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REPORT

Preserving the Competitiveness of European Industry & Power Prices

Impact on EU ETS and power markets if governments fail to deliver on renewables and coal exits

October, 2021

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Preserving the Competitiveness of European Industry & Power Prices - EU ETS and power market outcomes if governments fail to deliver on renewables and coal exits	Prepared by: Linus Beer (linus.beer@auroraer.com) Casimir Lorenz (casimir.lorenz@auroraer.com) Approved by: Hanns Koenig (hanns.koenig@auroraer.com)

The study was commissioned by the European Climate Foundation. The authorship of the content lies with Aurora Energy Research. The contents of the study do not necessarily correspond to the positions of the European Climate Foundation in all cases.

AURORA ENERGY RESEARCH

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List of Acronyms:

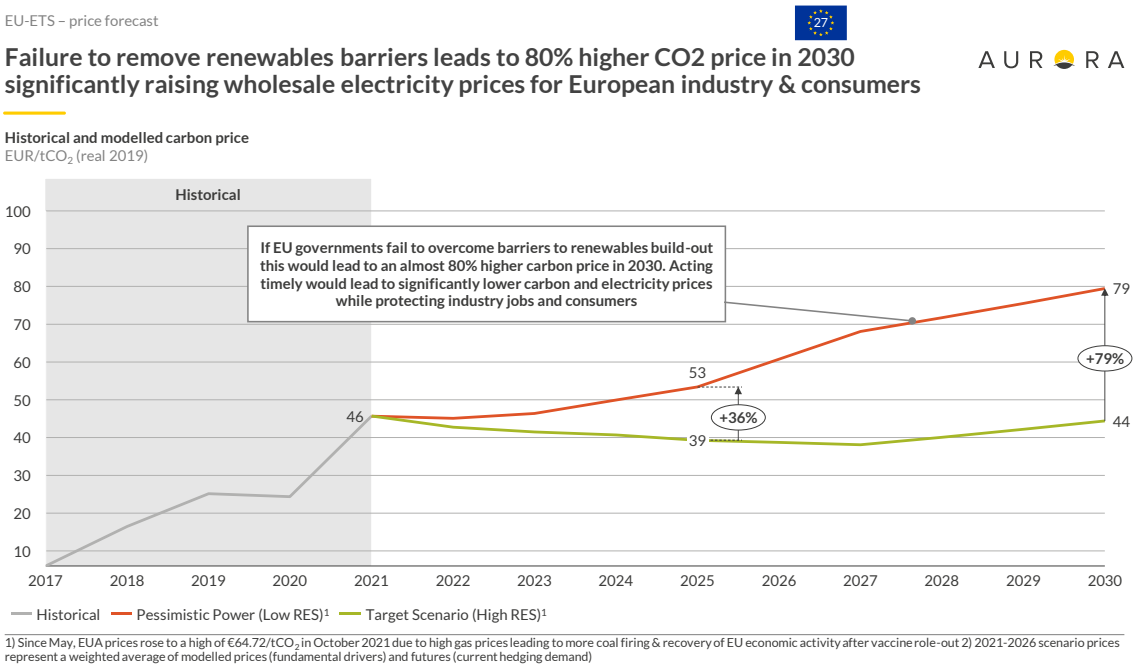
CfD	–	Contract for Difference
EUA	–	European Union (Emissions) Allowance
EU ETS	–	European Union Emissions Trading System
EU IA	–	European Commission Impact Assessment (of the effects of the European Green Deal)
FF55	–	(The European Union's) Fit for 55 package
IEA	–	International Energy Agency
LCOE	–	Levelised cost of energy
OECD	–	Organisation for Economic Co-operation and Development
RES	–	Renewable energy sources

1. Executive Summary

The announcement of the European Commission's Fit for 55 package in July 2021 outlines a significant increase in climate ambition until 2030, requiring a 55% net emissions decrease over 1990 levels. To reach this target, the Commission proposes a slightly steeper 61% emissions reduction for sectors covered under the European Emissions Trading Scheme (EU ETS) until 2030 compared to 2005 levels. By its design, the EU ETS limits power and industrial sector emissions but depending on member states' energy policies regarding renewables and coal exits, ETS carbon and wholesale electricity prices can vary significantly.

- **Low renewables build-out and slow coal exits will lead to high carbon and wholesale electricity prices that threaten the competitiveness of European industry, aggravate the problem of energy poverty in some member states, and increase the EU's dependence on imported natural gas. This would also increase power markets' exposure to commodity price volatility.**
- **Reaching the EU's renewables targets for 2030 and allowing for early coal exits would lead to stable or falling electricity and carbon prices, ensure a sustained competitiveness of the industrial sector, and lower the geopolitical dependence on natural gas imports. This would reduce power markets' exposure to future price volatility as currently seen during the European natural gas supply shortage.**

While the **EU ETS will likely deliver on the Commission's emissions targets** and the EU Renewables Directive encourages a high level of RES capacity, the two measures may fail to deliver on member states' individual climate goals. Meeting the EU's emissions and RES targets is also **not a guarantee for other areas of government concern such as the future energy mix as well as carbon and wholesale electricity prices. An incremental carbon price increase together with effective carbon leakage protection and stable wholesale electricity prices are required to ensure competitiveness of energy intensive industry and to enable increasing electrification of other sectors such as transport and heat.**



Sources: Aurora Energy Research, EIKON, S&P

Figure 1: Annual EUA price development for different scenarios

This study compares two scenarios, one **"Pessimistic Scenario"** where EU Governments fail to overcome existing barriers to renewables deployment while slowing down coal exits and a **"Target**

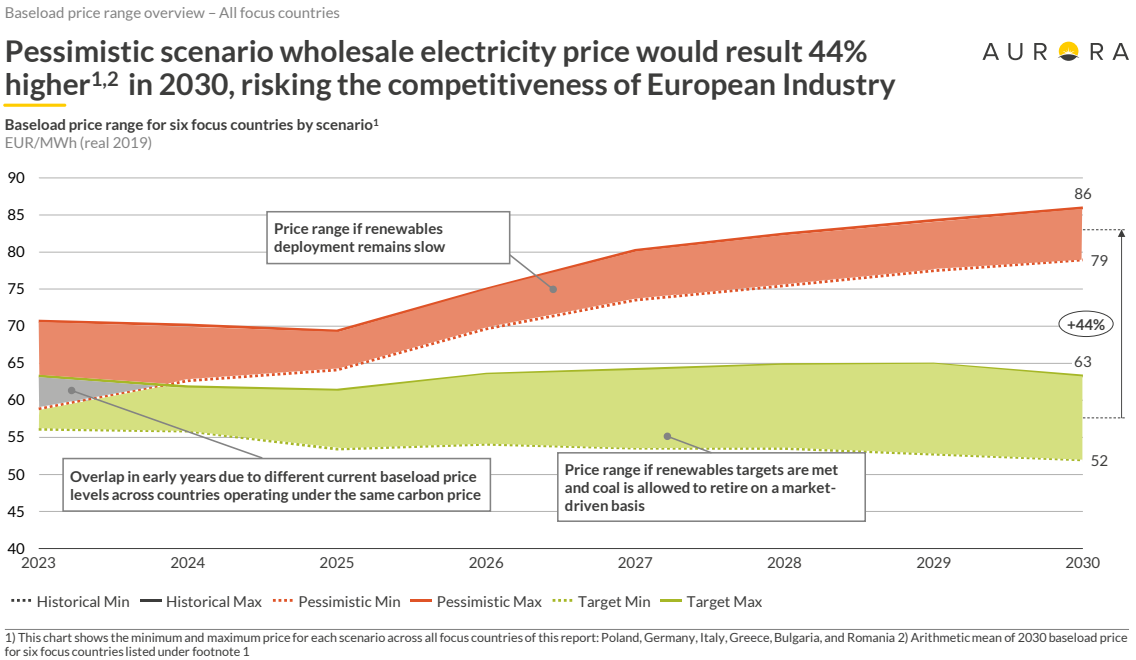
Scenario" where these barriers are removed, and renewables generation shares reach a level which is aligned with the European Commission's Renewables Directive for 2030 and the results of the Commission's Impact Assessment of the effects of the European Green Deal. This scenario allows unprofitable coal capacity to retire in the 2020s, i.e. earlier than current government plans.

We find that slowed renewables deployment under a Pessimistic Scenario would drive significant increases in both carbon and wholesale electricity prices. This would result in higher costs for industry and consumers and could threaten the competitiveness of European Industry.

- EUA prices would be almost 80% higher in 2030 than under a scenario where governments meet the renewables share outlined in the Commission's Impact Assessment Report and implied by the Commission's renewables targets under its Renewables Directive.
- Wholesale electricity prices would be 44% higher on average in 2030 between both Scenarios and across a list of six focus countries (Poland, Germany, Italy, Romania, Bulgaria, and Greece), which increasingly replace coal with new natural gas generation, thereby increasing the EU's import dependence.

Overcoming current barriers to renewables deployment, while allowing unprofitable coal and lignite plants to retire earlier than outlined under government plans would ensure stable to falling electricity and carbon prices that maintain the competitiveness of European industry. A more direct switch from coal to renewables would reduce the EU power sector's dependence on natural gas imports and limit its exposure to commodity price volatility. Avoiding overinvestments into natural gas capacity is of particular relevance in light of the IEA's Net Zero conclusion that the power sector in all OECD countries should be decarbonised by 2035 and for all other countries until 2040.

- EUA prices would fall below levels observed during the Fall 2021 natural gas supply shortage while renewables increasingly replace coal, limiting the need for natural gas as transition fuel.
- Wholesale electricity prices and natural gas generation in six focus countries would stagnate or fall until 2030 compared to historically observed levels.



Source: Aurora Energy Research

Figure 2: Wholesale price range overview, six focus countries

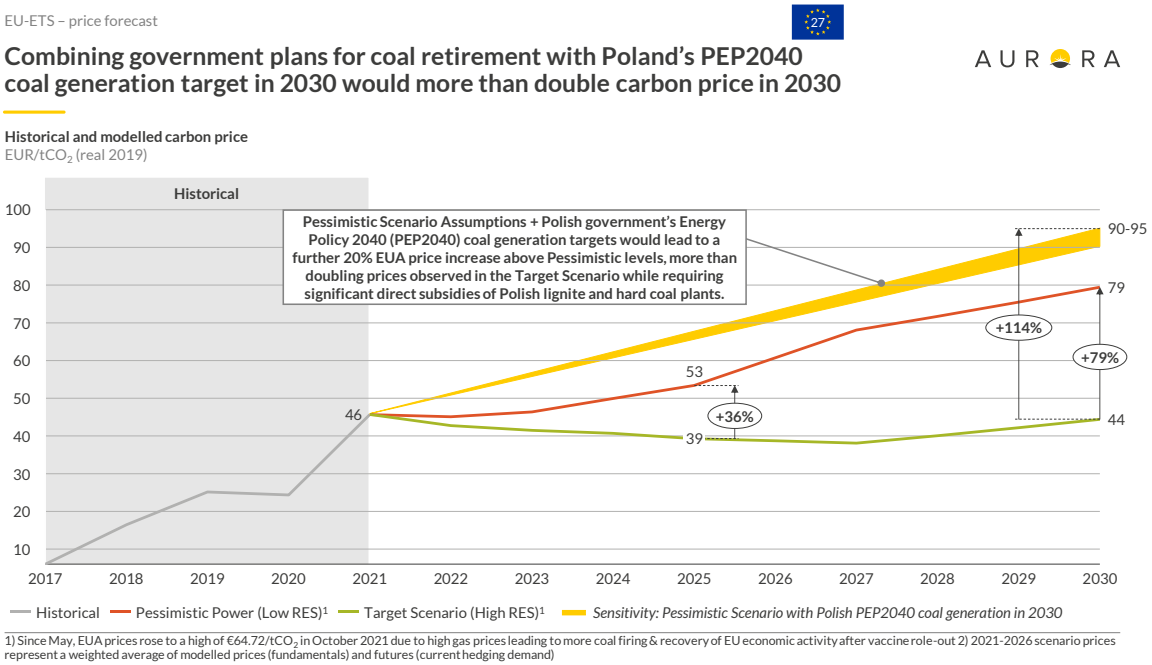
Figure 2 shows that higher renewables capacities as well as the lower carbon price result in significantly lower wholesale power prices across European markets ensuring affordable wholesale electricity prices for European industry and other consumers.

Building additional renewables will not necessarily require cash subsidies in most countries because many current delays are caused by administrative hurdles and market design. An important, but in many cases revenue-neutral support for solar, onshore-, and offshore wind build-out would be for governments to take on investors' financial risk via Market Premium or Contract-for-Difference schemes. This kind of risk transfer lowers project financing costs and thus the levelised-cost-of-electricity of projects which in return lowers any potential remaining subsidy payments.

