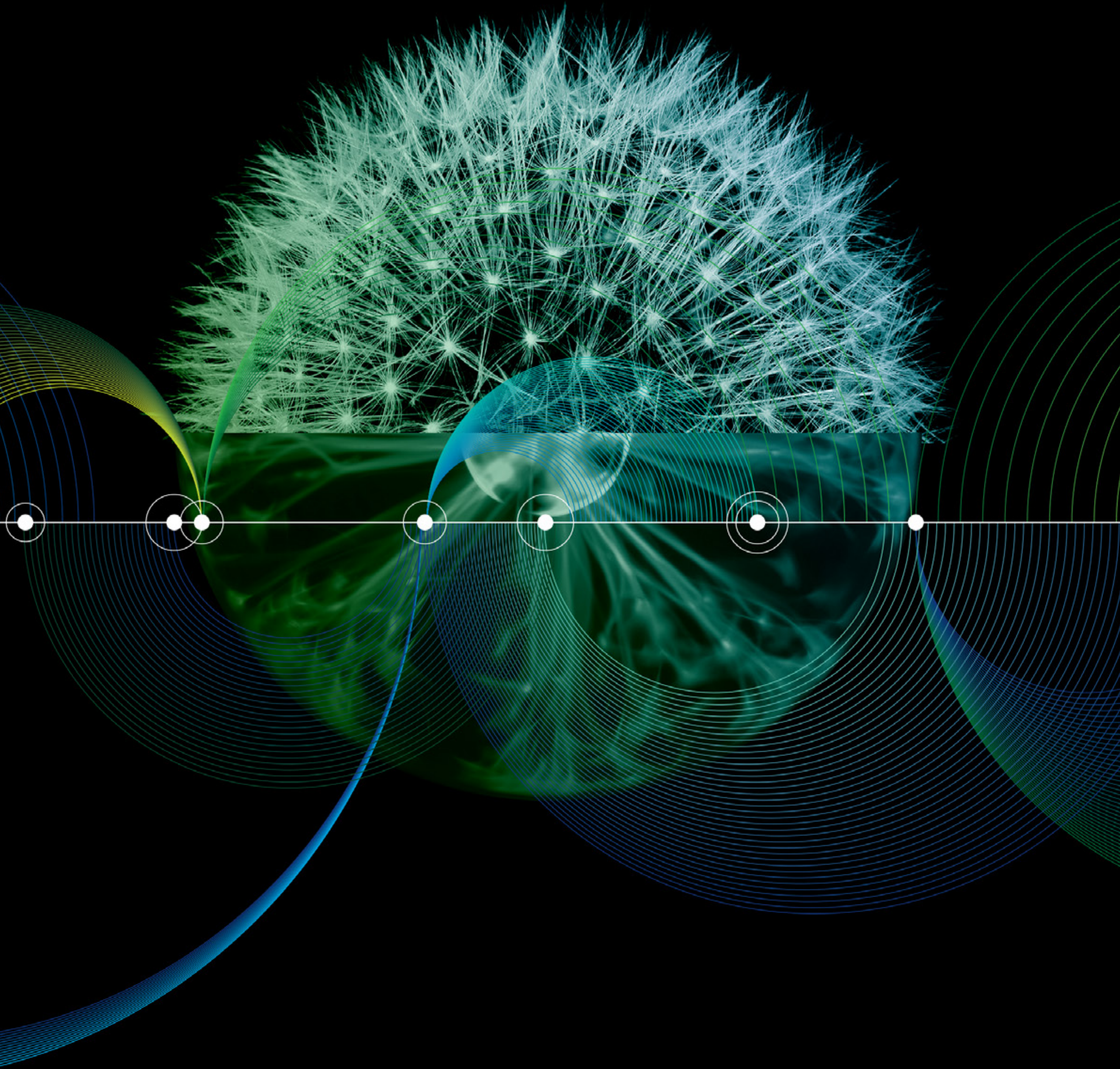


# The future of power is growth

MAKING AN IMPACT THAT MATTERS since 1845

# The classic utility is back

The proposed European climate law stipulates a clear objective: climate neutrality in the European Union's (EU) economy and society by 2050. On top of that, national climate neutrality targets have put most of the member states on the path to energy transition. This transition requires massive investments in low-emission energy supply technologies and the electrification of the European energy system. These have to cover new renewable generation capacities as well as the reinforcement of the European power grid and the decommissioning of carbon-intensive assets.

Since the 2010s, many utilities have been pursuing asset-light strategies based on network operations, market services, and retail business, without necessarily disposing of the generation assets[1]. This strategic change is in contrast with what had been the primary business model for decades: planning energy systems and long-term investments in generation and network assets. Although, in a decentralized energy system, energy services such as consumer-side optimization can gain high interest, the ambitious climate targets are going to revive the traditional organization of the European utilities based on long-term investments. These investments require recognizing the risks and understanding the future energy structure in which the companies will compete.

Derived from Deloitte's scenario-based modelling approach, this report unpacks the future low-carbon power system in Europe up to 2050, putting the challenges and risks that utilities face into perspective, and providing suggestions on how to revive the asset-intensive business model and make it future proof.

Furthermore, the report sets out to initiate a discussion with market participants regarding their strategic choices by firstly, qualitatively anticipating the future scenarios for the entire power system and secondly, enriching these scenarios with a quantitative European market model (Deloitte European Electricity Model (DEEM), while creating a common European narrative, curated by a team of Deloitte subject matter experts who are part of the Energy and Resources practise in Europe.

The European energy transition requires significant investments in renewable generation capacities, reinforcement of the European power grid and closure of carbon-intensive assets.

[1] IEA, *Changing utility business models and electricity investment*, 15.12.2017, accessed: 15.04.2021.

# Study design

The future is unknown, with many uncertainties such as technology cost development, electrification, political commitment and cohesion as well as the behavioral aspects of society. Thus, no single scenario can predict the future European power system. However, exploration of different plausible futures can highlight the strategic choices that power utilities may have and illustrate how the course of the power sector might be affected by changing some of the key variables that policy-makers and industry leaders control.

