind production (TWh)	58	147
Solar and wind % of annual consumption (TWh)	12%	29%

Flexible energy technologies	2022
Homes with electricity supply (million)	37.0
Domestic heat pumps ('000's)	3986
Domestic heat pumps/1000 homes	108
Heat pumps added/1000 homes	17
Total Battery EV's (000's)	761
Total Battery EV's (% of total fleet)	1.7%
% EV registrations of all new registrations	14%

Enabling technologies	2022
Smart meter penetration	85%

Markets - In 2022, France's annual renewable production represented 24% of its annual consumption (up from 22% in 2021) with the remainder dominated by nuclear generation. France's Transmission System Operator (RTE) estimates a 5% increase in electricity consumption between 2019 and 2030[13] to 510 TWh. France has targeted 40% renewables output for 2030, which could require an increase in wind and solar output by 89 TWh.

Flexibility resources - France had just under 2% penetration of electric vehicles in 2022, with electric vehicles representing around 14% of all new vehicle registrations, slightly higher than in the previous year. Heat pump penetration was around 12%. Smart meter penetration is high.

2. Survey

The 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	4	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
4	4	3

Overall, there is a clear policy goal of 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 growing uptake of renewables and distributed flexibility resources. Overall, scores remain similar to last year's survey.

Key points raised by survey participants were:

- High level policy goals are in place for the energy transition. Decision-making is centralised with high priority given to nuclear policy for energy independence and decarbonisation. Customers could be more involved.
- Support for decarbonisation and the energy transition is strong. Political and regulatory alignment is good.
- 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. Funding of innovation could be better.
- 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.

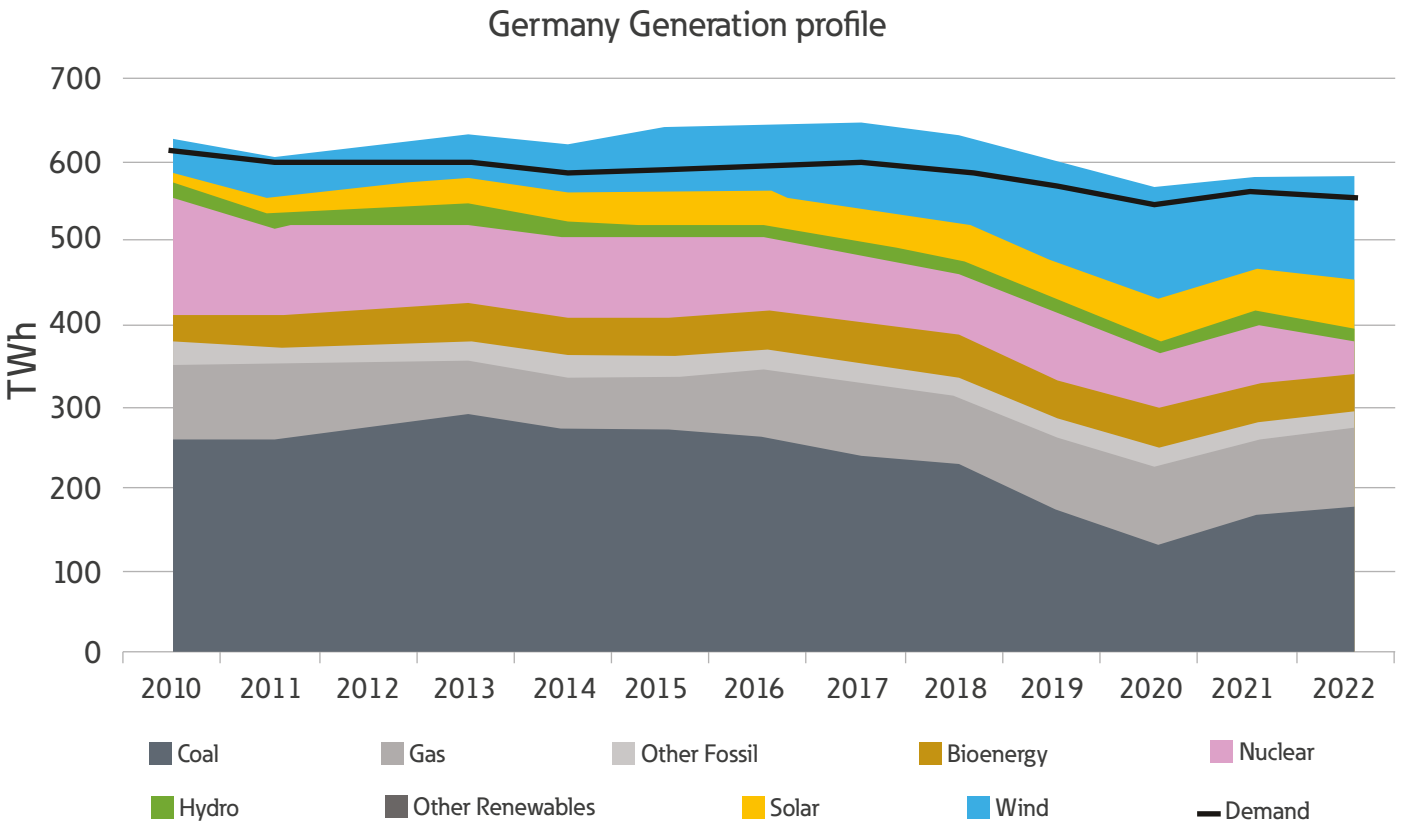
[13]https://www.rte-france.com/en/analyses-trends-and-perspectives/projected-supply-estimates#:~:text=In%20order%20to%20decarbonise%20the,5%25%20compared%20to%202019).

Germany

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 11: GERMANY GENERATION PROFILE



Germany is the largest electricity market in Europe. The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the growth of wind and solar generation over the last decade, but coal output has increased since 2020 and nuclear output decreased. In 2022, renewable output reached 45% of total consumption, up from 41% in 2021.

TABLE 10: GERMANY MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	554	658
Annual renewable production (TWh)	250	526
Renewable % of annual consumption	45%	80%
Annual solar and wind production (TWh)	185	462
Solar and wind % of annual consumption (TWh)	33%	70%

Flexible energy technologies	2022
Homes with electricity supply (million)	43.0
Domestic heat pumps ('000's)	1652
Domestic heat pumps/1000 homes	38
Heat pumps added/1000 homes	6
Total Battery EV's (000's)	1035
Total Battery EV's (% of total fleet)	2.0%
% EV registrations of all new registrations	16%

Enabling technologies	2022
Smart meter penetration	1%

Markets - In 2022, solar and wind represented 33% of annual consumption, an increase from 29% in 2021. Germany has a target of 80% renewable output by 2030 with consumption estimated at 658TWh[14]. This would require a 276 TWh increase in renewable output, up from the 185 TWh produced in 2021. While there is a clear and enhanced policy goal for decarbonisation, this has been accompanied by a decision to cease nuclear power generation.

Flexibility resources - Germany had 2% penetration of electric vehicles in 2022, with electric vehicles representing around 16% of all new vehicle registrations, similar to 2021 levels. Heat pump penetration was around 4%. Smart metering penetration is low but a national smart meter rollout is due to commence by 2025, and a target of 95% penetration has been set for 2030.

2. Survey

These are the survey scores for Germany.

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

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

Market factors		
Regulations	Compensation structures	Transaction costs
3	3	4

Overall, scores have improved slightly from last year's survey. Since the survey started four years ago, Germany has one of the greatest improvements in investor attractiveness. Overall scores for 2023 are around 15% higher than the historic survey average for Germany.

Key points raised by survey participants were:

- Energy security and the need to reduce reliance on Russian gas continues to be a priority in Germany following the energy crisis. There is an increasing ambition to develop renewable energy and reduce overall demand by improving energy efficiency. Concerns remain about energy affordability for businesses and domestic customers.
- Delivery of policy ambitions remains challenging because of cost impacts, and the complexity of implementing change.
- Grid access is generally available but there are some restrictions e.g., major North to South transmission is needed. There is policy support for EVs and EV charging, but growth is slow, and V2G has yet to be established. Metering and communications standards are unclear, presenting a market barrier to flexibility resources. Smart metering deployment is awaited.
- The flexibility markets are of limited scale for new smaller entrants due to the dominance of incumbents, making it difficult for new technologies to enter and compete.