Although by its design, the EU ETS reaches about the same level of cumulative emissions until 2030, a Target Scenario power sector would be a lot more future proof than the Pessimistic Scenario outlook as it would result in a much higher level of renewables capacity as well as lower wholesale prices and reduced amounts of thermal assets into the 2030s. Since the introduction of the EU's Net Zero Target for 2050 a full transition to carbon neutrality is inevitable – renewables build-out can only be delayed as done in the Pessimistic Scenario requiring faster abatement in later years. In the end it is important for governments to find the right balance on power, and carbon prices that preserve industrial competitiveness, while limiting Europe's dependency on imported natural gas and future price shocks.

Poland's PEP2040 coal generation targets for 2030 would increase carbon price for the entire Union

A sensitivity analysis was conducted as a variation of the Pessimistic Scenario to evaluate the carbon price effect of the Polish government's 2030 coal generation target defined in its Energy Policy for 2040 (PEP2040).



Sources: Aurora Energy Research, EIKON, S&P

Figure 3: Annual EUA price development under Polish PEP2040 coal generation

If Poland were to follow through on its coal generation plans until 2030, this would:

- raise carbon prices by 114% over Target Scenario levels, 20% above the Pessimistic Scenario price and more than doubling carbon price levels observed in the first half of 2021 (before the European gas supply shortage).
- require direct subsidies of coal generation at a high cost for rate payers or the government's budget and likely violate EU state-aid rules.
- significantly threaten the competitiveness of European Industry which would face not only higher carbon-, but also power prices due to the increased EU ETS price. This outcome would likely trigger public opposition from EU industry lobbies and governments alike.

2. Introduction and political context

The EU has set itself an ambitious new climate target until 2030 of reducing emissions by 55% over 1990 levels. The European Emissions Trading System (EU ETS), which lies at the center of this study, is the European Commission's most important instrument for achieving this target for the power and industrial sector.[1]

The European Commission proposes for the EU ETS to reduce emissions by 61% until 2030 over 2005 levels, meeting more than its proportional share of the abatement burden of -55% (compared to 1990). This reflects the fact that sectors covered by the EU ETS – in particular electricity generation and industry – are among the easier and cheaper abatement choices in the near future, i.e. when compared to much higher and politically more sensitive sectors such as buildings (heat) and transport.

The ETS drives power sector abatement through making the dispatch of more carbon intensive generation sources more expensive relative to sources with a lower carbon intensity. This can make i.e. coal and lignite generation more costly than natural gas, depending on their fuel costs[2]. In the long-term and under ideal circumstances (equilibrium commodity prices, competitive transparent markets, and an absence of coal and natural gas generation subsidies), higher costs resulting from higher carbon prices leads to less operating time and carbon emissions, as well as earlier closures of hard coal and lignite. Natural gas plants now set the price at a higher cost than coal did previously thus increasing wholesale prices. If governments enable more renewables build-out, this exerts downward pressure on carbon and power prices. Renewables have almost no dispatch cost, meaning that rising renewables generation gradually replaces natural gas generation. This lowers wholesale prices as natural gas plants are price-setting in less hours than before. At the same time renewable electricity leads to lower emissions which in return lowers carbon prices and thus the dispatch cost of the remaining natural gas capacities.

Despite ambitious new climate targets, we see several non-market-barriers to reaching the power sector outcomes aimed for by the European Commission as well as for renewables and coal exit targets set by individual members states. Among them are regulatory burdens such as regulatory uncertainty,

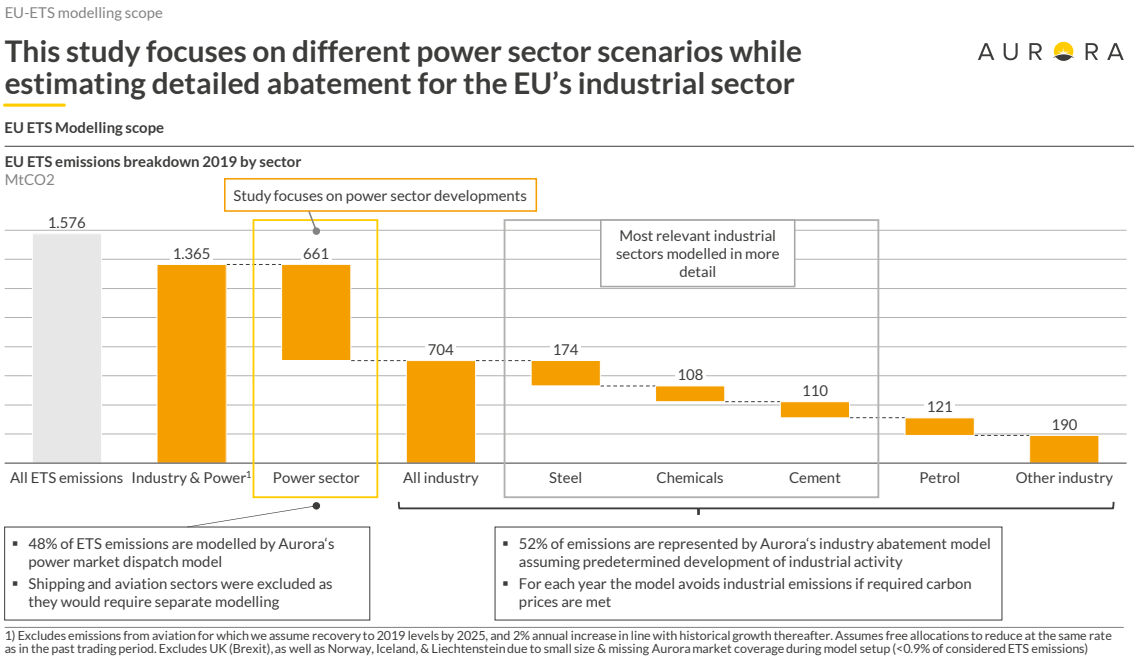
[1] The EU-ETS also covers European domestic aviation and the European Commission proposed to include shipping emissions in the future. However, this study focuses on power and industry emissions, since aviation and shipping emission shares are comparably small and face abatement costs well above the levels considered here, i.e. they can be treated as exogenous for the purposes of this study. Further details are listed under footnote 3

[2] Fall 2021 natural gas price peak has shown a different trend in the short-term, making many gas-powered power plants more expensive than coal and lignite despite high carbon prices

permitting delays, distancing rules etc. which slow down renewables development as well as individual governments that consider maintaining their coal industries throughout the 2030s.

The goal of this study is to contrast the impacts of a continued slow transition pace in the power sector with a world where governments step up their renewables delivery in line with the proposed EU renewables targets. While the **Pessimistic Power Sector Scenario** assumes continued regulatory barriers for renewables and a slow exit of coal capacities, the **Target Scenario** uses a renewables generation share in line with the European Commission's Impact Assessment (EU IA) of the Fit for 55 package for 2030 which considers the levels achieved under the Commission's Renewables Directive. The EU IA numbers might differ from individual countries' 2030 power sector targets but represent a reasonable aggregate European level of ambition for the next decade. A primary focus of the analysis lies on EUA and wholesale power price developments. Power and EUA price increases pose the risk of threatening the EU industrial sector's competitiveness while also impacting household and commercial consumer electricity prices.

The study's starting hypothesis is that higher support for renewables and allowing for EU coal and lignite capacity to retire by the early 2030s would benefit electricity consumers, as well as industrial competitiveness due to lower EUA prices which – together with wholesale electricity prices – directly affect the competitiveness of industry. Lower wholesale electricity prices and grid emissions intensity would also have the side-effect of further encouraging the electrification of residential heat and transport, two sectors that are mostly outside of the EU ETS. A more direct switch from coal to renewables capacity would also decrease the need for natural gas as a transition fuel. This would limit the European Union's dependence on fossil gas imports and its exposure to commodity price volatility which has been worrying policymakers and businesses alike during this year's natural gas supply shortage and related electricity and carbon price increases (the latter induced by increased coal generation and traders anticipated shortage of EUA supplies).



Source: Aurora Energy Research, Union Registry

Figure 4: EU ETS modelling scope

As illustrated on Figure 4, the focus of this modelling effort is on power and industrial sector emissions which were responsible for more than 87% of 2019 EU ETS emissions. Our modelling excludes emissions from shipping which are rather small while assuming a pre-defined emissions pathway for the EU's domestic aviation emissions[3]. While the power sector is covered by Aurora's European Power Market Model AER-ES, which represents bottom-up hourly decisions for individual European power plants, we have developed a separate industry and EU ETS model as part of this study. The industry model iterates together with the power and ETS price model to find a cost-optimal decarbonisation pathway. For the power model this could mean replacing more polluting generation such as coal through natural gas or renewables. On the industry-side, the model avoids CO2 emissions at the cost of abating one tonne of $CO2_e$ via switching to low-carbon technologies. It does so while considering typical reinvestment cycles of industrial installations and carbon price developments over the entire investment period of new-built assets. An overview of additional subsidies we expect for industrial sector abatement is provided in section 3.

EU-ETS modelling assumptions

Our model assumes carbon leakage protection until 2030, and an output-based free allocation of certificates for industry

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Key modelling assumptions

1. Free Allocation of EUA certificates based on production outputs

To increase the decarbonisation effect of EUA-price increases, we assume that the free allocation of certificates will be independent of the applied production process but based on an output-related emission allowance factor (i.e. hot metal benchmark)

→ *Without this assumption, a switch to lower carbon fuels would become unprofitable even under high carbon prices as it would lower the amount of freely allocated certificates, i.e. in a case where a coal-based steel blast furnace is replaced with a gas direct reduction installation.*

2. Our model runs without CO2-price-induced carbon leakage

Relocation of production facilities within or outside of Europe is still possible if non-CO2-related production factors are favourable

→ Moving polluting industries outside of the EU would result in lower demand for EUA certificates and thus lower EUA prices without avoiding carbon emissions.

3. A Carbon Border Adjustment Mechanism (CBAM) is in place for all imports covered by the EU-ETS, export are protected separately:

To prevent large-scale carbon leakage, we assume that a carbon border adjustment mechanism will charge imports according to the carbon content of individual products while ensuring that exports are otherwise protected, i.e. through continued free allocations or a climate club of countries with carbon pricing for industrial products

→ An absence of CBAM & export protections would lead to carbon leakage as excluded under modelling assumption 2

Source: Aurora Energy Research

Figure 5: EU-ETS modelling assumptions

A series of key modelling assumptions is necessary to reduce the amount of complexity and potential negative effects of the EU ETS, among them:

- Continued free allocation of EUA certificates, but now based on production outputs, not processes (this enabled a switch to low-carbon fuels without adding the cost of lost freely certificates).
- Carbon Border Adjustment Mechanism (CBAM) in place for all imports, while a separate protection for exports that become less competitive through rising carbon prices is introduced (i.e. a climate club of countries with carbon pricing for industrial products or a continuation of freely allocated certificates).

[3] Aviation emissions recover to 2019 levels by 2025 rising 2% annually thereafter, in line with historical growth

3. Scenario overview and definition

Modelled EU-ETS parameters are broadly aligned with the latest European Commission proposal while scenarios compare failure and success of accelerated renewables build-out and coal exits

Parameters		Pessimistic Scenario	Target Scenario
Key ETS Parameters	ETS Sector Target	-65%[4] relative to 2005 (current target: -43%)	
	Linear Reduction Factor (LRF)	2.2% until 2025, 6.9% after 2025	
	MSR Ambition	Threshold of 700 mio (instead of 833 mio), intake rate 18% after 2023 (instead of 12%)	
Scenario Rationale		▪ EU governments fail to overcome current barriers to RES deployment ▪ Announced phase-out timelines remain in place for coal keeping capacity connected beyond 2030, age-based retirement where no coal exit plans have been announced (no subsidies for coal generation)	▪ EU countries enable accelerated renewables build-out which reaches a renewables generation share aligned with the Commission's Renewables Directive ▪ Coal and lignite capacities are retired when no longer economic and/or in line with national coal phase-out commitments.
Power Sector	Renewables	▪ Slower RES build-out than Aurora Central Scenario[5] in 2030 leading to 19% less generation from RES compared to our Aurora Central, no market-driven build-out	▪ Faster RES build-out than Aurora Central Scenario[5] in 2030 leading to 17% higher gross generation[6] from renewables as in Aurora Central, market-driven build-out enabled
	Coal capacity	▪ Implementation of current governments' coal exit timelines (i.e in NECPs, by coal commissions or in existing coal exit laws) ▪ Age-based capacity retirement of coal capacity in Poland and Bulgaria	▪ Allows market-driven closures of hard-coal capacity in 2020s (slightly slowed in Poland/Bulgaria to ensure security of supply) ▪ Gradual market-driven lignite retirement in late 2020s enabled, full retirement allowed from 2030 onwards
Industrial Sector Subsidies	Steel	▪ 60% of reinvested blast furnaces convert to direct reduction of steel with green H2 gradually replacing natural gas as fuel by 2030 (-48 MtCO2 p.a. in 2030)	
	Chemicals	▪ Governments subsidise blending of 15% green H2 into existing ammonia production process, the Netherlands and Italy use blue H2, replacing a further 10% of total H2 demand in the European Ammonia Industry with a low carbon alternative (-6 MtCO2 p.a. in 2030)	
	Cement	▪ Oxyfuels CCS: 11 prime locations with low carbon transport & storage costs close to rivers & ports are converted (-9 MtCO2 p.a. in 2030)	

Figure 6: EU ETS Parameters and Scenario Definition

Aurora's EU ETS model assumes technical parameters that are broadly aligned with the European Commission's proposal published with the Fit for 55 package in July. While individual parameters differ

[4] Aurora's Central view on carbon prices was formed before the publication of the EU's FF55 package but is broadly in line with European Commission's proposal for the EU ETS. Differences in individual parameter assumptions cancel each other out, i.e. a slightly lower EU ETS effort sharing target of -61% (Commission) vs. -65% (Aurora) reduction in 2030 is neutralised by a more ambitious MSR intake rate of up to 24% vs. 18% in our modelling etc. .