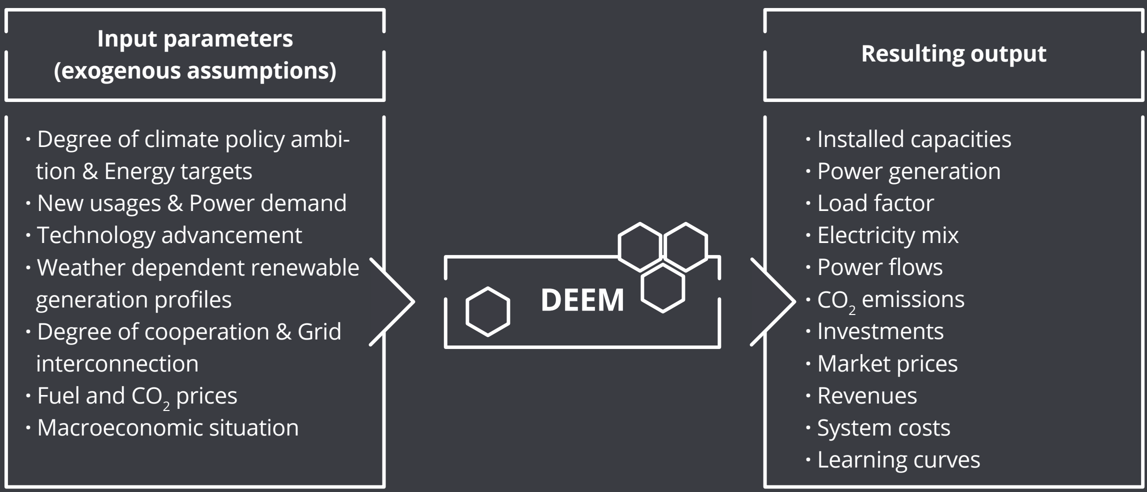
In this study, Deloitte has identified the main economic, policy, technological, social, and environmental trends. These trends are grouped by relative importance and level of uncertainty. Some relevant trends feature in all scenarios, such as cost-efficiency of renewables, prevalence of externality taxes etc. The relevant but uncertain trends, though, define differences between the future scenarios, like investments into the network structure, political coordination and ambition among different European states, electrification of different end-use demands, and the regulatory push for the energy transition overall. These trends are condensed into two defining axes: degree of electrification and determination of energy policy.

The resulting scenarios 1) Happy EU-lectrons, 2) United in Tech-Diversity, 3) Two Steps Forward, One Step Back and 4) Green Lone Wolves reflect a set of different but equally consistent trends and assumptions and hence, each represent a plausible future for the European power system.

Furthermore, these scenarios are quantitatively assessed using DEEM: a model that optimizes both investment in new power generation capacity (and the required flexibility) and the operation of each technology, taking into account hourly variability of renewables and electricity demand. The power market is modelled based on marginal pricing of each technology and the merit-order prioritization of different technologies, taking into consideration the technical and operational constraints of each technology and weather dependence of renewables. The key assumptions used as input parameters in DEEM and the resulting outputs of this model are presented in table 1.

Europe has been divided into four regions for modelling purposes: West, Central, Nordics and Iberia. West consists of France, Germany, Italy, Switzerland, Denmark, Netherlands, Belgium and Luxembourg. Iberia consists of Spain and Portugal. Sweden, Norway and Finland together, form Nordics. All the remaining countries in the EU27 are grouped in Central Europe, except Ireland and Cyprus which are not explicitly modelled in this study.

**Tab. 1 – Key inputs and outputs of DEEM (non-exhaustive)**



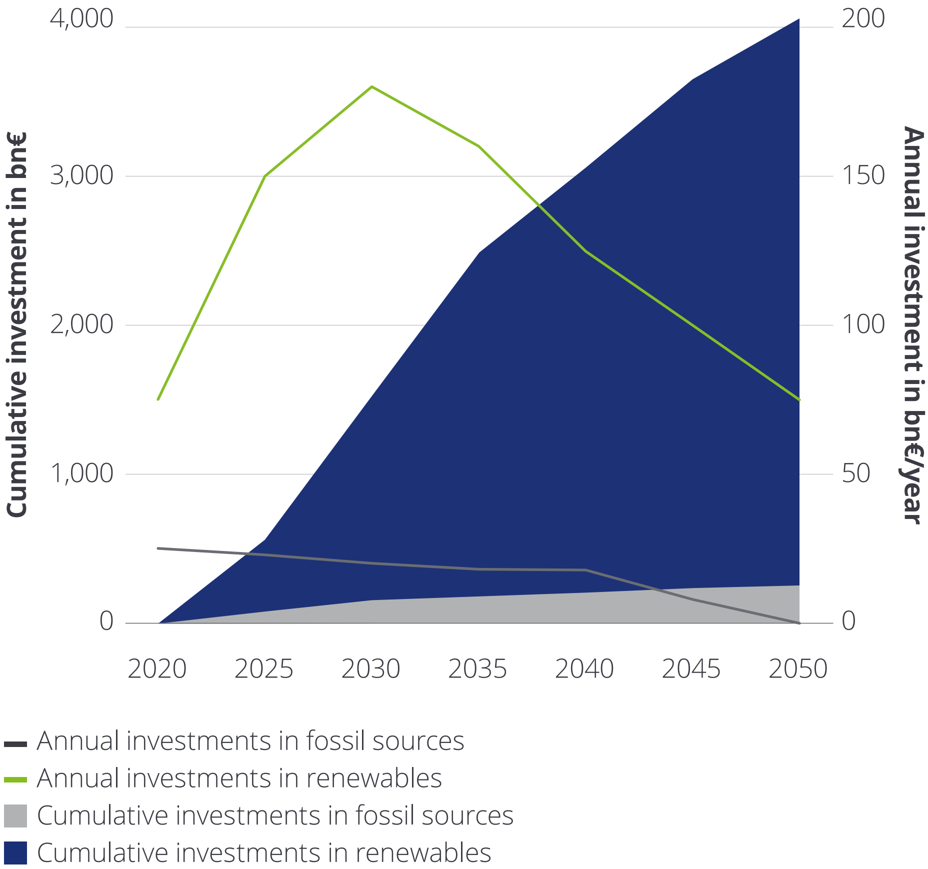

Source: Deloitte analysis.