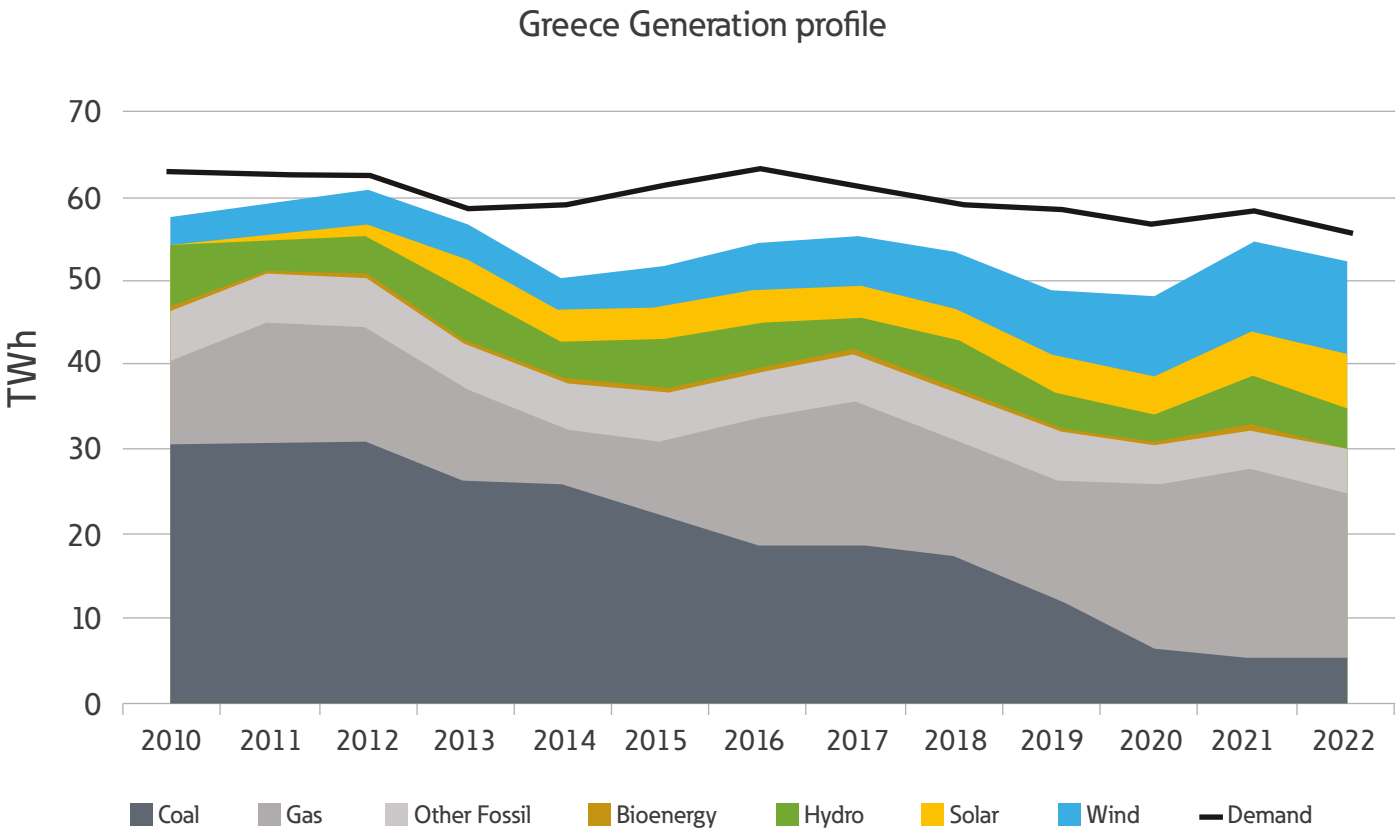
[14]https://www.bmwi.de/Redaktion/DE/Downloads/E/prognos-bruttostromverbrauch-2018-2030.pdf?__blob=publicationFile&v=2

Greece

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 12: GREECE GENERATION PROFILE



The chart shows the historic profile of generation output in Greece by fuel type between 2010 and 2022. It shows the growth of wind, solar and gas generation over the last decade, with coal output declining. Greece is a net importer of electricity.

TABLE 11: GREECE MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	56	68
Annual renewable production (TWh)	23	54
Renewable % of annual consumption	41%	79%
Annual solar and wind production (TWh)	17	48
Solar and wind % of annual consumption (TWh)	31%	71%

Flexible energy technologies	2022
Homes with electricity supply (million)	4.4
Domestic heat pumps ('000's)	n/a
Domestic heat pumps/1000 homes	n/a
Heat pumps added/1000 homes	n/a
Total Battery EV's (000's)	6
Total Battery EV's (% of total fleet)	0.1%
% EV registrations of all new registrations	5%

Enabling technologies	2022
Smart meter penetration	1%

Markets - In 2022, solar and wind represented 31% of annual consumption. Greece's latest National Energy and Climate Plan forecasts that renewables will account for 79% of electricity consumption (54 TWh) by 2030[15]. This could require an additional 31 TWh of solar and wind by 2030, up from the 17 TWh produced in 2022.

Flexibility resources - Greece only had a 0.1% penetration of electric vehicles in 2022, with electric vehicles representing only around 5% of all new vehicle registrations. Heat pump penetration data was not available. Smart metering penetration is low, but a national rollout is commencing and is expected to be complete by 2030.

2. Survey

The survey scores for Greece are shown below.

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

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

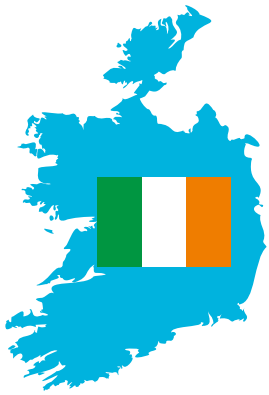
Market factors		
Regulations	Compensation structures	Transaction costs
4	3	3

Greece's energy policy focuses on boosting the use of renewable energy, especially for electricity generation, alongside increasing the share of electricity used for transport, and heating and cooling. Greece is a new entrant in the survey this year.

Key points raised by survey participants were:

- Energy security and independence is a priority, together with ensuring the transition has a fair economic impact across the country.
- Policy ambition and implementation measures are generally good. For example, alongside policies for supporting renewable development, battery storage auctions are being held to provide complementary flexibility resources. However, some inconsistencies exist between policy and regulatory design, and its implementation, resulting in uncertainty.
- Technology enablers such as grid access, smart metering, electric vehicles, and innovation funding were all considered to be weak. Lack of grid access is a significant issue for new flexibility resources.
- Market access arrangements for flexibility resources were considered good in principle, but there is limited liquidity in flexibility markets for new flexibility technologies. Transaction costs are high due to complex processes.

[15]https://www.argusmedia.com/en/news/2481589-greece-cuts-2030-solar-target-in-revised-energy-plan

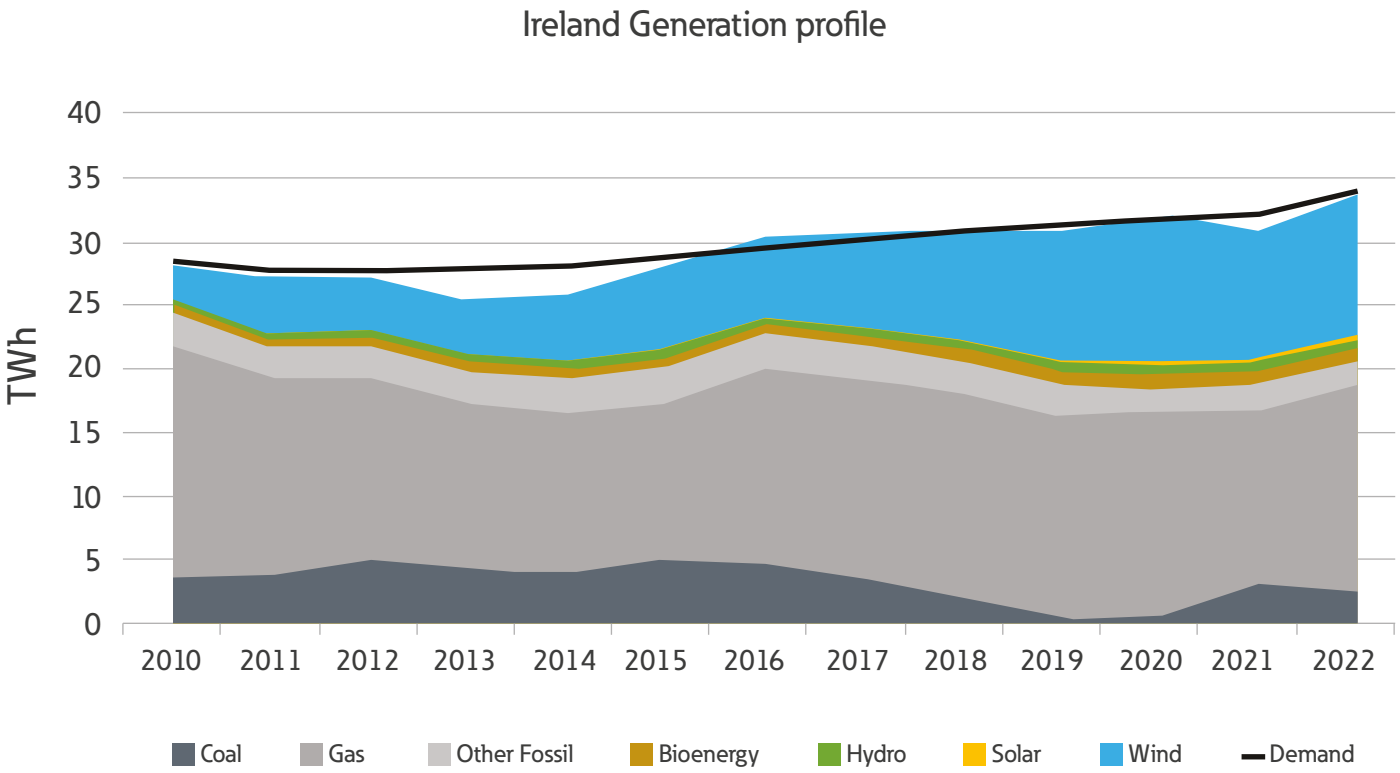


Ireland

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 13: IRELAND GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. 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 12: IRELAND MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	34	45
Annual renewable production (TWh)	13	36
Renewable % of annual consumption	38%	80%
Annual solar and wind production (TWh)	11	34
Solar and wind % of annual consumption (TWh)	33%	76%