[5] Represents Aurora Energy Research's Central view on most likely power market developments which was used as blueprint for scenario development (i.e. faster- and slower than most likely RES deployment & coal exits). It is important to consider that Aurora Central is not a EU Target Scenario, nor for individual member states

[6] Modelled renewables generation share is aligned with renewables generation share targeted under the European Commission's Renewables Directive and reflected in the Commission's Impact Assessment Report of raising the 2030 climate target to 55% compared to 1990 levels

slightly since they were determined before the package's publication, the aggregate effect on EUA prices balances out over the projected horizon (i.e. a slightly lower EU ETS effort sharing target of -61% vs. -65% reduction in 2030 by the European Commission is neutralised by a more ambitious MSR intake rate of up to 24% vs. 18% in our modelling etc.). It is also important to note that the current Commission proposal is still subject to changes during the European legislative process which is why the scenario setup for the EU-ETS represents reasonable assumptions given the current knowledge of the EU ETS' setup until 2030.

As illustrated on Figure 6, this study differentiates between two scenarios resulting in different EU ETS prices as well as power market outcomes, but with both scenarios aligning with the same emission reduction target for the ETS as a whole. One scenario considers ambitious (Target Scenario) and the other pessimistic (Pessimistic Scenario) power market outcomes for renewables and coal capacity. Industrial emissions outcomes do not differ markedly and are mainly driven by assumptions on subsidies for industrial decarbonisation. The reason is that the sector's abatement costs lie above carbon price levels reached within the next ETS trading period.

The **Target Scenario** describes a world where individual governments meet the EU's power sector emissions targets in 2030 as outlined in the Commission's Impact Assessment of the effect of implementing its Fit for 55 package and Renewables Directive. In terms of the energy mix, the scenario assumes a EU-wide aggregate renewables generation share which is aligned with the goals outlined in the Commission's Renewables Directive for 2030 and makes wind and solar by far the dominant source of electricity generation. This implies an almost complete coal exit by 2030 which will be market-driven and faster than agreed upon in existing coal exit regulations. In this scenario, the renewable energy share of net generation will reach approximately 66% in 2030 with 47% coming from solar, onshore, and offshore wind alone[7], while the share of coal and lignite combined is reduced to below 3%.

In the **Pessimistic Scenario** the EU also meets the 2030 emission reduction target for the sectors covered by the EU-ETS. However, we expect a more restrained renewables deployment while governments don't allow coal plants to retire before the end of their technical lifetime or existing – less ambitious coal exit – policies. Despite higher coal capacities, coal generation would be similar to Target Scenario levels in 2030 with the main difference in this scenario being that a delayed renewables build-out increases the amount of natural gas power plants required to meet overall energy demand.

As a rationale behind slower renewables deployment, we assume that governments fail to overcome current barriers to accelerated renewables deployment. Examples are continued delays in grid expansion and permitting, local opposition to renewables development (mostly onshore wind farms, but also building solar on agricultural land), as well as a failure to take on financing risks via Market Premium or Contract-for-Difference schemes which drive up project LCOE, especially in countries with less investor confidence (i.e. in South Eastern Europe, but also large offshore wind projects or general development in not-yet established offshore markets such as Italy, Greece, Romania, and Bulgaria).

A **variation from this Pessimistic scenario** was introduced through a separate ***Sensitivity Analysis*** implementing the generation targets proposed by the Polish government under its PEP2040. Out of all EU governments' energy plans, the Polish PEP2040 strategy sees the most significant role for future coal generation. To analyse the risks this poses to EU carbon prices we have added a ***Pessimistic Scenario Sensitivity with Polish PEP2040 coal generation in 2030.*** Assumptions for renewables and coal capacity are fully aligned with the Pessimistic Scenario. Beyond this, we assume subsidies that increase Polish coal running hours so that coal generation meets PEP2040 targets in 2030. Beyond Poland, these types

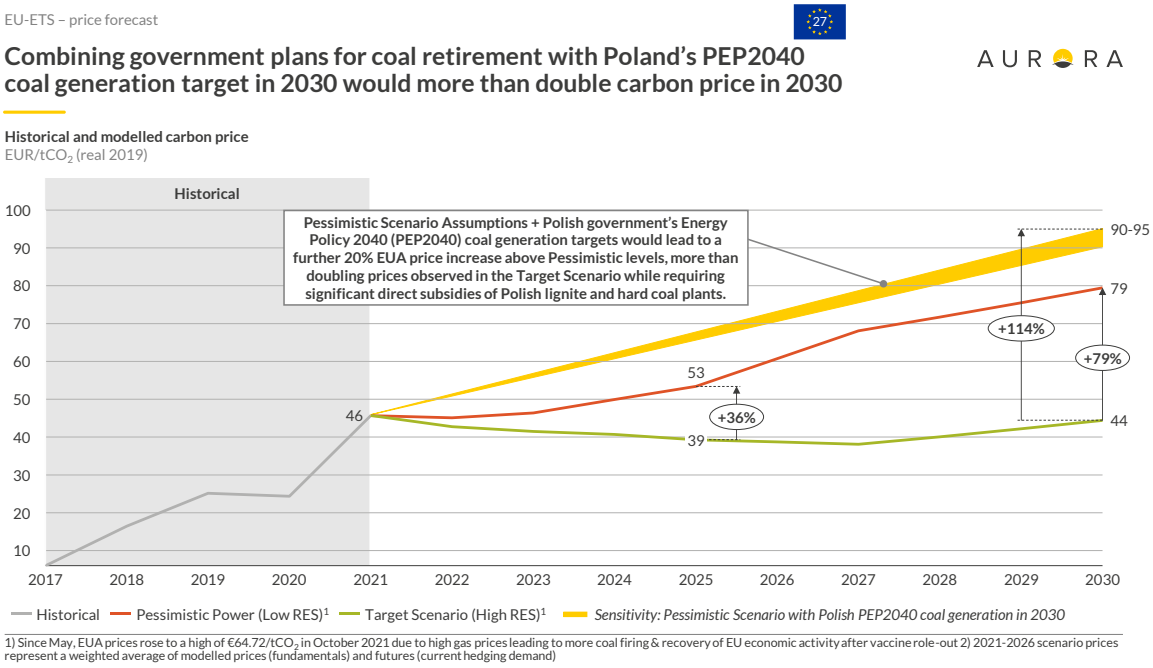
[7] The remaining 19% are from hydro, biomass, and other renewables such as geothermal or tidal power plants etc.

of subsidies with the goal to extend the role of the domestic coal industry have also been considered in Bulgaria.

For **industrial decarbonisation** we assume the same moderate political support for subsidies and demand-induced decarbonisation in both scenarios to isolate the effect of different power market outcomes. We expect most subsidies to be allocated to the steel-, chemicals-, and cement sectors. These sectors are dealing with hard-to-abate process-related carbon emissions, that require a shift towards entirely new production processes. At the same time, they are facing an increasing risk of carbon leakage, i.e., a loss of competitiveness on global markets for these products due to rising carbon prices. Within the next five years, a number of key low-carbon technologies will reach market-readiness, albeit at abatement costs above realised carbon prices. To maintain a domestic European heavy industry and protect jobs, we expect governments to provide subsidies that enable a shift to low carbon processes that are aligned with the European Union's Net-Zero strategy.

Moderate support as detailed on Figure 6 means we expect governments to subsidise some but not all industrial sites that face a reinvestment decision until 2030, as we believe it is likely that some competitive elements i.e. via auctions for Carbon Contracts for Difference are being considered while also leaving some room for the possibility to move production capability to the most favorable locations within the European Union (i.e. where green hydrogen production is cheapest or, for CCS sites: where transport and storage of CO2 is cheaply available). For demand-induced decarbonisation we expect governments to adopt regulation that mandates the use of low-carbon steel and cements in certain applications.

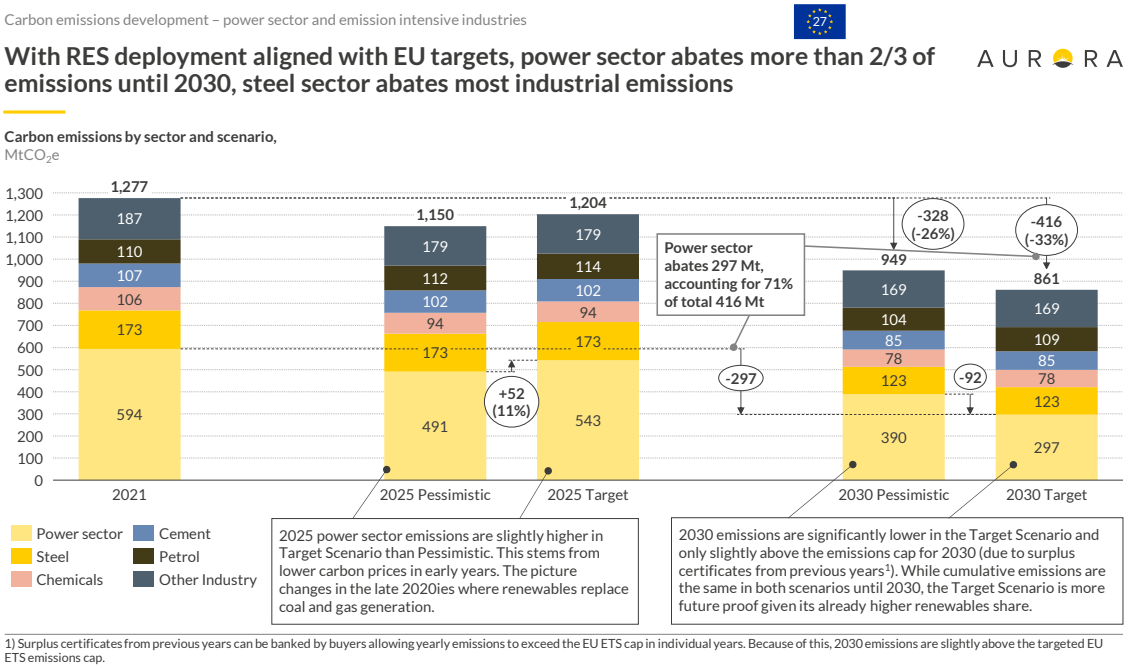
4. EU-wide results



Source: Aurora Energy Research

Figure 7: Annual EUA price development for different scenarios

On an EU-level, we compare EU ETS price and emissions outcomes across the different scenarios. Carbon prices would be almost 80% higher in a Pessimistic Scenario with low government ambition than under ambitious support for renewables deployment and allowing early coal retirements. On the contrary, in a Target Scenario, 2030 EUA prices fall slightly below levels observed in Mid-2021 and significantly below October 2021 levels of more than 60 EUR/tCO2 which were mainly driven by the European gas supply shortage. If the Polish government decided to subsidise enough coal and lignite generation to meet its PEP2040 generation targets in 2030, this would increase carbon prices by an additional 20% above Pessimistic Scenario levels by 2030, more than twice the level as if the EU reached a Target Scenario level of renewables.



Source: Aurora Energy Research

Figure 8: EU ETS Emissions Development by Scenario

2030 Scenario outcomes differ significantly in terms of annual ETS emission levels. Lower emission levels in the Target Scenario lay the ground for much faster decarbonization after 2030 and help to achieve climate neutrality even earlier than 2050, i.e. in countries such as Germany that have already committed themselves to Net Zero by 2045. The difference in year 2030 is driven by a significant increase in renewables that replace natural gas generation at a time where most of European coal capacity has already retired. The Pessimistic Scenario sees higher emissions mainly from natural gas generation which is needed in the electricity mix due to lower renewables deployment, and high carbon prices that drive coal generation out of the system. It is important to highlight that – despite some governments' targets to keep coal online well into the 2030s – most of European coal in this scenario is already unprofitable and mainly used at a low capacity factor for security of supply reasons which would likely require subsidies to cover fixed-costs.