# Growth all over

Energy transition is often seen as synonymous with high renewable energy deployment in power systems[2]. Accordingly, low-carbon energy supply targets and short development timelines create tremendous headroom for renewables asset growth, especially in a highly electrified world[3], underpinned by important policy support such as the European Green Deal. When modelling such a world , cumulative investments of nearly €4 trillion are needed in renewables by 2050, in order to provide more than 90 percent of installed electricity generation capacity in Europe (figure 1).

Although the capacity expansion of renewables follows a highly dynamic pathway, from the 2030s on, annual investment spending decreases. This is due to the combined effect of the falling cost of renewable generation technologies and the increased technology supply volume[4]. From an investment perspective, offshore and onshore wind will attract the highest investments (over €70 billion/year and €45 billion/year by the late 2020s) with annual average growth of 19 percent and 12 percent, respectively, between 2020 and 2050, followed by solar power (€40 billion/year by the late 2020s) with annual growth of 10 percent over the same period (figure 2.a). Figure 2.b shows the growth in renewable generation capacity. Renewable capacity increase is led by solar power (from 280 GW in 2025 up to 860 GW of installed capacity by 2050), followed by onshore and offshore wind power (from 200 GW and 20 GW in 2025 up to 580 GW and 350 GW of installed capacity by 2050, respectively). This divergence between spending and capacity growth of the renewable energy sources can be explained by comparing the investment costs of these technologies. Solar power has lower investment costs per unit of installed capacity compared to wind power technologies, especially compared to offshore wind. Thus, the required investments in wind power technologies are higher than the required investments in solar photovoltaic (PV), despite less installed capacity.

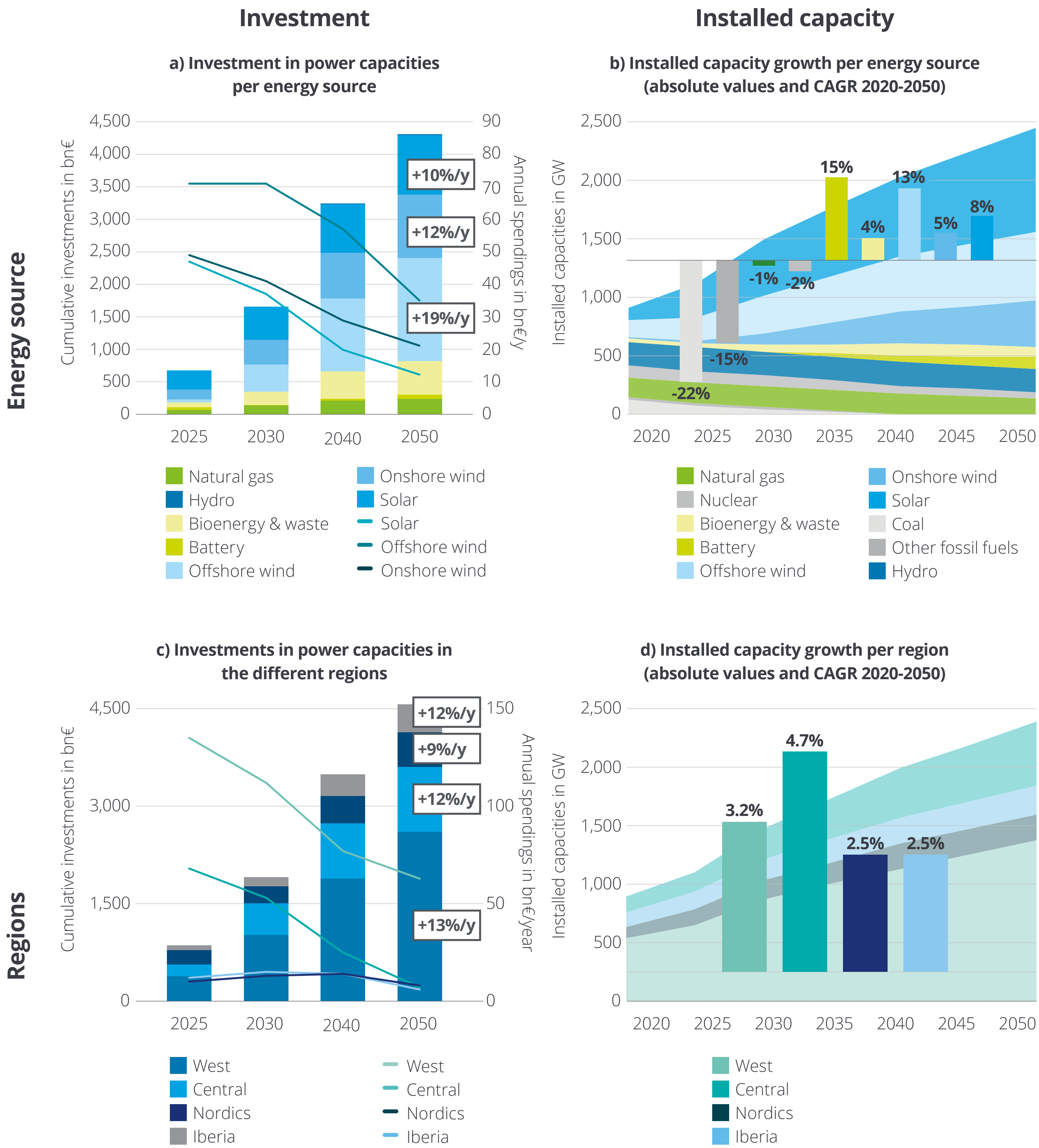
**Fig. 1 – Yearly (line) and cumulative (area) investments in renewables (green) and fossil (grey) energy supply technologies between 2020 and 2050**




Source: Deloitte analysis; Deloitte European Electricity Model (DEEM) .

[2] This transition pathway corresponds to the Happy EU-lectrons scenario in this scenario-based analysis, which will be presented in detail in the following.
[3] Later on, this scenario is called „Happy EU-lectrons".
[4] The volume effect: Unit fixed costs will reduce with increases in sales volume because the units are increasing while the total fixed cost of production units remains the same.

**Fig. 2 – Investment and installed power capacity growth per technology and per region**




Source: DEEM scenario-based modelling results.

The growth in renewable energy investments is led by Western Europe with annual growth of 12.5 percent in the period from 2020 to 2050, followed by Central Europe (with annual growth of 11.6 percent in the same period – figure 2.c). However, the installed capacity of renewables grows fastest in Central European countries (4.7%/year) between 2020 and 2050, followed by Western Europe (3.2%/year in the same period – figure 2.d).