Flexible energy technologies	2022
Homes with electricity supply (million)	2.1
Domestic heat pumps ('000's)	62
Domestic heat pumps/1000 homes	30
Heat pumps added/1000 homes	10
Total Battery EV's (000's)	38
Total Battery EV's (% of total fleet)	1.4%
% EV registrations of all new registrations	15%

Enabling technologies	2022
Smart meter penetration	55%

Markets - In 2022, Ireland's annual renewable production (mainly wind) represented 38% of annual consumption By 2030, Transmission System Operator, Eirgrid, forecasts a 33% increase in consumption, largely driven by data centre demand[16]. Ireland's Climate Action Plan[17] has targeted 80% renewables output for 2030, which could require an increase wind and solar output of 23 TWh.

Flexibility resources - Ireland had 1% penetration of electric vehicles in 2022, with electric vehicles representing about 15% of all new vehicle registrations, an increase from last year. Heat pump penetration is around 3%. Smart meter penetration is steadily increasing as a national rollout is well underway.

2. Survey

The survey scores for Ireland 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	4	3

Market factors		
Regulations	Compensation structures	Transaction costs
4	4	5

Ireland has an ambitious plan to decarbonise electricity though the deployment of renewables and access to flexibility markets. Overall, the survey scores remain similar to last year.

Key points raised by survey participants were:

- There is a high political and public consensus on the need for the energy transition, but the costs involved are not well communicated, creating doubt that they are properly understood. High inflation and cost of living concerns are a higher political and public priority than the energy transition, impacting confidence in policies to implement the transition.
- Grid capacity is generally available, but access may take time to realise. Flexibility is being utilised at a transmission level. Electric vehicle rollout is proceeding steadily but V2G is limited. National smart meter rollout has passed 50%. Innovation funding and activity is seen as more limited for new entrants than for incumbents.
- There is an open and transparent flexibility market design. There are few commercial barriers, flexibility markets are growing, and participation is widening.

[16]Eirgrid Median scenario https://www.gov.ie/pdf/?file=https://assets.gov.ie/245172/2c2fd729-261b-4b64-af5e-c7f5f8d18924.pdf#page=null

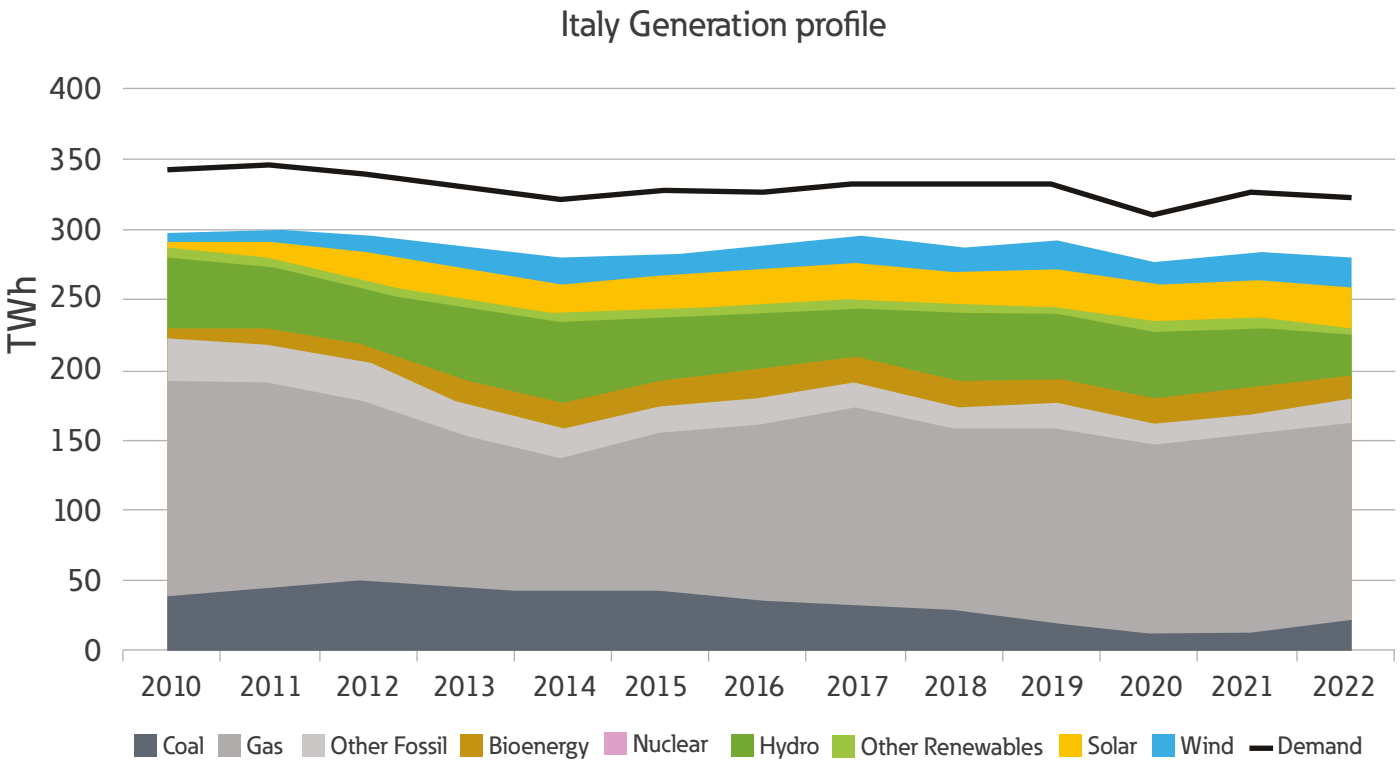
[17]https://www.gov.ie/en/publication/7bd8c-climate-action-plan-2023/

Italy

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 14: ITALY GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. 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. Italy is a net importer of electricity.

TABLE 13: ITALY MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	322	327
Annual renewable production (TWh)	102	160
Renewable % of annual consumption	32%	49%
Annual solar and wind production (TWh)	48	96
Solar and wind % of annual consumption (TWh)	15%	29%

Flexible energy technologies	2022
Homes with electricity supply (million)	26.2
Domestic heat pumps ('000's)	3199
Domestic heat pumps/1000 homes	122
Heat pumps added/1000 homes	20
Total Battery EV's (000's)	185
Total Battery EV's (% of total fleet)	0.4%
% EV registrations of all new registrations	4%

Enabling technologies	2022
Smart meter penetration	99%

Markets - In 2022, Italian annual renewable production represented 32% of annual consumption compared with 36% in 2021, mainly due to a reduction in hydro output. Solar and wind output increased from 14% to 15% of annual consumption. In its draft 2023 National Energy and Climate Plan update, Italy has forecast annual electricity consumption of 327 TWh in 2030 (slightly higher than current levels) with a target that renewable electricity should supply 49% of this figure. This would require an increase in wind and solar output of 48 TWh.

Flexibility resources - Italy had less than 1% penetration of electric vehicles in 2022, with electric vehicles representing around 4% of all new vehicle registrations, similar to 2021. Heat pump penetration is around 10%. Smart meter penetration is high.

2. Survey

The survey scores for Italy are shown below.

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

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

Market factors		
Regulations	Compensation structures	Transaction costs
3	2	3

Overall, there is a clear policy ambition and pathway towards decarbonisation and phasing out fossil fuels for electricity generation. Overall, the survey scores are lower than last year's survey.