In the short-term until 2025, differences in emissions between the two scenarios are driven by varying carbon price levels which are the result of different investor expectations around future demand and supply of certificates. The higher EU ETS price in the Pessimistic Scenario pushes down coal generation in the early 2020s and leads to higher natural gas run hours resulting in lower emissions in 2025 when compared to the Target Scenario. In the Target Scenario, we expect most additional renewables build-out to happen in the second half of the 2020s. Together with initially lower carbon prices, this leads to slightly higher run hours for coal and related emissions in 2025 than in the Pessimistic Scenario. These higher early emissions will be compensated in the second half of the 2020s when a more direct switch from coal to renewables is enabled that reduces both coal and natural gas run hours. At this lower carbon price level, natural gas remains less competitive which means it is less used as a transition fuel and more in hours of peak demand or low renewables supply. We took a more conservative stand when assuming most of the additional renewables deployment in the Target Scenario to happen in the second half of the 2020s. What this implies is that there is some room for governments to avoid higher coal run hours in the short-term through accelerating their renewables build-out within the next 3-4 years.

Overall, the Power sector accounts for more than two thirds of EU ETS abatement until 2030 in the Target Scenario, with the industrial sector accounting for about one third, mainly due to higher

abatement costs requiring subsidies. In the Pessimistic Scenario, this ratio is about 60 percent for the power sector and 40 percent for the industrial sectors.

Due to its higher abatement costs, industrial sector abatement is driven by subsidies and emissions and therefore does not vary between the two different scenarios despite very different EUA prices. However, lower carbon prices lead to higher cash payments, especially for more costly abatement options such as the use of green hydrogen for industrial sector decarbonisation. It is thus in the interest of EU governments to prevent EUA prices from increasing significantly to maintain industrial competitiveness, while also making sure they don't fall to very low levels, as this would increase the cost of subsidies and disrupt the ETS' investment signals.

Cumulative emissions between 2021 and 2030 are almost identical in both scenarios in our model. Any potential small differences would be the result of the MSR cancelling different amounts of certificates in circulation until 2030. The number of cancelled certificates is highly dependent on the development of surplus certificates in circulation which are not used up by the end of each annual trading period. While the emissions cap remains the same over time, annual emissions can vary depending on the amount of renewables capacity in the system which drives long-term coal-, and natural gas dispatch and the resulting carbon price.

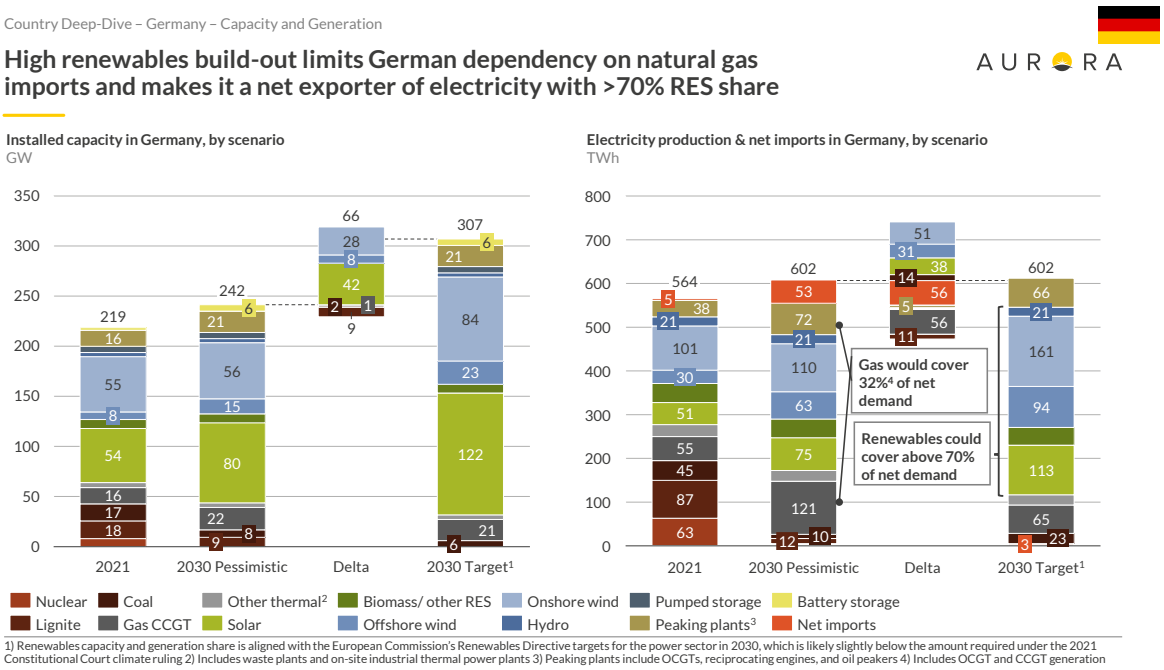
Although by its design, the EU ETS reaches about the same level of cumulative emissions until 2030, a Target Scenario power sector would be a lot more future proof than the Pessimistic Scenario outlook. Emissions in 2030 would be just slightly above the annual emissions cap (a 58% reduction compared to 61% over 2005) due to a high amount of banked certificates for hedging purposes at the end of the trading period. Further reasons why the Target Scenario is more future proof is that it would start with a much higher level of renewables capacity as well as lower wholesale prices and reduced amounts of thermal assets into the 2030s. Since the introduction of the EU's Net Zero target in 2050 a full transition to carbon neutrality is inevitable – it can only be delayed. In the end it is important for governments to find the right balance on power-, and carbon prices that preserve industrial competitiveness, while limiting Europe's dependency on imported natural gas and exposure to future price volatility. Finally, especially Eastern and South Eastern European countries have a particular interest in securing low wholesale electricity prices to be able to stabilise end-consumer prices and make progress on the challenge of energy poverty.

5. Key insights for individual countries

Beyond the analysis of EU-level carbon prices and emissions, we have evaluated the impacts of power generation and carbon market changes on individual countries. The final six focus countries were selected based on three criteria, first that they still have a relevant level of coal and/or natural gas generation, second a relatively high overall emissions intensity, and third they are countries that have decided to-, or are forced to phase out coal rather slowly due to political (i.e. Poland, Germany, Bulgaria, Romania) and security of supply concerns (mainly Italy and Greece). While both Greece and Italy have committed to quickly phasing out coal, security of supply concerns during summer heat waves (Greece) and island electricity supply (Sardinia) might remain as temporary barriers for a complete phase-out. They are explained in more detail in the following individual country sections. The Czech Republic was excluded from a detailed quantitative analysis as it faces the challenge of shutting down a large number of lignite-CHP plants for which the development of a sophisticated heat decarbonization Target Scenario would have been required. A "Comment on the Czech Republic" in Section 5.7 explains key qualitative takeaways for the Czech Republic that resulted from this analysis and our decision not to cover it quantitatively in this report.

For each country we have compared capacity, generation, as well as wholesale electricity price outcomes for both the Target and Pessimistic Scenario. Individual outcomes are then benchmarked against these countries' particular decarbonisation challenges and, where they are up-to-date (i.e. already aligned with the EU's new 2030 emissions goals) government targets for the power sector.

5.1 Germany



Source: Aurora Energy Research

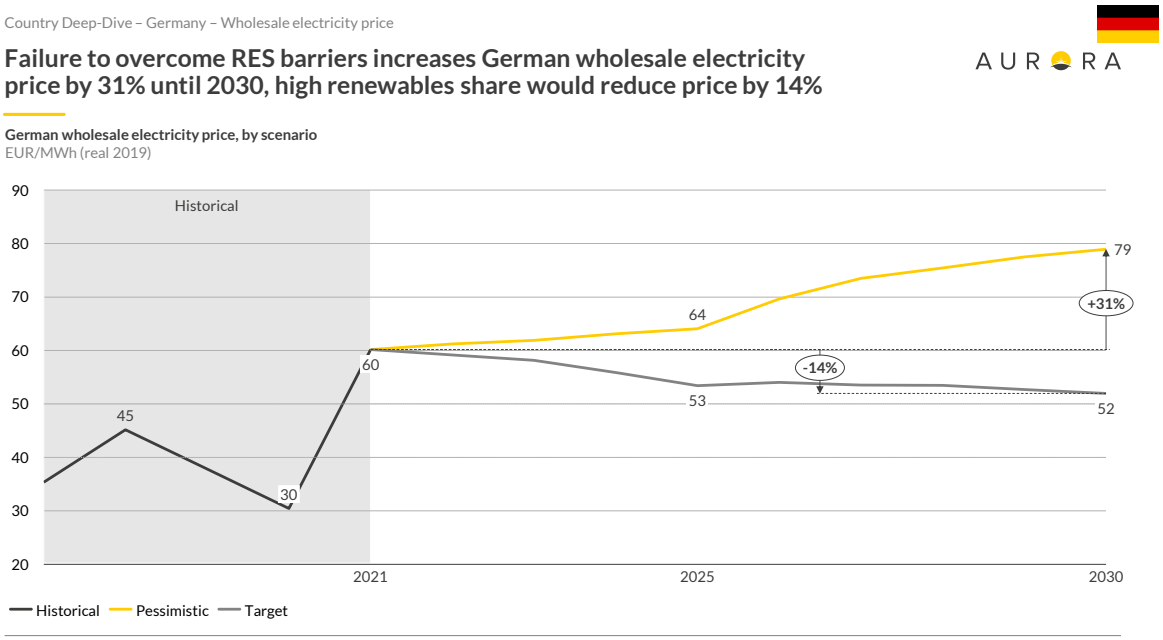
Figure 9: Modelling Results – Germany – Capacity and Generation

Capacity Outcomes

- 2021 intermittent renewables capacity of 117 GW almost doubles to 229 GW in the Target Scenario while reaching 151 GW in the Pessimistic Scenario.
  - For the Target Scenario, the largest difference is in solar capacity which more than doubles (+68 GW) to 122 GW, followed by onshore wind increasing more than 52% (+29 GW) to 84 GW, and offshore almost tripling (+15 GW) to a total 23 GW.
  - Under Pessimistic government action, solar increases by 26 GW, followed by offshore with 7 GW and onshore rising by just 1 GW, primarily due to sustained barriers such as slow permitting, distancing rules, as well as local opposition to wind farms.
- Total hard coal capacity drops to just 6 GW in 2030 if the German government overcomes barriers to renewables, with all remaining lignite capacity seeing market-driven retirement in that year as it becomes unprofitable due to the combination of a high level of renewables capacity and carbon prices. The Pessimistic Scenario instead, follows guidance from the German coal exit law aiming for a remaining 17 GW of total coal capacity in 2030, 9 GW of which remain for lignite which is considered politically more sensitive due to its relevance for jobs in structurally disadvantaged areas mostly in Eastern Germany.
- Gas CCGT capacity reaches 22 GW in the Pessimistic Scenario up from 16 GW in 2021, 1 GW more than in the Target Scenario, as higher run hours alone are not enough to replace exiting coal at slower renewables build-out rates. Capacity is about the same, but gas run hours are much higher in the Pessimistic Scenario, whereas the Target Scenario mostly uses gas plants as peaking capacity due to rising volatile renewables generation.

Generation Mix

- German intermittent renewables generation more than doubles (+185 TWh) to 378 TWh in 2030 in the Target Scenario, ending up 120 TWh higher than in the pessimistic case where generation increases about one third (+65 TWh).
  - Onshore wind drives most of the difference as the Pessimistic Scenario adds 9 TWh – mainly from repowering existing plants – compared to additional 60 TWh in the Target Scenario. The Pessimistic Scenario represents a world where the government is not able to overcome local opposition to wind farms, as well as slow permitting and current distancing rules.
- Total coal generation drops to similar levels in both scenarios, with 23 TWh hard coal in the Target Scenario, and 22 TWh in the Pessimistic Scenario, 12 TWh of which comes from more emissions-intensive lignite generation.
  - In the Target Scenario, the remaining 6 GW of hard coal capacity are primarily newer CHP plants that see slightly higher full load hours due to a relatively lower carbon price.
  - Despite higher remaining capacities, hard coal and lignite plants reach a similar aggregate generation as hard coal in the Target Scenario case. Run hours are limited to heat generation (hard coal CHPs) as well as hours of high demand or low renewables generation.
- More renewables lead to significantly lower CCGT and natural gas peaker generation in the Target Scenario (121 TWh) compared to Pessimistic (193 TWh). This results in a more direct switch from coal to renewables and avoids 1 GW of CCGT investments as transition fuel capacity. The amount of gas peaker generation falls despite more volatile renewables generation, while capacity remains stable (-1 GW for CCGTs, but same capacity for gas peaking plants). The reason is that overall renewables generation is much higher in the Target Scenario, with a particularly strong role for additional onshore and offshore wind which have a more stable load profile.
- While in the Pessimistic Scenario, Germany is a net importer of 53 TWh (9% of net demand) in 2030, more electricity from renewables makes it a net exporter of 3 TWh in the Target Scenario.
- German net electricity demand in both scenarios rises by almost 7% from 564 TWh 2021 to 602 TWh in 2030. Out of the total increase, we expect 30 TWh to come from heat pumps, electric vehicles, and green hydrogen production. The remaining base demand increase of 28 TWh is mainly driven by electrification of industry, and rising demand from data centers, a part of which is offset by efficiency gains.