If the ambitious climate goals are to be achieved, the next decade needs to be a growth catalyst. The investment timeline and the annual spending shown in figures 1 and 2 highlight the necessity of early efforts and investments in the power system, especially in renewables. Such high capacity growth requires a huge pipeline of projects, space, equipment, manpower and, last but not least, social acceptance. For instance, by 2050, installed and operational capacities of variable renewables in a highly electrified Europe would represent around 8,000 $km^2$ of surface for solar power and up to 70,000 offshore and 250,000 onshore wind turbines. For wind alone, this translates into a significant project pipeline of projects to arrive at the roughly needed 1,000 offshore and 7,000 onshore wind parks that Europe will have to operate. This ambitious renewable world is highly resource-intensive and requires consumer-side adaptation and enhanced technologies (digitalization, seasonal storage and advanced demand and weather forecasting) to manage the variability of both renewable generation and electricity demand. The significant development of renewables and required flexibility for their integration in power systems require large amounts of raw materials, especially cobalt, lithium, copper, and silver[5]. Similarly, in a highly renewable-intensive world, consumer-side efforts and demand-side management activities will gain in importance in addition to supply-side flexibility options such as thermal plants and storage options, since the gap between peak consumption and peak production needs to be reduced[6].

[5] Watari Takuma et al: *„Total material requirement for the global energy transition to 2050: A focuson transport and electricity"*, in: Resources, Conservation and Recycling, 23.05.2019, p. 91.

[6] European Parliament, *Decentralised Energy Systems*, June 2010, accessed: 15.04.2021.

# Certain, but uncertain

A highly electrified and unified European power market, i.e., the Happy EU-lectrons scenario, is a fascinating vision for many. However, this future may not necessarily be the most likely, nor the most desirable one. Our approach suggests three equally plausible scenarios that differ in terms of technology choice and determination of European energy policy. Figure 3 presents the narratives of these scenarios and their main characteristics.

All low-carbon technologies grow. However, renewables are the main growth segment.

**Fig. 3 – Identified scenarios of the future European power system**

All-encompassing

**Green Lone Wolves**

In this world, the EU has been challenged by draining economic conflicts which led to diverging interests and political stalemate. This urged governments to refocus on national competitiveness. National decarbonization programs resulted in high, yet heterogeneous, levels of sector coupling in the individual states. Fueled by public support schemes, consolidated national renewable energy champions were created to drive more efficient electricity generation and storage technologies. Customer involvement is rather low, demand flexibility and energy efficiency efforts are not deployed at scale. Due to a lack of political alignment, European markets are insufficiently integrated and only isolated initiatives remunerating capacity adequacy exist. All-in-all, this uncoordinated and superficial approach to the energy transition led to a medium degree of electrification and delays to reduce emissions resulting in the EU missing the 2050 climate goals slightly.

**Happy EU-lectrons**

In this world, the EU's COVID-19 recovery fund formed the basis for an increasing European integration which ushered in a period of stable economic growth and pinpointed EU-wide investments into the energy transition. Driven by EU stimulus, sector coupling has been successful. Public and private investments into renewable energy technologies and smart infrastructure have brought down the cost for these technologies, which led to a widespread adoption of renewables as an energy source for electricity generation and green hydrogen production. Political consensus and customer involvement in providing flexibility from the demand-side has enhanced the coordination across the European power grid. On the market side, incentives for the supply of energy, capacity and system services are established. All-in-all, this concerted European effort led to the Union meeting the 2050 climate goals.

Reactive, unaligned, patchwork ← Determination & implementation of energy policies → Harmonized grassroots-driven, unified

Degree of electrification

**Two Steps Forward, One Step Back**

In this world, the EU has been plunged into a succession of political and economic crises. National interests, influenced by lobbying and foreign powers, and lack of economic resources have turned the European Green Deal into a political gridlock. Without central support for the energy transition, member states keep their supply chains based on fossil fuels and imported power. Some countries are forced to fall back on conventional energy generation to secure base load power. CCS technologies have reduced carbon emissions. The European power market remains fragmented, with few incentives for supplying flexibility or ensuring capacity adequacy. There is a timid development in the clean energy transition, driven by a "coalition of the willing", key technologies are increasingly coming from abroad, where political stability has catalyzed R&D. All-in-all, the lack of European unison has resulted in the EU failing to meet the 2050 climate goals.

**United in Tech-Diversity**

In this world, the increasing pressure from geopolitical tensions has pulled the EU closer together. The Union is prioritizing energy security and has undertaken significant measures to increase self-sufficiency in energy. As a result, there is lively competition between energy technologies and primary energy carriers. Next to renewables, technologies in the areas of hydrogen (green and blue), nuclear power, biofuels, new synthetic fuels, carbon capture and energy efficiency have been advanced and deployed following significant investment. Power grids have developed to support electrification and energy efficiency. Customer involvement and novel tech solutions enable the supply of flexibility from the demand side. All-in-all, the EU has managed to meet the 2050 climate goals by investing into a variety of different technologies.

Significant

Source: Deloitte analysis.

The Happy EU-lectrons scenario is associated with a massive increase in the interconnection capacities (more than three times the 2018 levels). Rapid electric vehicle roll-out, significant green hydrogen production and ambitious $CO_2$ pricing are the main characteristics of this scenario. The second scenario, United in Tech-Diversity, is based on strong political determination but less electrification and lower renewable deployment, keeping a diversified power supply mix. The Green Lone Wolves scenario is based on national competitiveness and, therefore, national policy heterogeneity in Europe. This scenario, keeping a high share of renewables and significant electrification, is less efficient than the previous scenarios, which are based on a continent-wide cooperative political determination. Finally, the Two Steps Forward, One Step Back scenario is the one with the least political determination, where clean energy growth is limited because of lack of economic resources and a unified political will.