Key points raised by survey participants were:

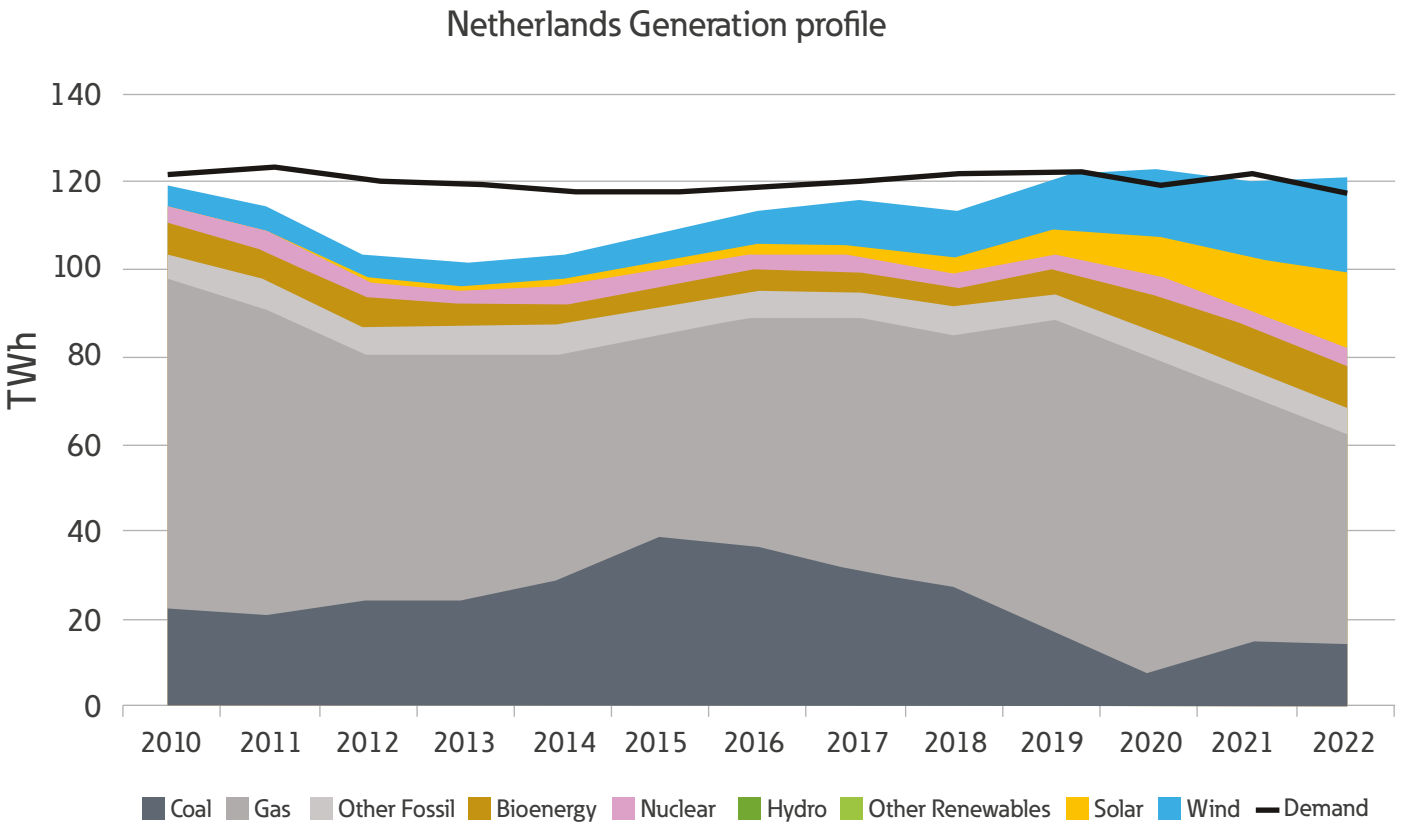
- The change of Government has led to some uncertainty because new policies for the energy transition are being developed and decisions are awaited. The impacts of inflation on cost of living are driving the prioritisation of energy efficiency.
- Grid accessibility is generally good, but gaining planning consents for renewable projects can be challenging. Incentives to encourage EV uptake are limited, resulting in low penetration and V2G is not currently possible.
- Market designs for flexibility resources are under development, with limited access by flexibility resources to date. Market and technical compliance requirements are complex and add additional cost.

Netherlands

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 15: NETHERLANDS GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal and gas. However, gas generation remains a significant proportion of the overall generation mix. In recent years, the Netherlands has become a net exporter of electricity.

TABLE 14: NETHERLANDS MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	117	119
Annual renewable production (TWh)	48	102
Renewable % of annual consumption	41%	86%
Annual solar and wind production (TWh)	38	92
Solar and wind % of annual consumption (TWh)	33%	78%

Flexible energy technologies	2022
Homes with electricity supply (million)	8.0
Domestic heat pumps ('000's)	426
Domestic heat pumps/1000 homes	53
Heat pumps added/1000 homes	16
Total Battery EV's (000's)	342
Total Battery EV's (% of total fleet)	3.4%
% EV registrations of all new registrations	26%

Enabling technologies	2022
Smart meter penetration	85%

Markets - In 2022, the Netherlands annual renewable production (mainly wind and solar) represented 41% of annual consumption, up from 33% in 2021. In its draft 2023 National Energy and Climate Plan update, the Netherlands has targeted 86% of renewable electricity to meet a forecast demand of 119 TWh[18] (similar to current levels). This could require an increase wind and solar output of 54 TWh.

Flexibility resources - the Netherlands had a 3.4% penetration of electric vehicles in 2022, with electric vehicles representing around 26% of all new vehicle registrations, an increase on the previous year. Heat pump penetration is around 4%. Smart meter penetration is high.

2. Survey

The survey scores for the Netherlands 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	4

As with many other countries in the survey, the latest scoring shows ongoing public and political support for the energy transition alongside concerns about inflation and cost of living. Overall, scores are similar to last year's survey.

Key points raised by survey participants were:

- The energy transition remains a high public and political priority with strong ambition but delivery challenges giving rise to some uncertainty. The costs of the transition may not be well understood, nor are there measures in place for fair allocation of these costs.
- Grid infrastructure investment, and access delays, remain a big concern. They present a potentially growing barrier to the integration of renewables and flexibility resources. Electric vehicle deployment is increasing and V2G trials are underway.
- Flexibility markets are considered fair and open. Smaller flexibility resources access the markets through aggregation, but participation is limited. Some concerns that technical requirements may impose additional costs on smaller market participants.

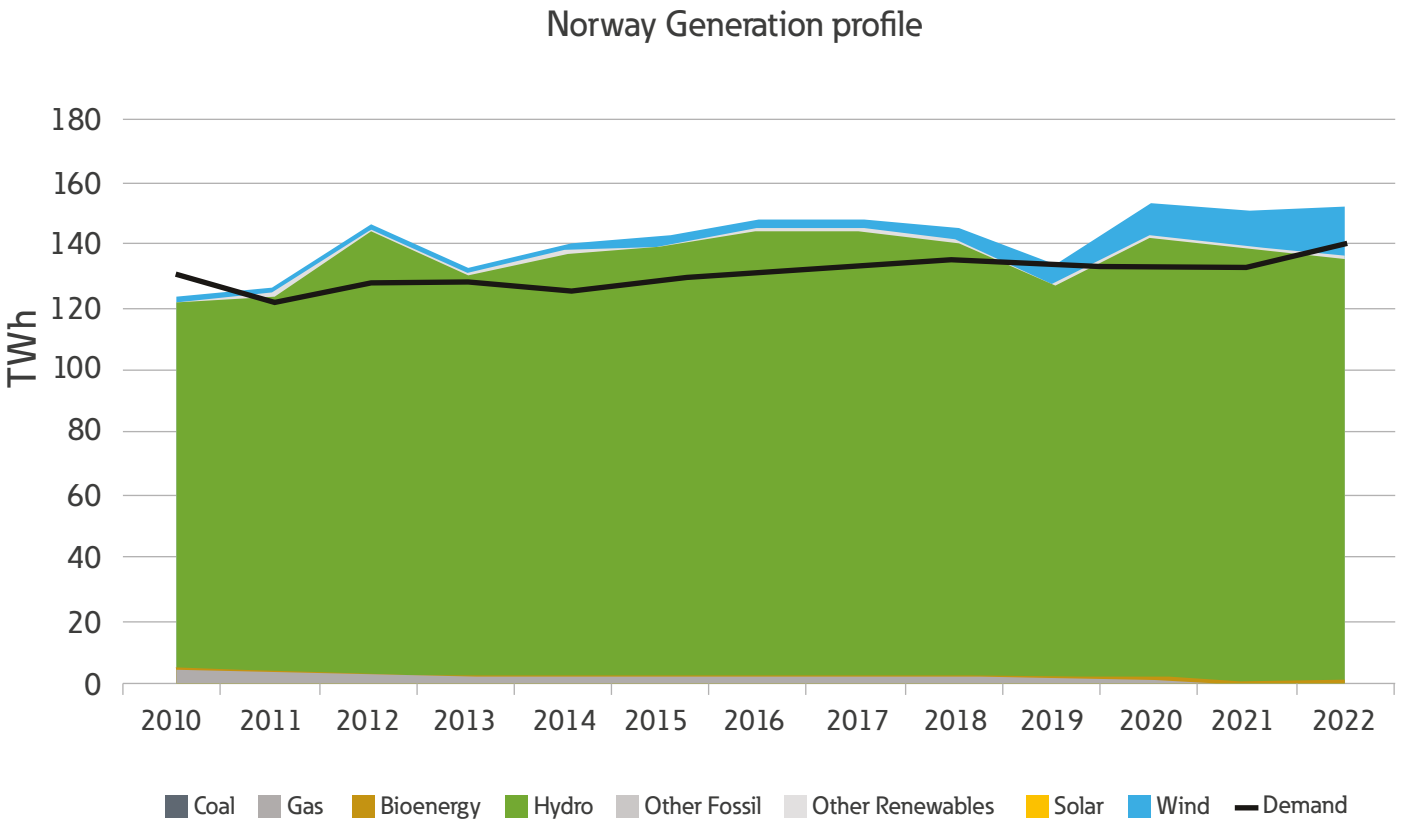
[18]The draft Netherlands NECP update forecasts electricity consumption of 10200ktoe for 2030, which is 119 TWh using the conversion factor of 1ktoe = 11.63 GWh.