Sources: Aurora Energy Research, EPEX Spot, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Figure 10: Modelling Results – Germany – Wholesale Electricity Price

Wholesale electricity price outcomes

- Wholesale prices are 52% higher in the Pessimistic Scenario than in the Target Scenario in 2030. Compared to 2021 levels, prices would rise by 31% until 2030, if governments fail to remove renewables barriers, while decreasing a total 14% if Target Scenario renewables capacity is met. The delta would be even more pronounced when compared to the higher wholesale electricity prices observed in October 2021 which were driven by the European natural gas supply shortage.
- With 52%, the overall price delta between both scenarios in 2030 is particularly strong for Germany, and above the average of 44% for the six focus countries considered in this report. The main reason for this is the large difference in renewables capacity outcomes if Germany were to remove its current deployment barriers and align its build-out with the EU's climate targets. The higher renewables share would drive out more expensive gas generation and imports while also leading to lower carbon prices for the entire European Union.

Key Takeaways - Germany

- If the German government fails to remove existing barriers to renewables build-out while pursuing its target to keep 17 GW of lignite and hard coal capacity online until 2030:
  - Pessimistic Scenario power prices in 2030 could end up more than 50% higher than if renewable generation shares reach a level aligned with the European Commission's Renewables Directive.
  - Total natural gas generation would be 72 TWh (+60%) higher than in the Target Scenario with potentially 1 GW additional CCGT capacity being built. This significantly increases Germany's natural gas import dependence and the associated exposure to commodity price volatility as can be observed during the 2021 European natural gas supply shortage.
  - Hard coal and lignite capacities would be forced to remain online beyond 2030, despite low running hours. This is rather unlikely unless capacity payments, i.e. in form of a strategic reserve compensation for unprofitable coal plants would be introduced in Germany.
- If the government reaches renewables levels aligned with the shares represented in the European Commission's Renewables Directive for 2030:

- overall generation from renewables would reach more than 70% while natural gas would be less required as transition fuel. This assumption is rather on the moderate end for Germany as it is likely still below the level of renewables required for Germany to meet its 2030 climate target of -65% emissions reduction compared to 1990 levels.
- Only 6 GW of newer coal-, and CHP capacity would remain online and would be fully replaced by 2035 on a market-driven basis. Lower natural gas and electricity imports in this scenario would significantly decrease Germany's import dependence.

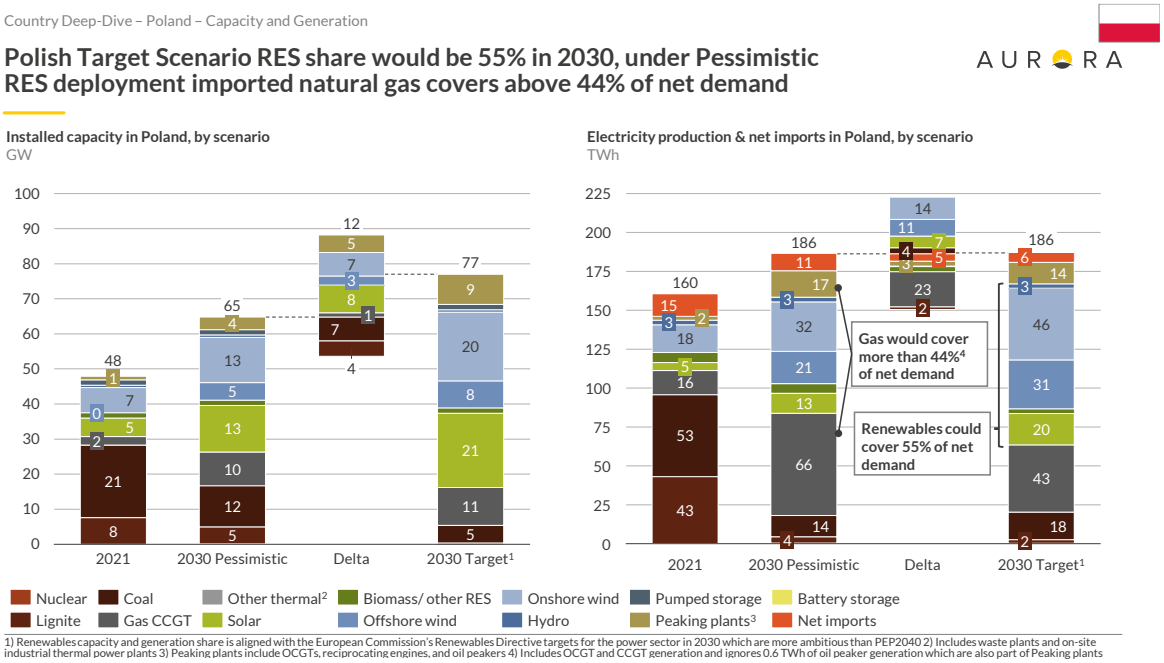
After its recent federal elections in September 2021, the new German government, will have to make important decisions on how to meet new climate targets set after the March 2021 climate change ruling of the federal constitutional court. As a response to the court's decision that the previous Federal Climate Protection Law was not sufficiently protecting the freedom and interest of future generations, on August 31st 2021 the outgoing government coalition passed a new climate law mandating a net zero emissions target by 2045 (previously 2050) with a 65% reduction over 1990 levels in 2030 (up from 55%). The law includes detailed targets for each sector until 2030, as well as a continuous monitoring requirement to ensure compliance.[8] Among the most important topics for the newly-elected government is the question of how to increase German renewables generation to a level that enables rapid decarbonisation of the electricity sector, while enabling the electrification of other areas such as parts of transport, industry, and heating.

- If current barriers are not overcome, this risks the competitiveness of German industry, due to higher carbon and wholesale electricity prices and increases exposure to natural gas price volatility.
- If barriers are removed, this would also limit the role of natural gas as a transition fuel together with Germany's geopolitical dependence on imported natural gas.

The Target Scenario in this report plans with a share of just above 70% renewables generation in 2030. This is aligned with the European Commission's Renewables Directive for 2030 which sets targets at EU level. However, it is very likely below the amount of renewable electricity required to meet Germany's domestic 2030 targets as outlined in the new Climate Protection Law and probably as well below the targets which will be set by updated EU efforts sharing regulations. As a result, Target Scenario renewables shares for Germany can be seen as rather moderate and may result more aggressive than the considered levels. Still, the conclusions of this report remain the same and partly result even stronger for Germany: All-else being equal, higher-than Target Scenario renewables shares would lead to even lower German wholesale power prices and gas generation, which would further widen the gap to a potential Pessimistic Scenario outcome.

[8] https://www.bundesregierung.de/breg-de/themen/klimaschutz/klimaschutzgesetz-2021-1913672

5.2 Poland



Source: Aurora Energy Research

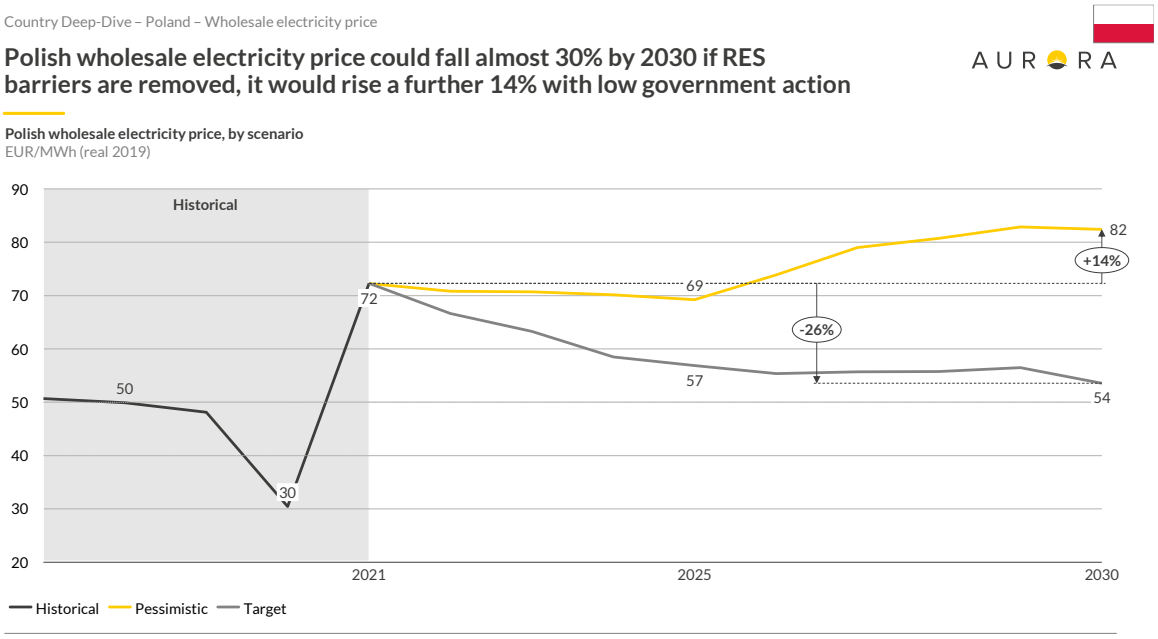
Figure 11: Modelling Results – Poland – Capacity and Generation

Capacity Outcomes

- 2021 intermittent renewables capacity of 12 GW almost quadruples to over 48 GW in the Target Scenario while reaching 31 GW in the Pessimistic Scenario.
  - Target Scenario solar capacity increases the most adding 16 GW, followed by onshore wind almost tripling from 7GW to 20 GW, and offshore building a total 8 GW until 2030.
  - Under Pessimistic government action, solar increases 8 GW, followed by onshore with 6 GW, and offshore adding 5 GW. This reflects overall lower government ambition in terms of i.e. a continuation of the current 10h distancing rule and for taking on investor risks.
- Total hard coal and lignite capacity drop to 5 GW and 400 MW respectively in 2030 if the Polish government allows for a market-driven retirement of hard coal and lignite plants as reflected in the Target Scenario. Due relatively stable carbon prices, coal retirement is primarily driven by increasing renewables. The Pessimistic Scenario instead, assumes retirements based on the technical lifetime of coal plants which for hard coal capacity is broadly aligned with the Polish Energy Policy for 2030 (PEP2040) in year 2030, but retires some lignite plants where shut-downs have already been announced. A total 12 GW of hard coal and 5 GW of lignite would remain in the system, mainly to meet political demands to maintain the domestic coal industry, and to address concerns around security of supply and even further gas investments.
- Total natural gas capacity is 6 GW higher in the Target Scenario in 2030 as under Pessimistic Scenario developments, with 5 GW coming from OCGT peaking plants and about 1 GW in additional CCGTs. This moves a bit against the European trend of generally stagnant or lower gas capacity in the Target Scenario by 2030. It reflects an overall quicker shift in the Polish power market – which currently has very low gas capacities – to a renewables-based system without coal to provide security of supply. More renewables require more flexible capacity that can react quickly in hours of high demand or low renewables generation. Overall gas generation however, is lower in the Target Scenario as will be explained in the following section.

Generation Mix

- Generation from intermittent renewables in Poland more than quadruples (+75 TWh) to 98 TWh in 2030 in the Target Scenario, ending up 32 TWh higher than in the pessimistic case where generation almost triples (+42 TWh).
  - In Poland, onshore wind is responsible for most of the difference between scenarios with Pessimistic adding 14 TWh, whereas the Target Scenario results 28 TWh higher. The difference stems from a continuation of the 10H distancing rule and continued low effort to take on investor risks.
- Total coal generation drops to similar levels in both scenarios. In the Target Scenario 18 TWh come from hard coal plants and 2 TWh from lignite, whereas the Pessimistic Scenario sees 14 TWh of hard coal and 4 TWh of more emissions-intensive lignite generation in 2030.
  - In the Target Scenario, the 5 GW remaining hard coal capacity are mostly newer hard coal plants or CHPs that are either heat-driven or run slightly more due to a lower carbon price.
  - Despite higher remaining capacities, hard coal (12 GW) and lignite plants (5 GW) reach almost the same aggregate generation as hard coal in the pessimistic case. Run hours are limited to heat generation (hard coal) as well as hours of high demand or low renewables generation where coal meets security of supply at much higher costs than natural gas peaking plants do in the Target Scenario (resulting in higher wholesale electricity prices).
- More renewables and market-driven retirements lead to a significantly faster retirement of coal and lignite capacity, which in turn requires additional flexible generation to provide security of supply. Despite 1 GW higher CCGT-, and 5 GW higher OCGT capacity required for peak demand hours in 2030, Target Scenario generation ends up more than 34% lower for CCGTs (-23 TWh) and 19% lower for OCGTs (-3 TWh) compared to Pessimistic Scenario levels. If the Pessimistic Scenario were to prevail, about 44% of Polish generation would come from natural gas, resulting in a significant import dependence and exposure to commodity price volatility in 2030.
- If the Polish government would enable renewable generation shares aligned with the European Commission's Renewables Directive, 2030 imports (6 TWh) would be just half the level as in the Pessimistic Scenario (11 TWh) and 60% lower than levels modelled for 2021.
- Polish net electricity demand rises 16% from 160 TWh in 2021 to 186 TWh in 2030. Out of the total increase, we expect 7 TWh to come from heat pumps and electric vehicles with significant green hydrogen demand for electricity not seen before the 2030s. A 12% rise in the remaining base demand of19 TWh is primarily driven by strong economic growth expected until 2030 which is partially offset by an increasing decoupling of economic growth and electricity demand due to rising efficiency.