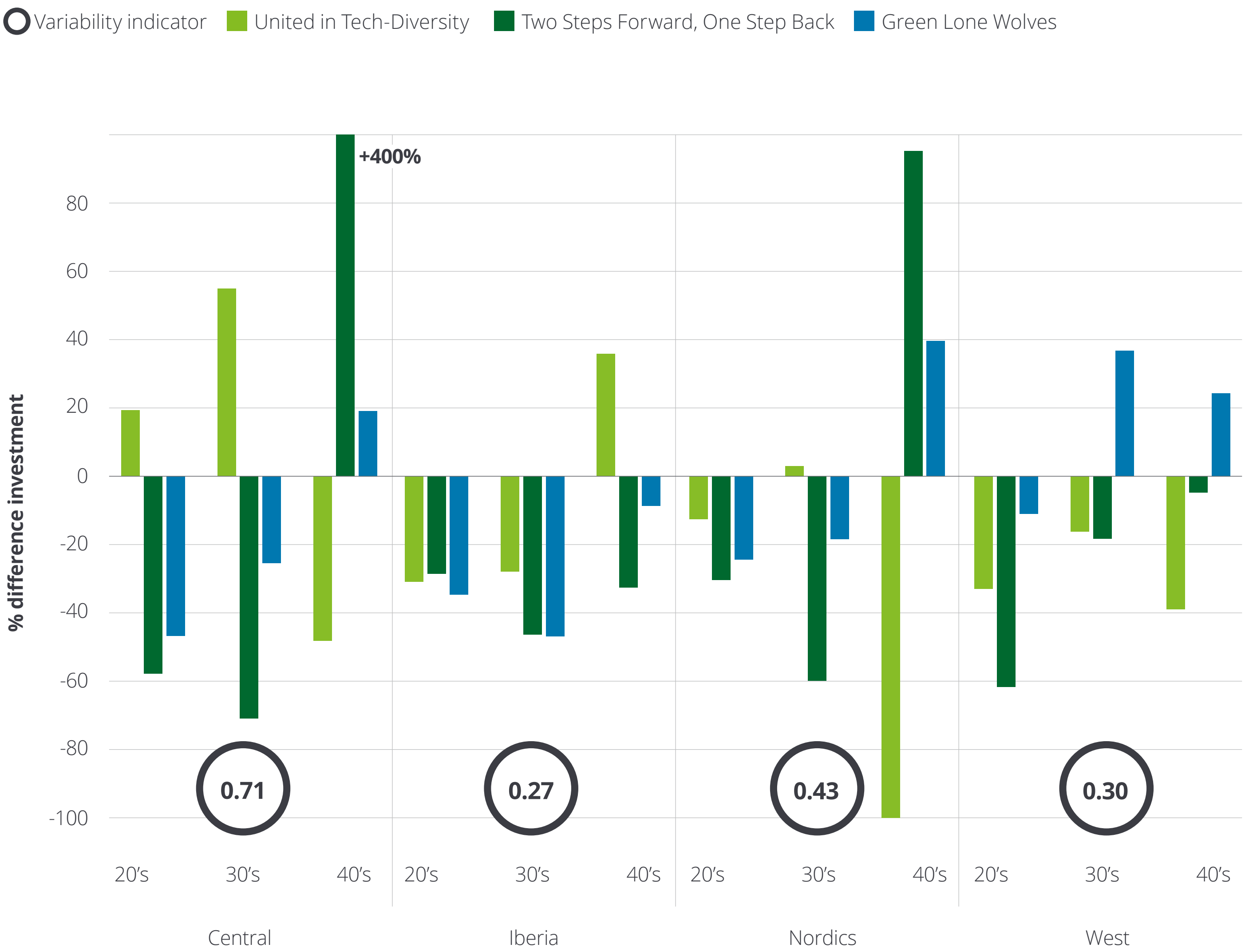
When modelling these different scenarios, clean energy sources provide 94 percent of the electricity mix in the Happy EU-lectrons scenario (87% renewables and 7% nuclear power), leading to a carbon intensity of around 25 $gCO_2$/kWh by 2050 (vs. 320 $gCO_2$/kWh in 2018). Thus, this scenario is consistent with pathways towards meeting the Paris Agreement. Compared to this scenario, the United in Tech-Diversity scenario consists of a higher nuclear share in the power mix (15%) but lower renewable deployment (64%). Thanks to the deployment of the carbon capture and storage (CCS) with natural gas, carbon intensity of the electricity supply remains at the same level as in the Happy EU-lectrons scenario. The Green Lone Wolves scenario has a lower share of low-carbon energy supply compared to the two previous scenarios (68% renewables and 8% nuclear). In combination with the important flexibility role of (unabated) natural gas plants, this implies that the carbon intensity does not fall below 50 $gCO_2$/kWh in the European power sector. This scenario reflects the inefficiency of national actions in the absence of a common European climate policy. Finally, the scenario with the highest carbon intensity (above 100 $gCO_2$/kWh), Two Steps Forward, One Step Back, consists of less than 60 percent low-carbon electricity, and natural gas as a relatively clean fossil source takes a lead role in the power mix. In this scenario, although deployment of carbon capture and storage (CCS) technology is relatively high, it decarbonizes less than one third of overall natural gas used in electricity supply.

**Fig. 4 – Difference in the investments per technology from the Happy EU-lectrons scenario**


Source: Deloitte analysis: DEEM scenario-based modelling results.