Norway

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 16: NORWAY GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the dominance of hydro with growth in wind over the last few years. Norway is a net exporter of electricity.

TABLE 15: NORWAY MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	140	164
Annual renewable production (TWh)	151	177
Renewable % of annual consumption	108%	108%
Annual solar and wind production (TWh)	16	42
Solar and wind % of annual consumption (TWh)	11%	26%

Flexible energy technologies	2022
Homes with electricity supply (million)	2.6
Domestic heat pumps ('000's)	1631
Domestic heat pumps/1000 homes	625
Heat pumps added/1000 homes	58
Total Battery EV's (000's)	534
Total Battery EV's (% of total fleet)	14.9%
% EV registrations of all new registrations	75%

Enabling technologies	2022
Smart meter penetration	98%

Markets - In 2022, Norway generated 11% of annual consumption from solar and wind, up from 8% in 2021. In 2022, total renewable output exceeded domestic consumption. Recent forecasts from Norway's Transmission System Operator, Statnett, show electricity consumption of 157 TWh for 2028[19]. A constant growth rate to 2030 results in 164 TWh of electricity consumption. If Norway maintains its current levels of renewable energy exports, then an additional 26 TWh of wind, hydro or solar electricity output will be required by 2030.

Flexibility resources - Norway has a high level of penetration of electric vehicles, reaching 15% in 2022, and electric vehicles represent 75% of all new vehicle registrations. Heat pump penetration is over 60%. Smart meter penetration is very high.

2. Survey

The survey scores for Norway are shown below.

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

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

Market factors		
Regulations	Compensation structures	Transaction costs
4	5	5

The average survey score has increased slightly from last year's survey, but Norway has consistently been amongst the leaders in previous surveys.

Key points raised by survey participants were:

- Overall, there is a strong and clear policy ambition in support of the energy transition, but affordability issues and the costs of the transition are of increasing concern. There is an increased focus on ensuring that cheap renewable energy is available for use in Norway and so decreasing exposure to price volatility from international electricity markets. There are some concerns about regulatory uncertainty impacting investment.
- 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 for flexibility resources.

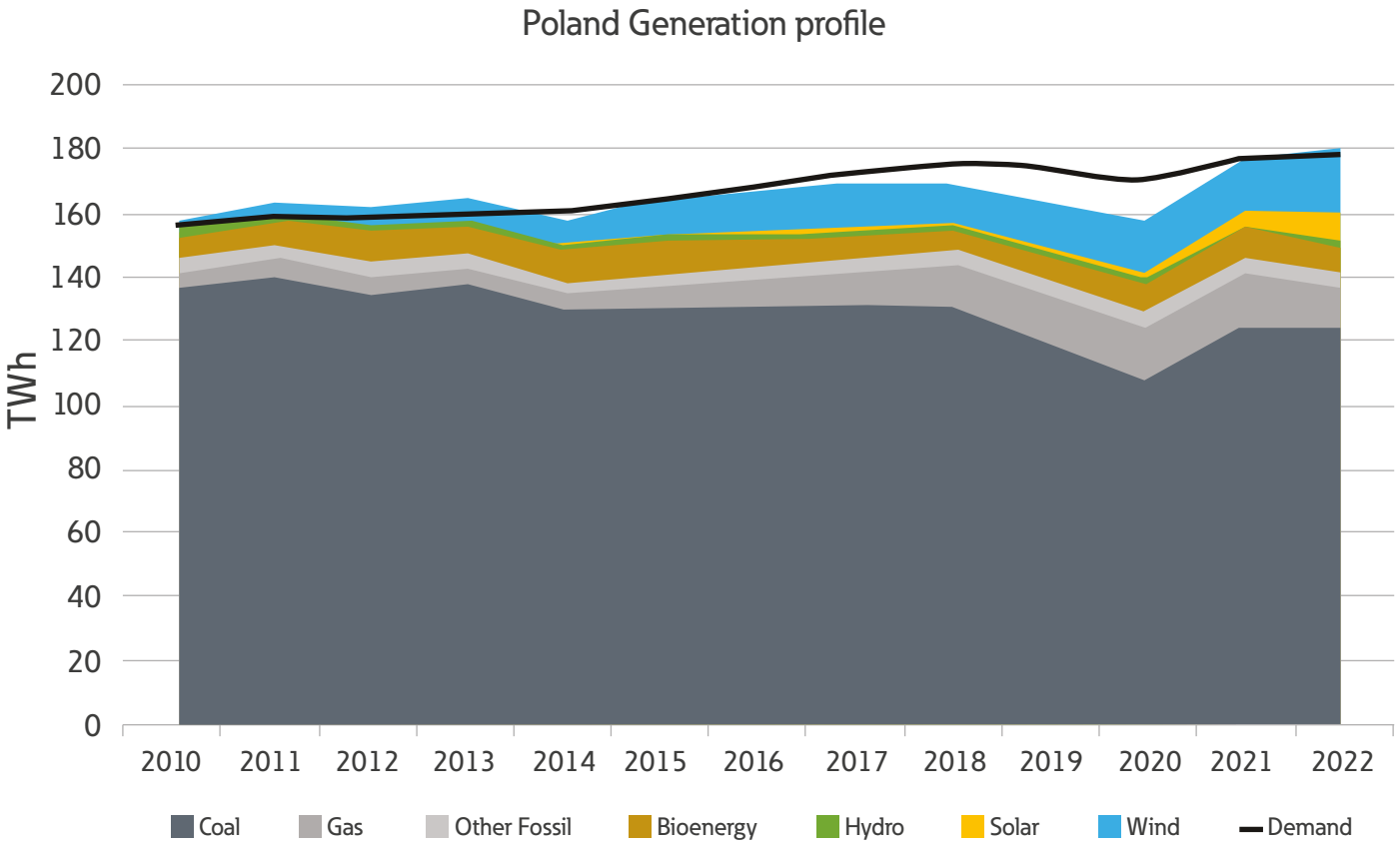
[19]https://www.powersystems.technology/news-pst/us-news/slowed-demand-pushes-norway-s-power-surplus-into-2028-says-statnett.html

Poland

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 17: POLAND GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the gradual decline in coal over the last decade as it is replaced by gas, solar and wind.

TABLE 16: POLAND MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	178	201
Annual renewable production (TWh)	38	64
Renewable % of annual consumption	21%	32%
Annual solar and wind production (TWh)	28	55
Solar and wind % of annual consumption (TWh)	16%	27%

Flexible energy technologies	2022
Homes with electricity supply (million)	16.3
Domestic heat pumps ('000's)	563
Domestic heat pumps/1000 homes	35
Heat pumps added/1000 homes	13
Total Battery EV's (000's)	28
Total Battery EV's (% of total fleet)	0.1%
% EV registrations of all new registrations	4%

Enabling technologies	2022
Smart meter penetration	12%

Markets - In 2022, Poland's annual renewable electricity production was 21% of annual consumption, up from 17% in 2021, due to increased wind and solar. According to the Energy Policy of Poland to 2040[20], Poland's target is for 32% of 2030 electricity consumption to be derived from renewables by 2030. Electricity consumption is forecast to increase by 13% from 2022 to 2030. This could require an increase in wind and solar output of 26 TWh.

Flexibility resources - Poland has low level penetration of electric vehicles, reaching 0.1% in 2022, and electric vehicles represent just 4% of all new vehicle registrations. Heat pump penetration is 3%. Smart meter penetration is low, although it is expected to increase through a national rollout.

2. Survey

The survey scores for Poland are shown below.