Sources: Aurora Energy Research, entso-e

Figure 12: Modelling Results – Poland – Wholesale Electricity Price

Wholesale electricity price outcomes

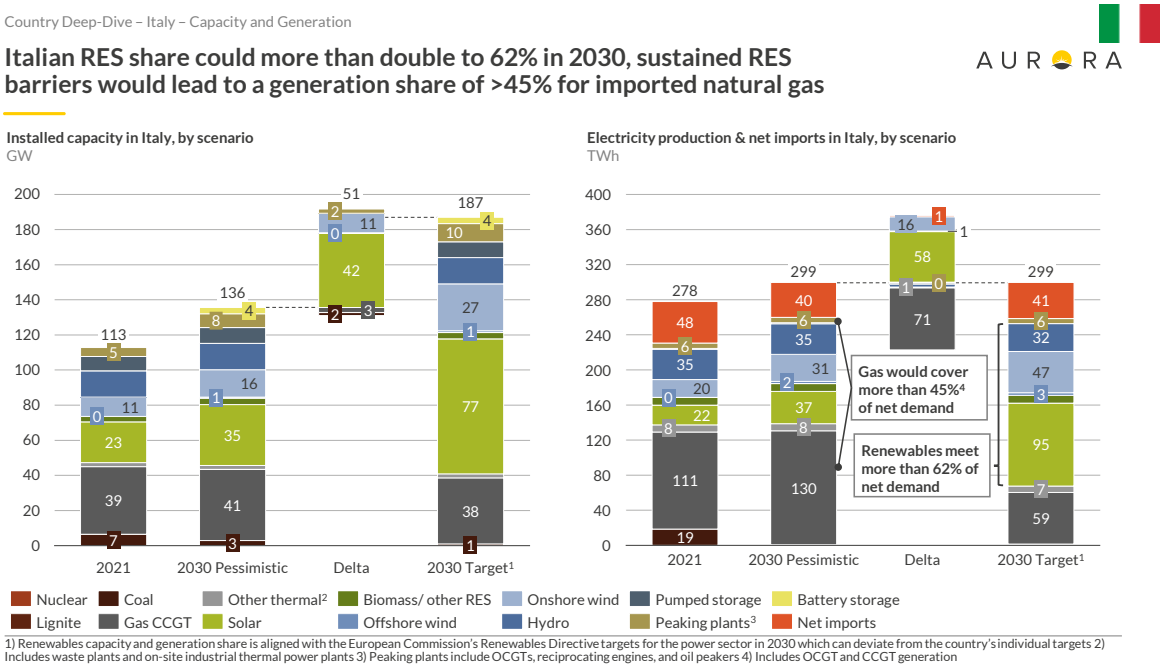
- Wholesale prices are 55% higher in 2030 in the Pessimistic Scenario when compared to Target Scenario levels in the same year. Target Scenario prices would result 26% lower than 2021 wholesale prices which are relatively high due to Poland's high emissions intensity resulting from hard coal and lignite generation. The difference would be even more pronounced if 2030 Target Scenario prices were compared to even higher prices observed in October 2021, which were driven by the European natural gas supply shortage.
- Pessimistic Scenario wholesale prices would be 14% higher than 2021 price levels. Since Poland is among the countries with the highest emissions intensity, 2021 prices are already at a high level and the price reduction potential of decarbonising the power sector (i.e. through additional renewables) is larger than in other countries with lower emissions intensity. Wholesale electricity prices don't rise much further in the Pessimistic Scenario as coal and lignite generation is not encouraged and mostly unprofitable due to the high carbon price. Instead it would be mostly replaced by additional natural gas generation due to its lower emissions intensity than coal.
- ***Note on PEP2040 sensitivity:*** If Poland were to subsidise coal and lignite generation to meet its PEP2040 generation targets, this would lead more emissions-intensive coal to set the price in many hours while paying carbon prices above 90 EUR/tCO2. As a result Polish wholesale electricity prices would rise significantly above the levels observed in the Pessimistic Scenario.
- Both the outcomes of the Pessimistic Scenario, and the PEP2040 sensitivity would aggravate the problem of energy poverty in Poland due to rising wholesale electricity prices which would increase end-consumer electricity bills.

Key Takeaways - Poland

- Even if the government does not provide generation subsidies for coal to meet its PEP2040 generation targets as represented in the Pessimistic Scenario, a continuation of age-based instead of economically driven retirement combined with a failure to deliver on renewables capacities would:
  - Increase wholesale electricity prices by a further 14% above levels observed in Mid-2021, further complicating the problem of energy poverty in Poland due to likely higher end-consumer electricity bills.
  - result in a significantly higher dependence on imported natural gas covering 44% of net demand in 2030. This would increase Poland's exposure to future gas price volatility, without leading to politically desired higher coal capacity factors.
  - see Polish dependency on electricity imports remain at 11 TWh, or 6% of net demand in 2030 as opposed to just 6 TWh or 3% in the Target Scenario.
  - likely require strategic reserve payments for coal and lignite plants – which even further increases end-consumer costs – because these plants are unlikely to recover their fixed costs from very low run-hours in 2030.
- Were Poland to overcome its renewables barriers and implement a strategy in line with reaching EU Renewables Directive targets in 2030, this would:
  - result in wholesale electricity prices to fall by 26% compared to 2021 levels in 2030
  - limit Polish dependency on imported natural gas and associated price volatility and reduce electricity imports from currently 15 TWh to about 6 TWh (instead of 11 TWh in the Pessimistic Scenario)
  - cover more than 55% of net demand through domestic renewables generation
- ***Sensitivity analysis – Pessimistic Scenario with Polish PEP2040 coal generation in 2030:*** *The Polish Government's current Energy Policy for 2040 (PEP2040) was published before the EU agreed on its higher 2030 emissions target and sets out very conservative targets for the reduction of coal firing and for raising renewables generation until 2030. If beyond the implementation of Pessimistic Scenario assumptions at the EU level, Poland were to follow through on its PEP2040 coal generation targets, this would:*
  - *result in a significantly larger share of coal in the energy mix than reached under the Pessimistic Scenario for Poland and require direct subsidies of coal generation which could become a strain for the government's budget and likely violate EU state-aid rules.*
  - as shown on Figure 7, by itself raise carbon prices by 114% over Target Scenario levels, or 20% above Pessimistic Scenario levels, reaching more than twice the level observed in Mid-2021. This further reduces the profitability of coal plants that remain in the system.[9]
  - *significantly threaten the competitiveness of European Industry which would face not only higher carbon-, but also power prices due to the increased EU ETS price. This is likely to trigger public opposition from EU industry lobbies and governments alike.*
  - *Further aggravate the problem of energy poverty due to the effect of rising wholesale electricity prices on end-consumer electricity bills*

[9] Please note that electricity prices under a PEP2040 coal generation levels in 2030 were not modelled within the scope of this study, but would result even higher than in the Pessimistic Scenario due to the higher carbon price

5.3 Italy



Source: Aurora Energy Research

Figure 13: Modelling Results – Italy – Capacity and Generation

Capacity Outcomes

- 2021 intermittent renewables capacity of 34 GW triples to 104 GW in the Target Scenario while reaching 51 GW in the Pessimistic Scenario.
  - Target Scenario solar capacity increases by far the most with 54 GW, followed by onshore wind rising 16 GW. Offshore builds 1 GW of capacity due to comparably low wind speeds and ocean depths requiring floating installations.
  - Under Pessimistic government action, solar increases 12 GW, followed by onshore with 5 GW, and offshore adding 600 MW. This reflects overall lower or failed government efforts to accelerate permitting processes.
- Italian hard coal capacity drops to 1 GW in 2030 and is fully phased-out at the end of the year in both scenarios – slower than the government had originally planned, when it aimed to shut down all coal by 2025. The reason is that it is not foreseeable how the remaining hard coal capacity in Sardinia will be replaced. The coal plant on the island is considered relevant for security of supply and a replacement would require three conditions to be met: First the finalization of the Sicily-Sardinia Interconnector which is likely not done completed before 2028 according to Italian TSO TERNA, second a flexible replacement capacity such as a new natural gas plant or batteries and thirdly, if the option is natural gas-based, the construction of a gas pipeline to the island that enables the operation of this natural gas plant which is considered controversial.

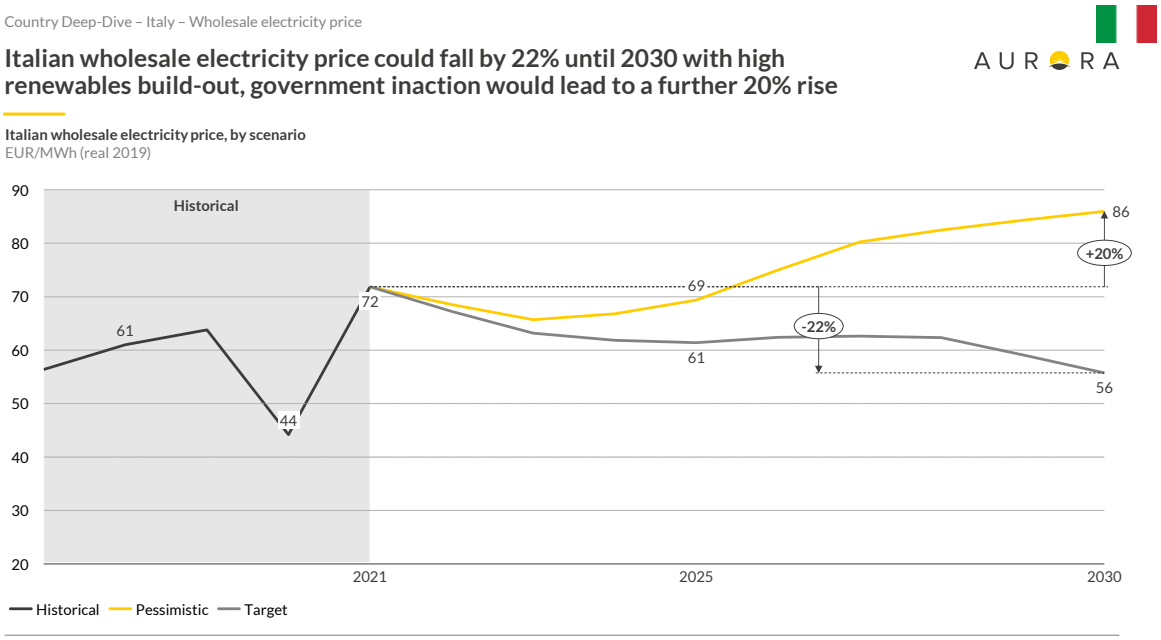
  Beyond the Sardinia coal plant, the Pessimistic Scenario assumes that 2 GW of capacity in Brindisi remain online until 2030 which is still a possibility as the plant is considered relevant for security of supply. If the Italian Capacity Market continues to deliver less capacity than targeted by TERNA the plant might be required to remain online until 2030.
- Total natural gas capacity is about 1 GW higher in the Pessimistic Scenario than in Target. Most relevant to mention is that the Target Scenario sees 3 GW less CCGT capacity, but 2 GW more gas

peakers, a reflection of a system that requires mainly natural gas peaking plants with lower run hours for a system with a higher share of renewable generation. Total CCGT capacity is even 1 GW lower in 2030, than in 2021. In the Pessimistic Scenario, 2 GW of additional CCGT capacity would be built by 2030, increasing Italy's dependence on natural gas in the power sector.