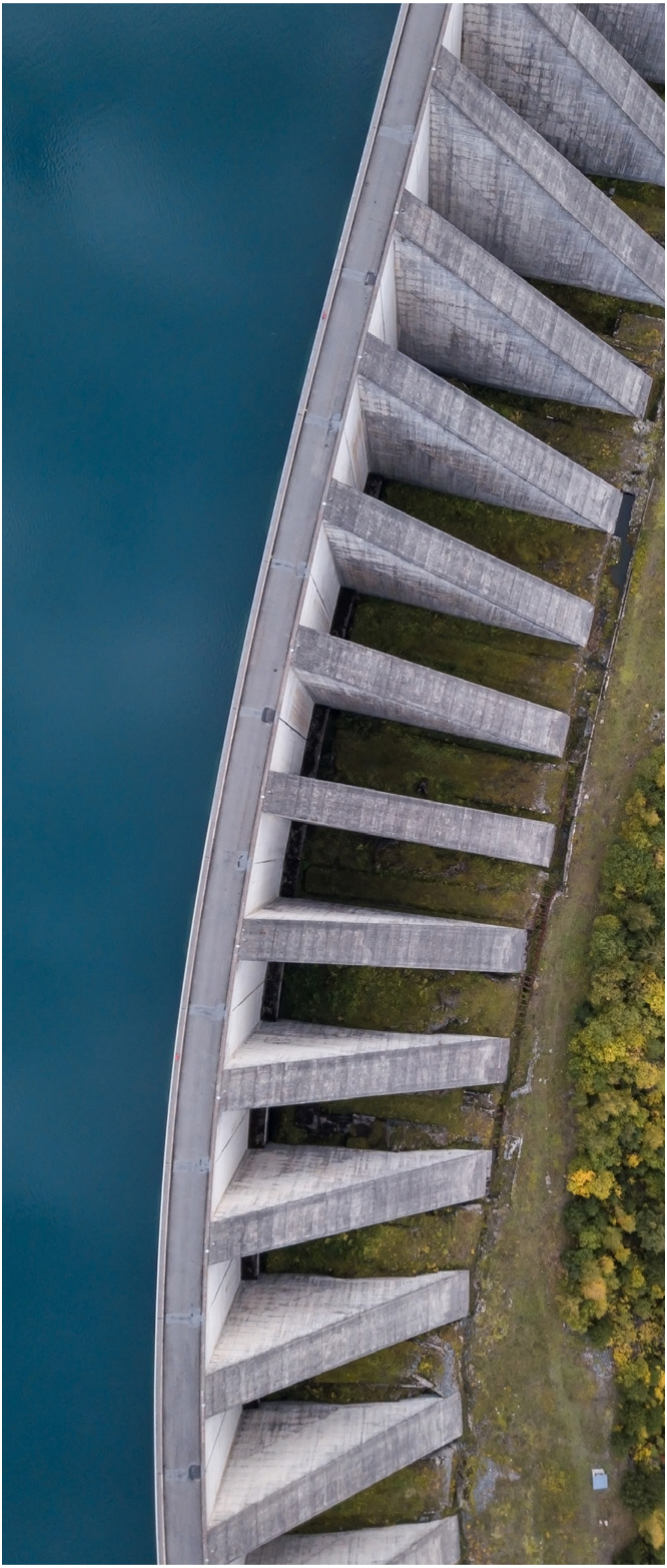
Figure 4 shows the variability in required investments across technologies in the four scenarios. The investment in renewables shows the Happy EU-lectrons and Green Lone Wolves scenarios are on par; however, the Two Steps Forward, One Step Back scenario shows a €1 trillion lower investment.

**Fig. 5 – Difference in investment per region from the Happy EU-lectrons scenario as function of timeline**



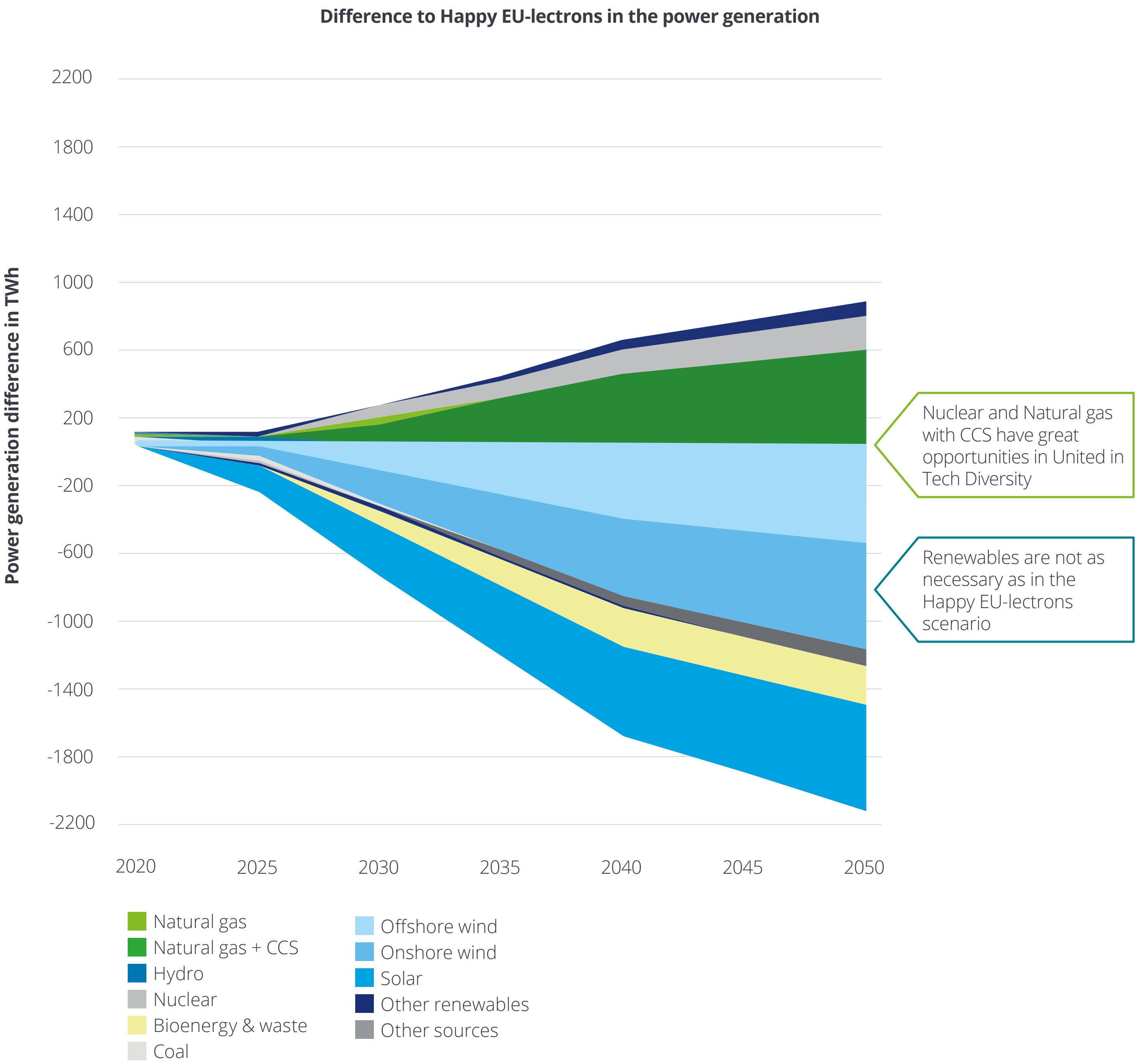

Source: Deloitte analysis: DEEM scenario-based modelling results.