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

Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
1	2	2	2

Market factors		
Regulations	Compensation structures	Transaction costs
2	2	2

Overall, the scores reflect that Poland is in the early stages of transitioning from a fossil-fuel dominated electricity sector and is facing challenges in funding the necessary investment. Transition policies and regulation are at early stages of development and implementation.

Key points raised by survey participants were:

- Poland is prioritising other economic policies over the energy transition. The Government has developed ambitious plans for decarbonisation to contribute to EU targets, but the multibillion Euro funding needed to realise the transition from fossil fuels is not available. It is anticipated that agreement will be needed with the EU to provide such funding.
- Grid accessibility is a significant barrier, with little funding available for grid reinforcement investments. Policies and incentives for EVs and EV charging are limited, leading to slow EV rollout. Smart metering penetration is low.
- Market rules have been developed to meet EU requirements but there is little evidence that flexibility resources are able to participate.

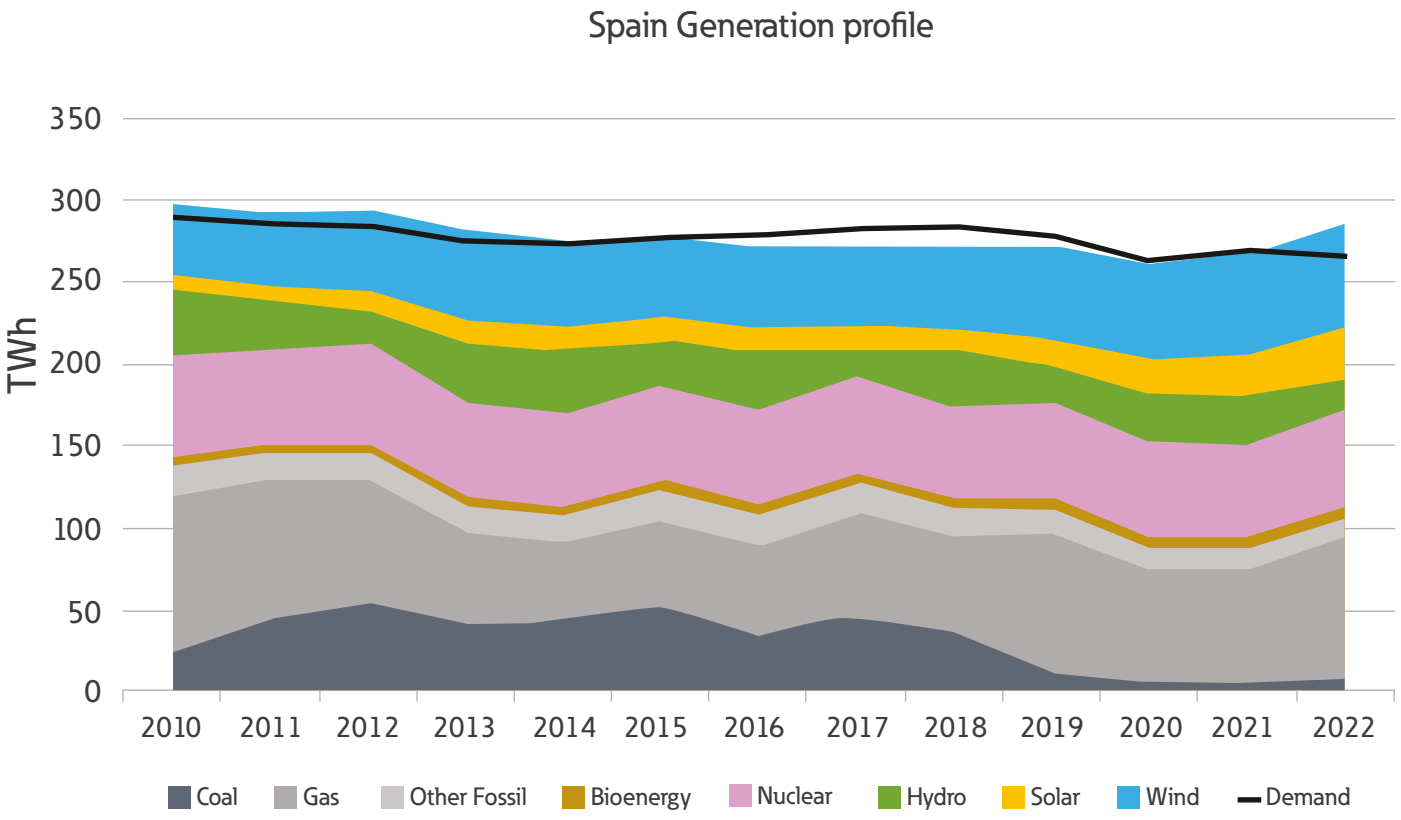
[20]https://www.gov.pl/web/climate/energy-policy-of-poland-until-2040-epp2040

Spain

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 18: SPAIN GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal. In 2022, Spain was a net exporter of electricity.

TABLE 17: SPAIN MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	265	281
Annual renewable production (TWh)	120	228
Renewable % of annual consumption	45%	81%
Annual solar and wind production (TWh)	95	191
Solar and wind % of annual consumption (TWh)	36%	68%

Flexible energy technologies	2022
Homes with electricity supply (million)	25.8
Domestic heat pumps ('000's)	1264
Domestic heat pumps/1000 homes	49
Heat pumps added/1000 homes	6
Total Battery EV's (000's)	118
Total Battery EV's (% of total fleet)	0.4%
% EV registrations of all new registrations	5%

Enabling technologies	2022
Smart meter penetration	100%

Markets - In 2022, Spain's annual renewable production represented 45% of annual consumption, very similar to the previous year. Solar and wind comprised 36% of annual consumption. In its draft 2023 National Energy and Climate Plan update, Spain has targeted 81% of renewable electricity to meet a forecast demand of 281 TWh (slightly higher than current levels). This could require an increase in wind and solar output of 96 TWh.

Flexibility resources - Spain had less than 1% penetration of electric vehicles in 2022, with electric vehicles representing around 4% of all new vehicle registrations. Heat pump penetration is around 5%. Smart meter penetration is high.

2. Survey

The survey scores for Spain are shown below.

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

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

Market factors		
Regulations	Compensation structures	Transaction costs
3	3	2

Overall, there is a good support for the energy transition but some concerns about implementation. Concerns about the affordability of energy following the energy crisis appear to have been overtaken by concerns about climate change given the impact of exceptionally high temperatures over the last year. Overall, the average survey score is similar to last year's survey.

Key points raised by survey participants were:

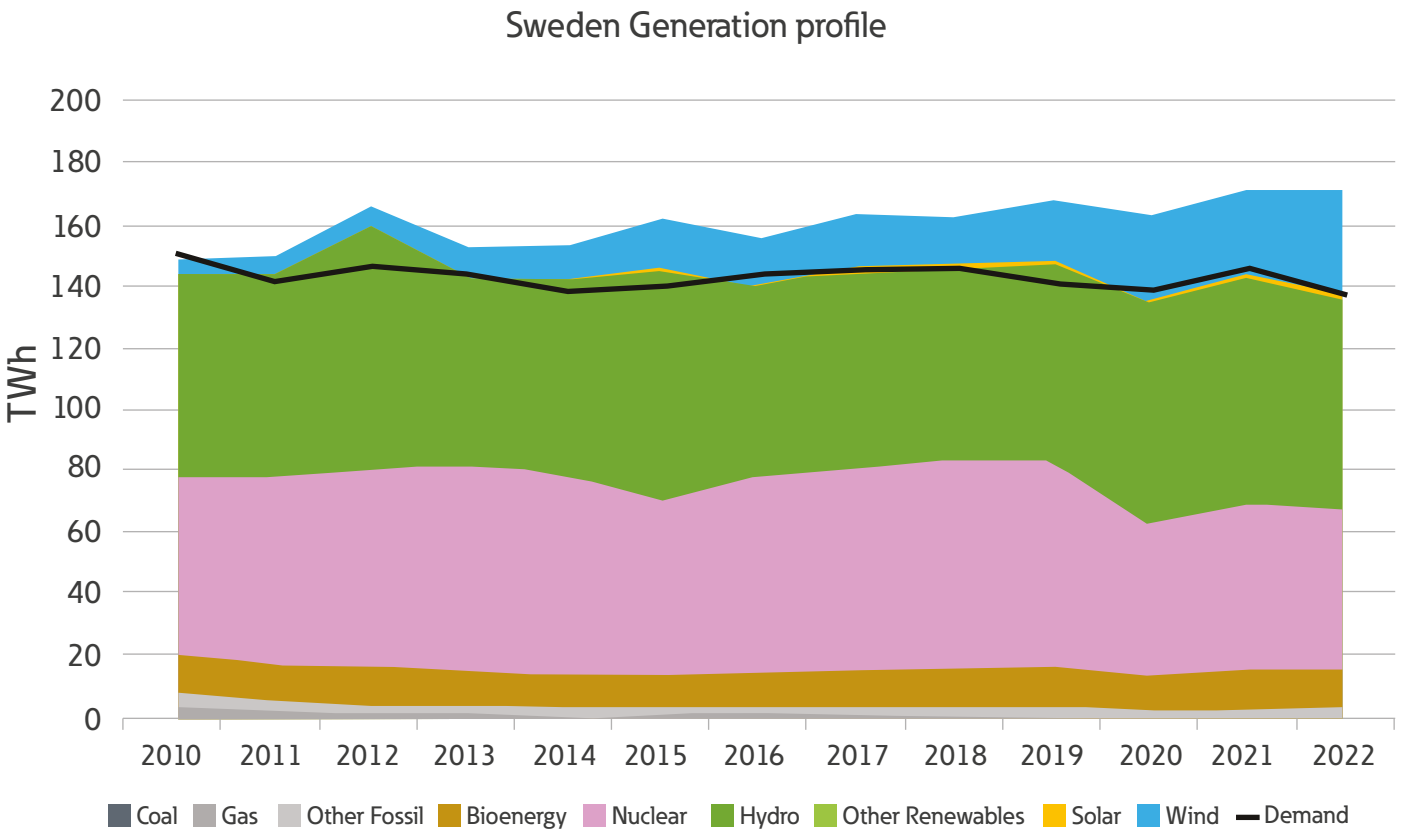
- The consensus for policies to address the energy transition seems to have strengthened in the face of extreme climate events. However, the implementation of policy and regulatory change can be slow.
- Grid accessibility is considered weak and additional investment is needed to enable access by flexibility resources. Policies to encourage EV rollout are having limited effect, with EV growth remaining slow.
- While market rules are in place to allow access by flexible technologies, complex access requirements mean that market participation by new technologies and market participants in limited.