Generation Mix

- Intermittent renewables generation in Italy more than triples (+102 TWh) until 2030 in the Target Scenario. This is 74 TWh higher than in the Pessimistic Scenario where generation increases by 64% (+27 TWh).
  - Italian solar generation drives most of the increase in renewables in the Target Scenario, adding 73 TWh alone until 2030 and more than quadrupling 2021 generation. This is followed by onshore with 27 TWh. A nascent offshore industry adds 3 TWh. In the Pessimistic Scenario, solar adds 15 TWh, onshore 11 TWh, and offshore 2 TWh until 2030.
- Italian coal generation drops from 19 TWh to zero in both scenarios. Coal generation in 2030 is replaced mostly by renewables in the Target Scenario and – to a larger degree – by additional CCGT generation in the Pessimistic Scenario. In both cases plants would likely be put in a strategic reserve with the sole purpose of ensuring security of supply, especially on the Island of Sardinia.
- More intermittent renewable electricity with simultaneous coal capacity retirement requires additional flexible generation to provide security of supply. Despite rising from 4 to 10 GW OCGT capacity in the Target Scenario, generation remains stable at just above 5 TWh per year, reflecting higher but similarly frequent demand peaks that cannot be met by renewables alone. CCGT generation drops by a total 52 TWh, or 47% of 2021 levels due to higher renewables shares. Overall generation from natural gas drops from covering 42% of net demand in 2021, to just 21% in 2030, significantly reducing Italy's dependence on natural gas imports for the power sector as well as its exposure to commodity price volatility.
- In the Pessimistic Scenario, generation from OCGT plants also remains stable at 5 TWh annually, while 3 GW instead of 5 GW of capacity as would happen in the Target Scenario. CCGT generation rises by 20 TWh to 130 TWh until 2030, 17% above 2021 levels. This reflects a shift from coal to natural gas as a transition fuel which would cover approximately 45% of Italian net demand in 2030, increase the country's dependence on natural gas imports in the power sector as well as its exposure to future commodity price volatility.
- Net imported electricity would remain at a similar level of about 40 TWh in the Pessimistic Scenario, and 41 TWh in the Target Scenario in both cases receding slightly from 2021 levels of 48 TWh.
- Italian net electricity demand rises more than 7% from 278 TWh[10] in 2021 to 299 TWh in 2030. We expect most of the increase to be driven by EVs and heat pumps adding 14 TWh of demand. At the same time, we don't assume significant green hydrogen electricity demand before the 2030s. Base demand rises by more than 8 TWh or 3%, with 1.5 TWh additional demand growth in industry behind the meter. This is mainly driven by moderate economic growth expectations of around 1% after the end of the COVID-19 pandemic for which we expect 2019 demand levels to be reached in 2025. Further efficiency gains also partially offset economic growth until 2030.

[10] excludes behind the meter consumption of almost 30 TWh in 2021



Sources: Aurora Energy Research, entso-e

Figure 14: Modelling Results – Italy – Wholesale Electricity Price

Wholesale electricity price outcomes

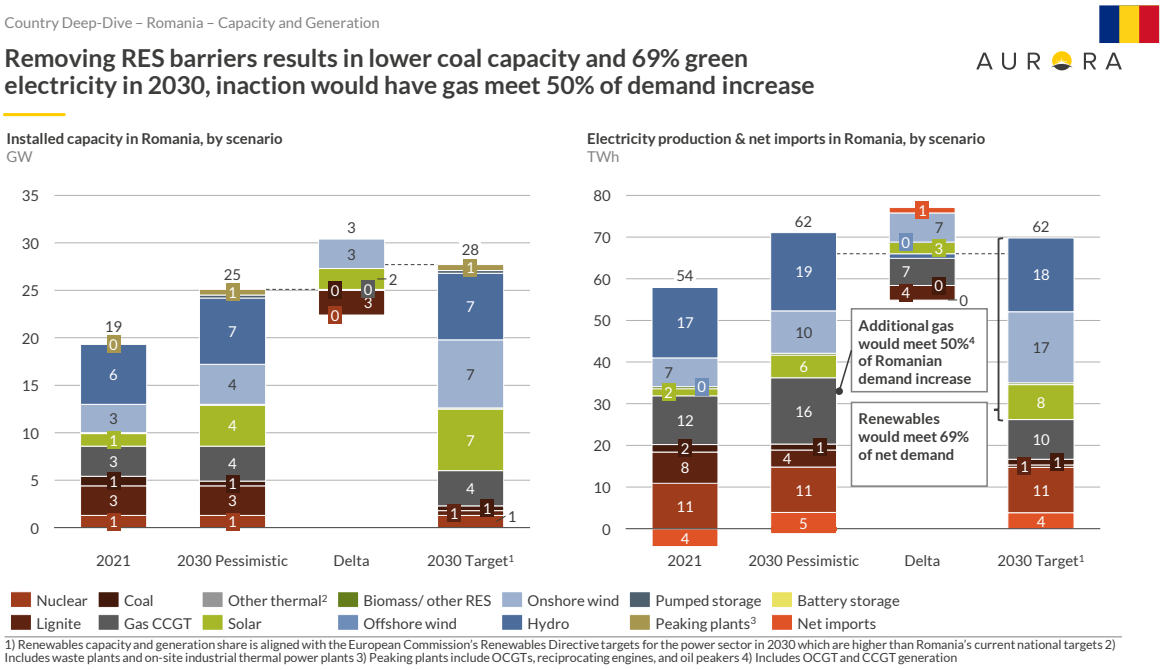
- Wholesale prices are 54% higher in 2030 in the Pessimistic Scenario than levels seen under Target Scenario assumptions.
- Compared to Mid-2021 prices, Target Scenario wholesale electricity prices would result 22% lower, opposed to rising 20% in the Pessimistic Scenario with more natural gas and less renewables generation. The difference between 2021 prices and Target Scenario prices in 2030 would be even more pronounced when compared to price levels observed in October 2021 which were driven by the European natural gas supply shortage.

Key Takeaways - Italy

- If Italy fails to support renewables and overcome existing deployment barriers this would lead to:
  - wholesale prices rising 54% above levels reached in the Target Scenario in 2030 or 20% above levels observed in Mid-2021.
  - a further increase in the country's dependence on natural gas in the power sector rising from meeting 43% of net demand in 2021 to about 45% in 2030. This would maintain or even increase the risk of being adversely affected by future natural gas price volatility as seen during the supply shortages in Fall 2021.
- If Italy enabled renewables build-out in line with the generation shares targeted in the European Commission's Impact Analysis and Renewables Directive, it would enable:
  - wholesale electricity prices to fall by 22% below Mid-2021 levels (opposed to rising 20%), a decrease which is even more pronounced when compared to levels observed in October 2021, during the European natural gas supply shortage.
  - halving Italian dependence on natural gas in the power sector. The share of net demand met by natural gas plants would be reduced from over 42% in 2021 to just over 20% in 2030 and significantly reduce Italy's power market exposure to natural gas price volatility.

  - intermittent renewables generation reaching a total 144 TWh, more than three times higher than current levels covering a total 67% of net demand after adding hydro and biomass generation (total 185 TWh).
- Electricity imports would fall slightly from 48 TWh to about 40 TWh in both scenarios, either driven by higher natural gas (Pessimistic Scenario) or renewables generation (Target Scenario).

5.4 Romania



Source: Aurora Energy Research

Figure 15: Modelling Results – Romania – Capacity and Generation

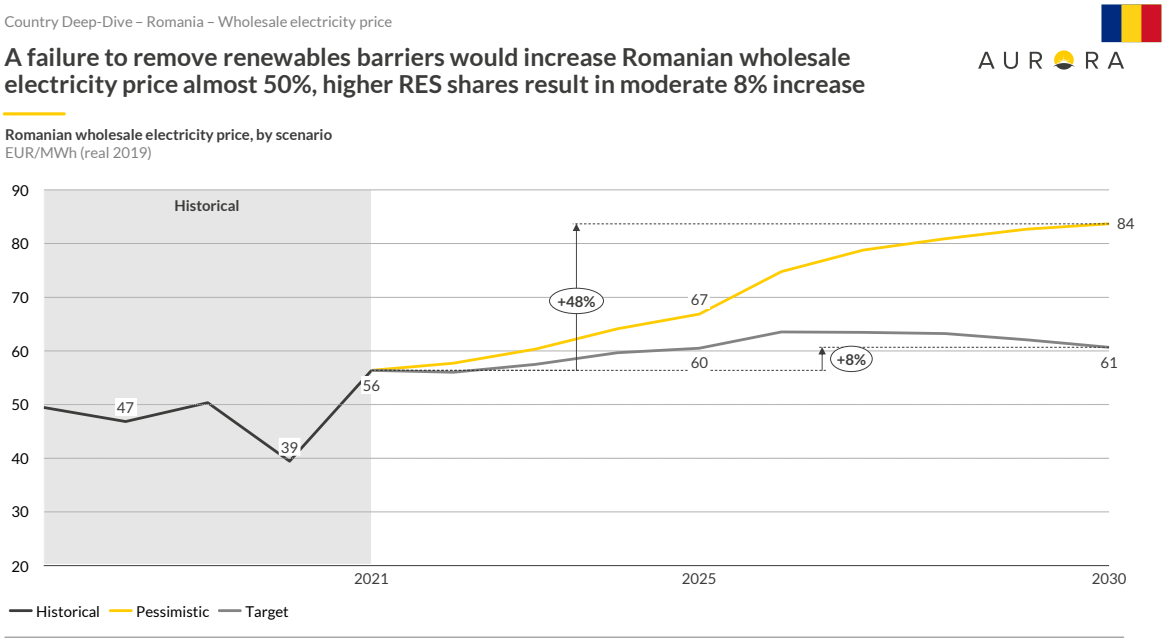
Capacity Outcomes

- Romanian intermittent renewables capacity more than tripples from 2021 levels of 4 GW to almost 14 GW in 2030 in the Target Scenario while reaching 8 GW in the Pessimistic Scenario.
  - Target Scenario solar capacity increases the most by 6 GW to reach 7 GW in 2030, followed by onshore wind increasing from 3 GW to 7 GW. Due to the relatively low amount of RES build-out this scenario would likely not require any subsidies, but rather reflect increased investor trust in merchant projects and lower administrative barriers. We don't expect any offshore wind to be deployed until the 2030s.
  - Under Pessimistic Scenario government support for renewables, solar increases 3 GW and onshore wind about 1 GW reaching a total 4 GW of installed capacity for each technology in 2030. This scenario reflects more investor uncertainty around the development of merchant projects, i.e. a difficulty in finding credit-worthy PPA offtakers and a persistence of currently high balancing costs.
- Romanian hard coal and lignite capacity drop to about 500 MW each in 2030 in the Target Scenario which allows for market-driven retirements of coal plants. This represents a closure of ¾ of total capacity, which stands at around 3 GW for lignite and 1 GW for hard coal in 2021.
- In the Pessimistic Scenario, all lignite plants continue to operate due to security of supply concerns under rising demand and continued low levels of renewables generation. Hard coal capacity lands at 500 MW, the same as in the Target Scenario due to retirements at the end of plants' technical lifetime. The Pessimistic Scenario is still a bit more optimistic than Romania's NECP which would see just a 12% decline in coal generation between 2019 and 2030. These targets were posted before the EU increased its climate target for 2030 from a 40% to a 55% emissions decrease over 1990 levels. In August 2021, Romania announced its coal capacity would retire by 2032, with a majority to close until 2025. Considering this, assuming a Pessimistic Scenario with a faster-than NECP targets coal exit seemed reasonable.

- Total natural gas capacity rises by about 1 GW in both Scenarios with 400 MW new CCGTs and 600 MW new OCGTs. The small difference between the two scenarios is mainly due to the fact that Romania has approximately 7 GW of hydro capacity which provides flexibility in hours of peak demand.

Generation Mix

- Romanian intermittent renewables generation triples until 2030 in the Target Scenario (+17 TWh) to almost 26 TWh, 10 TWh higher than generation reached under the Pessimistic Scenario which increases by 83% reaching 16 TWh.
  - Onshore generation increases the most adding 10 TWh, followed by 7 TWh of solar. We expect offshore wind not to take off until the 2030s, even in the Target Scenario.
  - As listed in the capacity outcomes section, Pessimistic Scenario onshore wind build-out is limited due to investor uncertainty around the development of merchant projects, i.e. difficulty finding credit-worthy PPA offtakers and a persistence of currently high balancing costs. As a result, solar adds 4 TWh, and onshore 3 TWh of generation until 2030.
- Coal- and lignite generation in Romania drop from almost 2 TWh and 8 TWh (rounded) each, to about 1 TWh for each technology in 2030 representing an 80% reduction of coal generation in the Target Scenario. In the Pessimistic Scenario, lignite generation remains four times as high at 4 TWh, while hard coal remains the same. Total coal generation is thus reduced by just over 40% until 2030. This scenario follows mainly a security of supply logic by the government in case not sufficient renewables or gas capacity is commissioned. Besides the capacity difference, the coal generation gap between the two scenarios is mainly filled by 10 TWh higher renewables generation, and 1 TWh lower imports in 2030 in the Target Scenario.
- Higher renewables generation leads to a 2 TWh decline in generation from CCGT plants in the Target Scenario compared to 2021 levels opposed to a 4 TWh increase in the Pessimistic Scenario, where some retiring coal and little renewables build-out meets increasing Romanian electricity demand. Higher RES shares would decrease Romania's reliance on natural gas as a transition fuel as opposed to replacing coal with natural gas emissions in the Pessimistic Scenario.
- In both scenarios Romania becomes a net importer of electricity in 2030, primarily driven by an 8 TWh (15%) increase in net demand. Still, the Target Scenario sees 1 TWh less of net imported electricity (4 TWh) than the Pessimistic Scenario (5 TWh) due to higher amounts of renewable generation.
- Romanian net electricity demand rises 15% from 54 TWh in 2021 to 62 TWh in 2030. Out of the total increase, we expect 1.5 TWh to come from heat pumps and electric vehicles. A 7 TWh or 13% rise in the remaining base demand is primarily driven by strong economic growth expected until 2030 which is partially offset by an increasing decoupling of economic growth and electricity demand due to rising efficiency.