Scenarios also differ markedly in terms of investment per region, not only in terms of cumulative investments, but also in investment dynamics over the next three decades (figure 5). The timing of investments is highly dependent on the coordination between grid expansion policies and the evolution of electricity demand. The scenario-based variability of investments is lowest in Western Europe, as the political determination to combat climate change in this region leaves fewer uncertainties regarding the energy mix and the respective investment levels. The same trend can be observed for the Nordics with the exception of the United in Tech-Diversity scenario investments in the 2040s. This is because this region already has a decarbonized power system with a large share of flexible hydroelectricity in its power mix, and its electric demand is not expected to increase much by 2050. In contrast, the investment in the power system in Central Europe varies significantly from one scenario to another. This region has a relatively carbon-intensive electricity mix with greater uncertainties regarding the policy incentives towards the decarbonization of the power system. Accordingly, the future power system in this region is associated with higher uncertainties compared to Nordics and Western Europe.



The Happy EU-lectrons scenario is underpinned by high shares of renewables, a strong electrification of the energy system and a unified European political determination. A more balanced scenario with lower electrification and lower shares of renewable energy is the United in Tech-Diversity scenario. As both scenarios are broadly consistent with the $CO_2$ emission reduction targets of the Paris Agreement, a closer comparison is warranted. Overall, the more diversified scenario (see figure 6) requires roughly 15 percent less cumulated investments. This is due to a broader range of competing technologies, especially with regards to natural gas with CCS and nuclear, at least in Central/Eastern Europe, driving cost-efficiency. As a result, each of the main low-carbon electricity supply options – solar, onshore wind, offshore wind, hydro, nuclear, and natural gas with CCS – would represent around 15 percent of the electricity supply, complemented with just a small share of natural gas without CCS (~5%), by 2050.

**Fig. 6 – Power generation by energy source – difference between United in Tech-Diversity and Happy EU-lectrons**

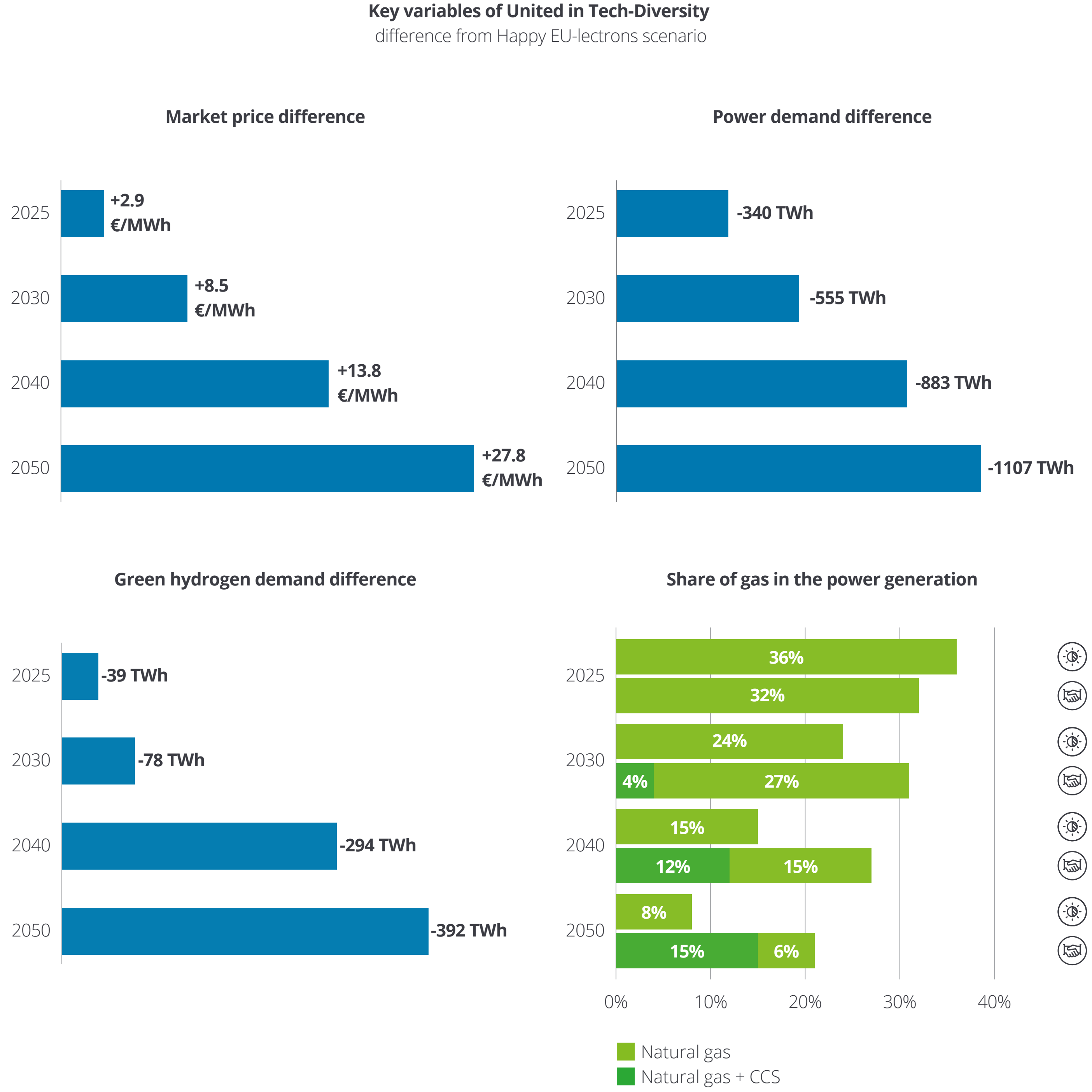



Source: Deloitte analysis: DEEM scenario-based modelling results.

However, such a future may still lead to higher electricity market prices compared to the Happy EU-lectrons scenario (on average nearly €28/MWh higher in 2050), as power generators have to procure costly natural gas to run the needed combined cycle gas turbines (CCGT) with or without CCS (figure 7). This effect persists despite lower poer demand lower power demand due to less electrified end-uses and a lower need for green hydrogen from industry.

The winners are variable renewables: offshore and onshore wind and solar power. The higher their share in the electricity supply, the lower the electricity price.