Sweden

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 19: SWEDEN GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the dominance of hydro and nuclear, together with growth in wind over the last decade. Sweden is a net exporter of electricity.

TABLE 18: SWEDEN MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	138	190
Annual renewable production (TWh)	117	167
Renewable % of annual consumption	85%	88%
Annual solar and wind production (TWh)	36	80
Solar and wind % of annual consumption (TWh)	26%	42%

Flexible energy technologies	2022
Homes with electricity supply (million)	4.8
Domestic heat pumps ('000's)	2403
Domestic heat pumps/1000 homes	503
Heat pumps added/1000 homes	45
Total Battery EV's (000's)	224
Total Battery EV's (% of total fleet)	4.0%
% EV registrations of all new registrations	35%

Enabling technologies	2022
Smart meter penetration	100%

Markets - In 2022, Sweden's annual renewable production represented 85% of annual consumption up from 79% in 2021. Most renewables were hydro, with 26% derived from solar and wind. In its draft 2023 National Energy and Climate Plan update, Sweden has targeted 88% of renewable electricity to meet a forecast demand of 190 TWh. This could require an increase in wind and solar output of 44 TWh.

Flexibility resources - Sweden had a 4% penetration of electric vehicles in 2022, but with electric vehicles representing 35% of all new vehicle registrations, an increase on 2021. Heat pump penetration is 50%. Smart meter penetration is high.

2. Survey

The 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	5	4

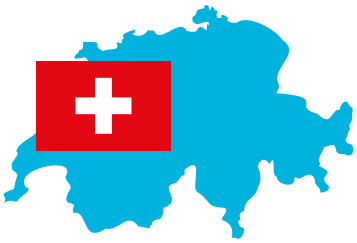
Technology factors			
Grid Accessibility	EV Infrastructure and EV charging	Digital technology enablers	Innovation
4	4	5	3

Market factors		
Regulations	Compensation structures	Transaction costs
4	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 transition compared to other countries. Overall, scores remain similar to last year's survey.

Key points raised by survey participants were:

- 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.

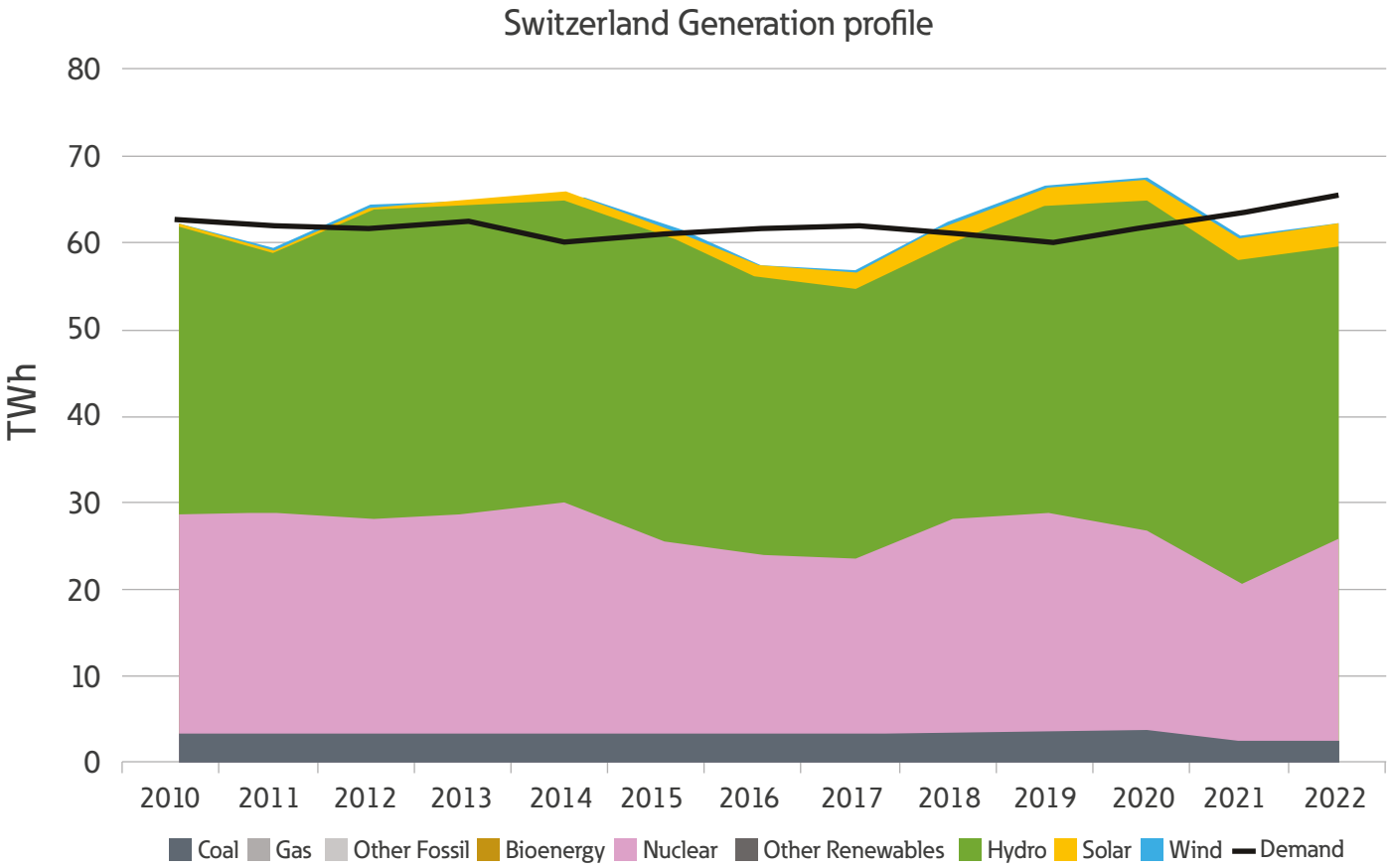


Switzerland

1. Energy characteristics

The chart and table summarise the key electricity sector characteristics.

CHART 20: SWITZERLAND GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the dominance of hydro and nuclear, accompanied by some growth in solar over the last few years. Switzerland was a net importer of electricity in 2022.

TABLE 19: SWITZERLAND MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	65	70
Annual renewable production (TWh)	37	42
Renewable % of annual consumption	57%	60%
Annual solar and wind production (TWh)	3	8
Solar and wind % of annual consumption (TWh)	4%	11%

Flexible energy technologies	2022
Homes with electricity supply (million)	4.6
Domestic heat pumps ('000's)	435
Domestic heat pumps/1000 homes	95
Heat pumps added/1000 homes	9
Total Battery EV's (000's)	128
Total Battery EV's (% of total fleet)	2.5%
% EV registrations of all new registrations	18%

Enabling technologies	2022
Smart meter penetration	20%

Markets - In 2022, Switzerland's annual renewable production (mainly hydro and solar) represented 57% of annual consumption. Annual consumption growth of 1% per annum is estimated to 2030, with additional consumption assumed to be met by renewables. This could require on increase in wind and solar output by 5 TWh by 2030, with renewables representing 60% of total consumption.

Flexibility resources - Switzerland had 2.5% penetration of electric vehicles in 2021, with electric vehicles representing around 18% of all new vehicle registrations. Heat pump penetration is 10%. Smart meter penetration is low.

2. Survey

The survey scores for Switzerland are shown below.

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

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

Market factors		
Regulations	Compensation structures	Transaction costs
2	4	3

Switzerland already has a highly decarbonised electricity system. Switzerland is aligning with EU approaches, including market design and delivery of change. Scores should be higher as a result, but regional governance structures in Switzerland mean that the pace of implementing reform varies, limiting the scope and pace of the transition. Overall, scores remain similar to last year's survey.

Key points raised by survey participants were:

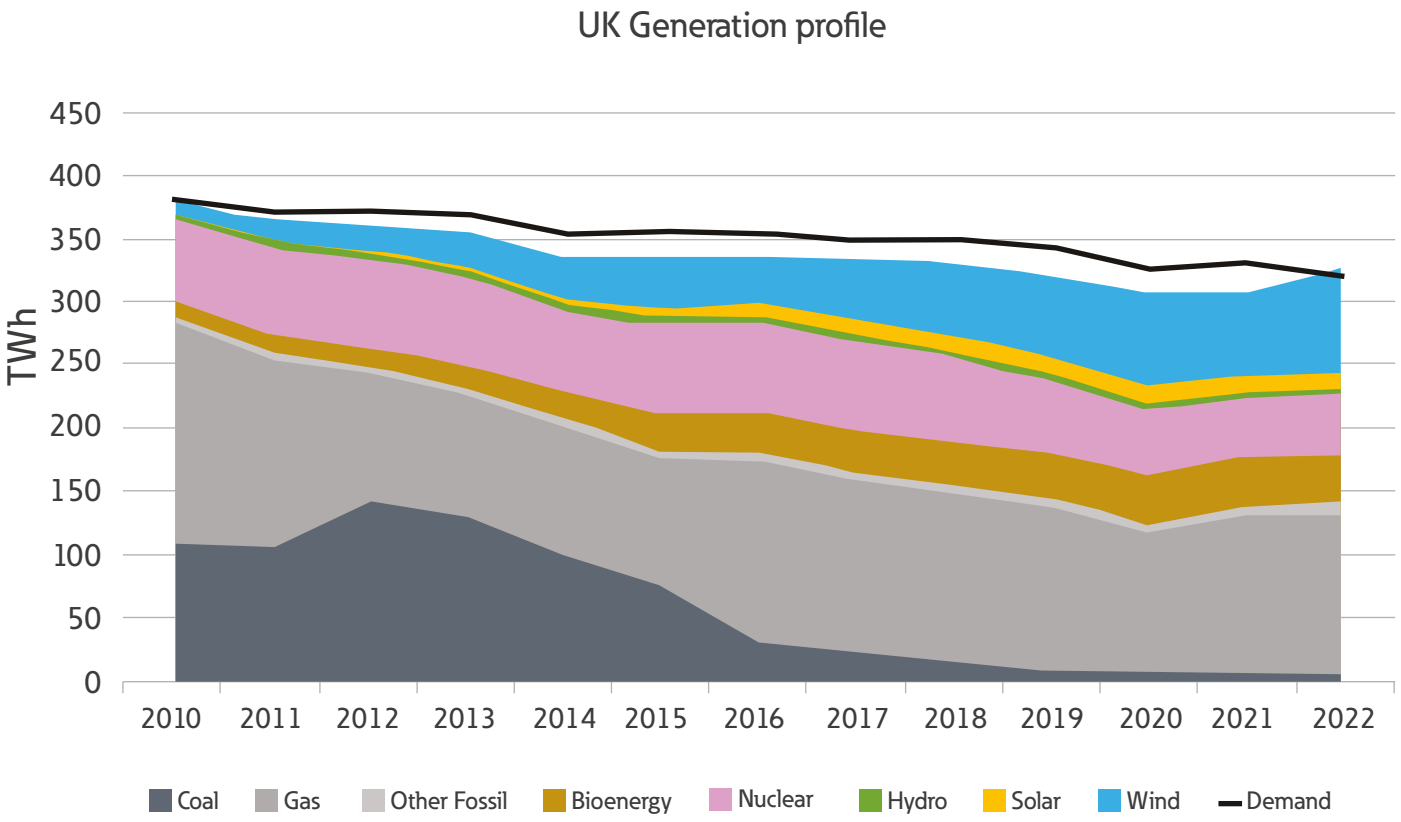
- Energy transition goals and policy are in place, but the regional governance structure of Switzerland means there is less co-ordination of policy delivery than would be desirable. As a result, the policy and regulatory environment is uncertain.
- Overall, the grid is strong and can accommodate bi-directional flows, but V2G has yet to be widely rolled out. Digital enablers are limited by low smart meter penetration. Metering and communications standards are 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 chart and table summarise the key electricity sector characteristics.

CHART 21: UK GENERATION PROFILE



The chart shows the historic profile of generation output by fuel type between 2010 and 2022. It shows the growth of wind and solar generation over the last decade, accompanied by a reduction in coal. In 2022, the UK became a net exporter of electricity.

TABLE 20: UK MARKET CHARACTERISTICS

Electricity markets	2022 actual	2030 estimate
Annual consumption (TWh)	321	369
Annual renewable production (TWh)	135	267
Renewable % of annual consumption	42%	82%
Annual solar and wind production (TWh)	94	226
Solar and wind % of annual consumption (TWh)	29%	61%

Flexible energy technologies	2022
Homes with electricity supply (million)	28.0
Domestic heat pumps ('000's)	381
Domestic heat pumps/1000 homes	11
Heat pumps added/1000 homes	2
Total Battery EV's (000's)	664
Total Battery EV's (% of total fleet)	1.8%
% EV registrations of all new registrations	14%

Enabling technologies	2022
Smart meter penetration	55%

Markets - In 2022, UK annual renewable production represented 42% of annual consumption, up from 37% in 2021. Solar and wind represented 29% of annual consumption. The UK Government's Energy Security Strategy targeted that 95% of electricity consumption could be low carbon by 2030[21]. Using the Electricity System Operator's electricity consumption forecast[22] of 369 TWh for 2030 together with unchanged nuclear and biomass output, meeting this target could require an increase in wind and solar output of 132TWh.

Flexibility resources - the UK had about 2% penetration of electric vehicles in 2022, and electric vehicles represent around 14% of all new vehicle registrations. Heat pump penetration is 1%. Smart meter rollout is 55% complete.

2. Survey

The survey scores and comments for the UK are shown below.

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

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	4	4

The UK has set ambitious decarbonisation goals for 2030 and beyond. While recent policy announcements appear focused on short-term political imperatives, future investment attractiveness remains strong. Overall, 2023 scores show a slight increase over last year's survey. Since the survey started four years ago, the UK has one of the greatest improvements. Overall scores for 2023 are around 15% higher than the historic survey average for the UK.

Key points raised by survey participants were:

- Managing the high cost of living crisis is a political priority and there appears to be a decline in confidence about the public acceptability of the costs involved in the energy transition.
- Despite ambitious targets, implementation policies are 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 a critical issue, and obtaining planning consents can be slow, but initiatives to address these issues are underway. Policies to encourage EV uptake are encouraging a steady rollout of EV's and charging infrastructure. Domestic smart meter rollout is progressing and has passed 55%.
- Flexibility markets are increasingly opening for distributed flexibility technologies, but some access barriers e.g., IT systems, remain. There is growth in demand-side flexibility resources used to alleviate grid congestion as an alternative to long-term network investment needs.

[21] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1069969/british-energy-security-strategy-web-accessible.pdf

[22] 2023 Leading the way scenario https://www.nationalgrideso.com/future-energy/future-energy-scenarios

Appendix B - Detailed scorecards

SOCIO-POLITICAL FACTORS

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

TECHNOLOGY FACTORS

	Grid Accessibility	EV Infrastructure and EV charging	Digital techno-logy enablers	Innova-tion	Average
Denmark	4	4	5	5	4
Finland	4	4	5	3	4
France	4	4	4	3	4
Germany	3	4	3	4	3
Greece	2	2	2	2	2
Ireland	4	4	4	3	3
Italy	4	2	4	2	3
Netherlands	3	4	4	4	4
Norway	4	5	5	5	5
Poland	1	2	2	2	2
Spain	2	3	3	2	3
Sweden	4	4	5	3	4
Switzerland	3	3	2	3	3
UK	3	3	3	4	3

MARKET FACTORS

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

Notes

Notes

ENERGY TRANSITION READINESS INDEX

2023

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

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EATON
Powering Business Worldwide

Foresight

REA

For further information please contact:

info@r-e-a.net

www.r-e-a.net