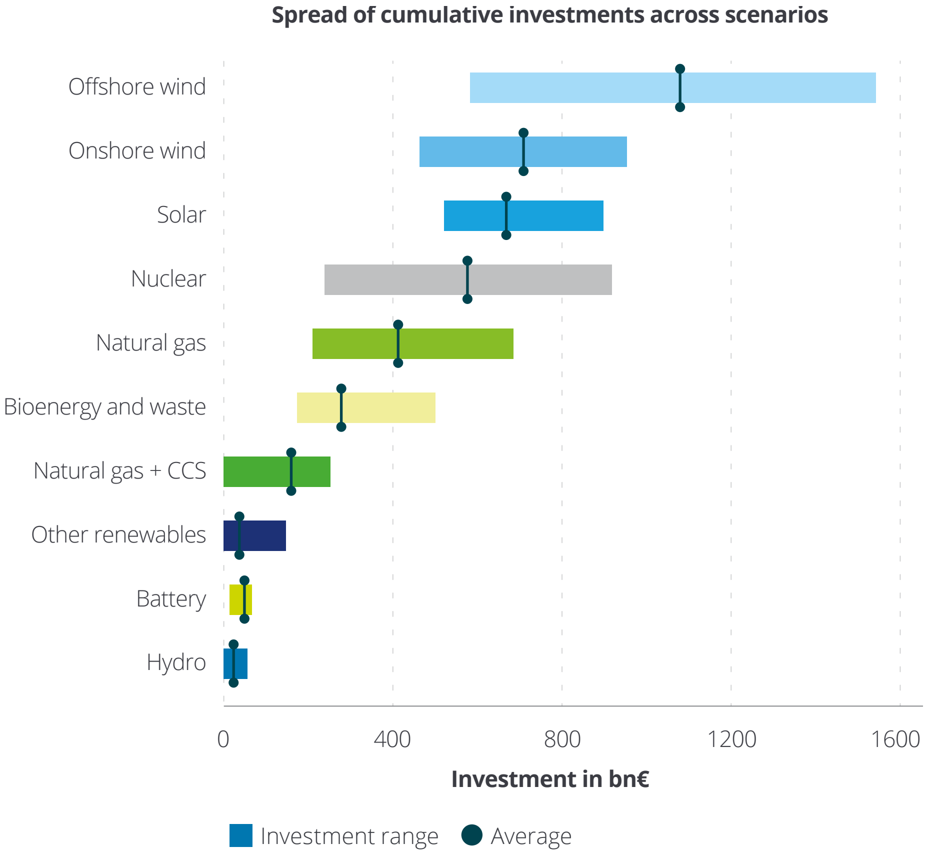
**Fig. 7 – Key differences between the United in Tech-Diversity and the Happy EU-lectrons scenarios**




Source: Deloitte analysis: DEEM scenario-based modelling results.

Summing up, there are some obvious losers, winners, and question marks when it comes to investments in energy generation (figure 8). Coal no longer attracts investment, new technologies like batteries do not capture significant shares in all futures. The winners are clearly solar and onshore wind with offshore wind exposed to the highest uncertainty in our analysis. The big question mark evolves around the future role of natural gas in combination with CCS. Here, we see the highest relative variance of all major technologies.

**Fig. 8 – Spread of cumulative investments to 2050 across the four scenarios**




Source: Deloitte analysis: DEEM scenario-based modelling results].

# Back to the future

What seems certain is that the power markets in Europe are set for growth in the coming decades. There is growth in demand, growth in electricity generation, growth in electric vehicles, growth in hydrogen electrolysis, growth in strengthening the interconnectors and growth in adapting distribution networks to a more decentralized energy world ahead of us. What is uncertain is the magnitude of this growth, creating a multitude of uncertainties for the industry.

Firstly, the industry needs to organize for growth. This seems to be a good problem to have and should revive utilities' strength in organizing long-term investments in energy infrastructure, be it renewables, grids, or hydrogen-based applications. This is largely dependent, though, on the ability to keep the license to operate, especially through credible environmental, social and governance (ESG) programs, and continued access to low cost capital as well as the best sites, esp. for renewable energy generation.

Secondly, flexibility options (storage options, thermal capacity and demand-side management), require important investment levels to complement renewables by handling their variability. However, they fare much better in an electrified world as one would expect. Our results confirm that the variability of hourly electricity prices is significantly higher in a highly renewables-based system. This price volatility provides strategic market opportunities for new actors such as demand-side flexibility providers (load-shedding and load-shifting), thus improving the viability of their future business models. Utilities need to invest in such technology to be prepared if the Happy EU-lectrons scenario should make the race.

Thirdly, technology choice is beneficial but not a given. Utilities should aim to keep CCS technology and nuclear in the mix, at least in countries where social acceptance is favorable.

Fourth, all scenarios are consistent with a functioning energy-only wholesale market that is complemented with remuneration mechanisms for system services. The risk management function of energy trading is strengthened by increasing price volatility. However, capabilities will have to be expanded for aggregating and marketing massive amounts of decentralized load in a real-time fashion, while at the same time the trading horizon will have to be expanded to service power purchase agreement (PPA) type arrangements required to finance massive renewables growth.

The fifth and possibly most important challenge is the change required to balance and transport power in the future European system. Such a power system will require highly automated and efficient power networks. Without investing in the digitalization of processes and the intelligence of network operations, the required expansion and the European power grid will not be achieved.

In conclusion, utility executives should embrace scenario thinking when developing their strategies and planning investments and prioritize critical capabilities to be developed. Based on this assessment, decision makers should make sure that this strategy is flexible enough to adapt to change. Adapting the strategy to changing conditions requires constant monitoring of key scenario parameters.

# To start this journey, we suggest three steps that companies could take:

**1. Dive into the possible worlds of the European power markets:**

- Enrich the scenarios with your own insights and planning
- Identify additional drivers and critical uncertainties
- Develop your own narratives and get relevant stakeholders on board

**2. Determine the impact on the organization:**

- Link qualitative market drivers to relevant organizational key performance indicators (existing and new)
- Model the financial impact per scenario
- Determine the technological and organizational impact of the scenarios on your organization

**3. Derive strategic courses of action:**

- Analyze existing gaps to identify critical threats and opportunities
- Define strategic actions to address the gaps
- Prioritize and plan potential actions

**The European future of power is within reach. It's time to shape it.**

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