Sources: Aurora Energy Research, entso-e

Figure 16: Modelling Results – Romania – Wholesale Electricity Price

Wholesale electricity price outcomes

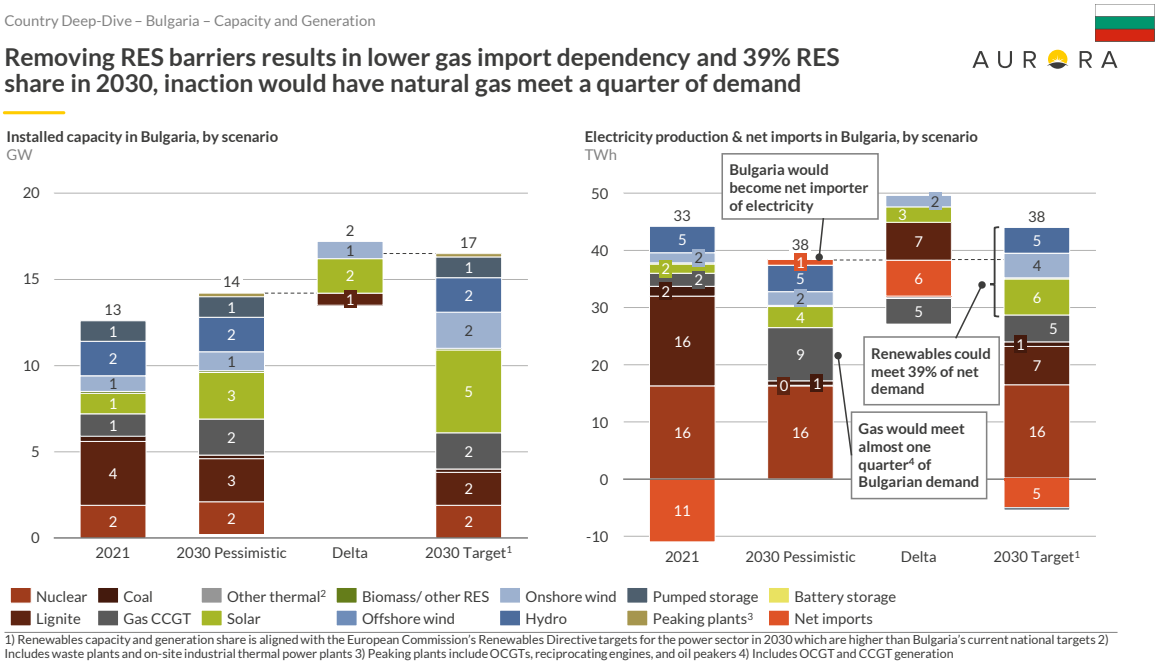
- Wholesale prices would be 38% higher in the Pessimistic Scenario vs. Target Scenario levels in 2030. Compared to Mid-2021 levels, Romanian wholesale prices would increase by almost 50% in the Pessimistic Scenario, reflecting rising carbon prices together with rising gas generation and 5 TWh of coal and lignite generation remaining in the power mix. Due to its effect on end-consumer electricity prices, rising wholesale electricity prices would further complicate the problem of energy poverty in Romania.
- To the contrary, Prices would rise about 8% if barriers to renewables deployment were removed between 2021 and 2030. Still, they would reach levels well below the prices observed during the European natural gas supply shortage in October 2021. The increase is primarily driven by increasing demand while we expect renewables to not receive much support beyond allowing for more market-driven development.

Key Takeaways - Romania

- If Romania fails to support the buildout of renewables and to overcome existing deployment barriers, as well as failing to implement an early phase out of coal and lignite, this would lead to:
  - Wholesale prices rising 38% above levels reached in the Target Scenario in 2030 or almost 50% above levels observed in Mid-2021 (before the European natural gas supply shortage). This would further complicate the problem of energy poverty in Romania since increasing wholesale electricity prices would also lead to rising end-consumer prices.
  - An increase in the reliance on natural gas as a transition fuel despite Romania's geographically favorable conditions with large amounts of flexible hydro generation and enough space for renewables deployment available. Instead, about 50% of Romania's 8 TWh demand increase until 2030 would be met by additional natural gas generation.
- If barriers to renewables development were removed to enable construction at a pace in line with generation shares reached under the Commission's Renewables Directive, this would enable:

  - Intermittent renewables generation to reach a total 26 TWh (41%), more than three times higher than current levels with renewables covering a total of 70% of net demand after adding hydro and biomass generation (total 44 TWh).
  - The reduction of Romania's reliance on natural gas in the power sector by 19% (-2 TWh) despite a 15% demand increase during the same time period. From currently 22%, CCGTs would cover just over 15% of net demand in 2030. This would enable Romania to become more self-sufficient with its current level of natural gas production and lower its reliance on gas imports for the electricity sector.
  - Wholesale prices would be about 8% higher than in Mid-2021 before the European natural gas supply shortage, mainly driven by a significant increase in electricity demand and a rather moderate renewables build-out where most capacity is still added on a market-driven basis.
- Due to its significant rise in electricity demand, Romania would become a net importer of electricity in both scenarios until 2030. It would import 1 TWh less in the Target Scenario due to higher renewables generation (4 TWh) compared to the Pessimistic Scenario (5 TWh).

5.5 Bulgaria



Source: Aurora Energy Research

Figure 17: Modelling Results – Bulgaria – Capacity and Generation

Capacity Outcomes

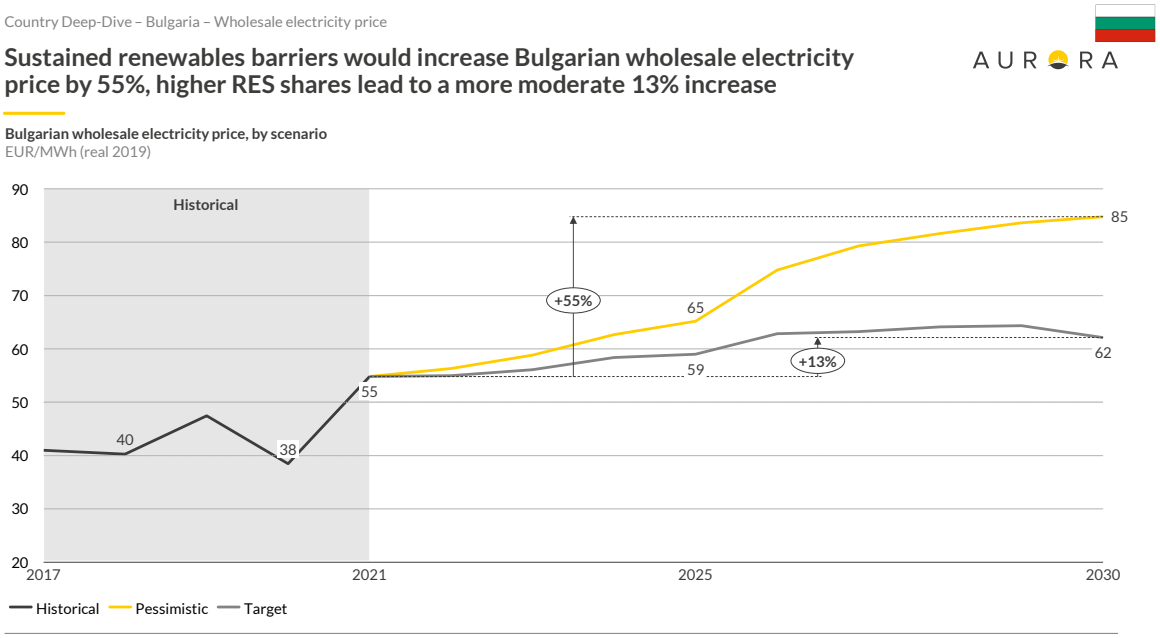
- Intermittent renewables capacity in Bulgaria increases more than threefold until 2030 in the Target Scenario reaching 7 GW, while under Pessimistic government support it almost doubles reaching 4 GW.
  - Target Scenario solar capacity rises the most adding almost 4 GW to reach 5 GW in 2030, followed by onshore wind more than doubling its capacity to 2 GW. We expect no offshore capacity in Bulgaria until the late 2030s.
  - Under Pessimistic government support for renewables, solar increases by just over 1 GW, and onshore wind about 200 MW. This reflects a list of factors leading to low investor trust for investing into merchant assets: First, the sudden reduction in feed in tariffs in 2012, after the country had met its initial EU targets one year early, second, the introduction of a 20% fee on FiT revenues for wind and solar in 2014, and third, continued levels of low transparency and an absence of a broader decarbonisaton plan for the country. Finally, this reflects the expectation of a continued slow development of the Bulgarian renewables PPA market due to a lack of clear regulation combined with low perceived credit worthiness of potential industrial and commercial offtakers. The combination of these factors significantly limits private investments in the country's renewables sector.
- Bulgarian lignite capacity is reduced by 50% or 2 GW until 2030 in the Target Scenario with hard coal retiring about 150 MW of its remaining 300 MW. The Target Scenario allows for a market-driven retirement of lignite plants.
- In the Pessimistic Scenario, lignite capacity falls by 1 GW until 2030 compared to 2021 levels mainly for political reasons to safeguard the domestic lignite mining industry but using the argument of security of supply concerns under rising demand and continued low levels of renewables generation. With 2.5 GW (rounded to 3 GW on Figure 17), the Pessimistic scenario is slightly more optimistic than Bulgaria's National Energy and Climate Plan (NECP) target for 2030 which would see 2.6 GW

of remaining lignite capacity in 2030. However, given that the NECP was published before the EU updated its 2030 climate ambition and in order to avoid even higher wholesale electricity prices, plus the sustained challenge of energy poverty for low income families in Bulgaria, we expect it is likely that the government will not support more coal capacity than currently considered in our Pessimistic Scenario.

- Total natural gas capacity in form of CCGTs rises by about 500 MW in both scenarios. About 2 GW of hydro and more than 1.2 GW of pumped storage capacity limit the need for additional natural gas plants despite an anticipated demand rise of 16% until 2030.

Generation Mix

- Bulgarian generation from intermittent renewables triples until 2030 in the Target Scenario (+7 TWh) to almost 11 TWh, 5 TWh higher than generation reached under the Pessimistic Scenario which increases about 75% to reach 6 TWh.
  - Solar generation increases the most adding almost 5 TWh, followed by onshore wind adding close to 3 TWh. We expect offshore wind not to take off until the late 2030s, even in the Target Scenario.
  - In the Pessimistic Scenario, onshore wind build-out is further limited as mentioned in the capacity outcomes section adding less than 1 TWh, while solar generation increases about 2 TWh until 2030.
- In the Target Scenario hard coal and lignite generation in Bulgaria drop by 1 TWh and 9 TWh each, to about 1 TWh for hard coal and 7 TWh for lignite in 2030 representing a 57% reduction of total coal generation from 2021 levels. In the Pessimistic Scenario, lignite generation falls to almost zero, due to high carbon prices and Bulgarian plants being among the oldest and least efficient lignite plants in the European Union. Hard coal generation in this scenario drops to below 1 TWh.
- The idea of keeping a total 1 GW additional lignite capacity online (2.5 GW total, rounded to 3 GW) in the Pessimistic Scenario when compared to the Target Scenario (1.9 GW, rounded to 2 GW) reflects mainly the government's wish to protect jobs in its domestic lignite industry while likely citing security of supply concerns as rationale for capacity payments to avoid investigations into state-aid violations (i.e. through direct subsidies of coal generation). Besides the capacity difference between the two scenarios, lower coal generation in the Pessimistic Scenario mainly leads to lower exports which drop less in the Target Scenario driven by higher renewables generation.
- Higher renewables generation leads to a modest increase in CCGT-generated electricity reaching 5 TWh from 2 TWh in 2021. In the Pessimistic Scenario, CCGT generation more than quadruples to 9 TWh or 24% of Bulgarian net demand in 2030. The Target Scenario would limit Bulgaria's use of natural gas as a transition fuel opposed to replacing coal with natural gas emissions in the Pessimistic Scenario despite favorable conditions for a hydro plus intermittent renewables system.
- In the Target Scenario Bulgaria remains a net exporter of electricity, albeit its net exports fall from 11 TWh to 5 TWh, driven by retiring lignite generation and rising domestic demand. In the Pessimistic Scenario, Bulgaria becomes a net importer of 1 TWh of electricity since domestic renewables (+3 TWh) and natural gas generation (+ 9 TWh) are not sufficient to cover rising demand (+5 TWh) and retiring coal capacity (-18 TWh).
- Bulgarian net electricity demand rises 16% from 33 TWh in 2021 to 38 TWh in 2030. Out of the total increase, we expect below 0.5 TWh to come from heat pumps and electric vehicles. An almost 5 TWh or 15% rise in the remaining base demand is primarily driven by strong economic growth expected until 2030 which is partially offset by an increasing decoupling of economic growth and electricity demand due to rising efficiency.



Sources: Aurora Energy Research, entso-e

Figure 18: Modelling Results – Bulgaria – Wholesale Electricity Price

Wholesale electricity price outcomes

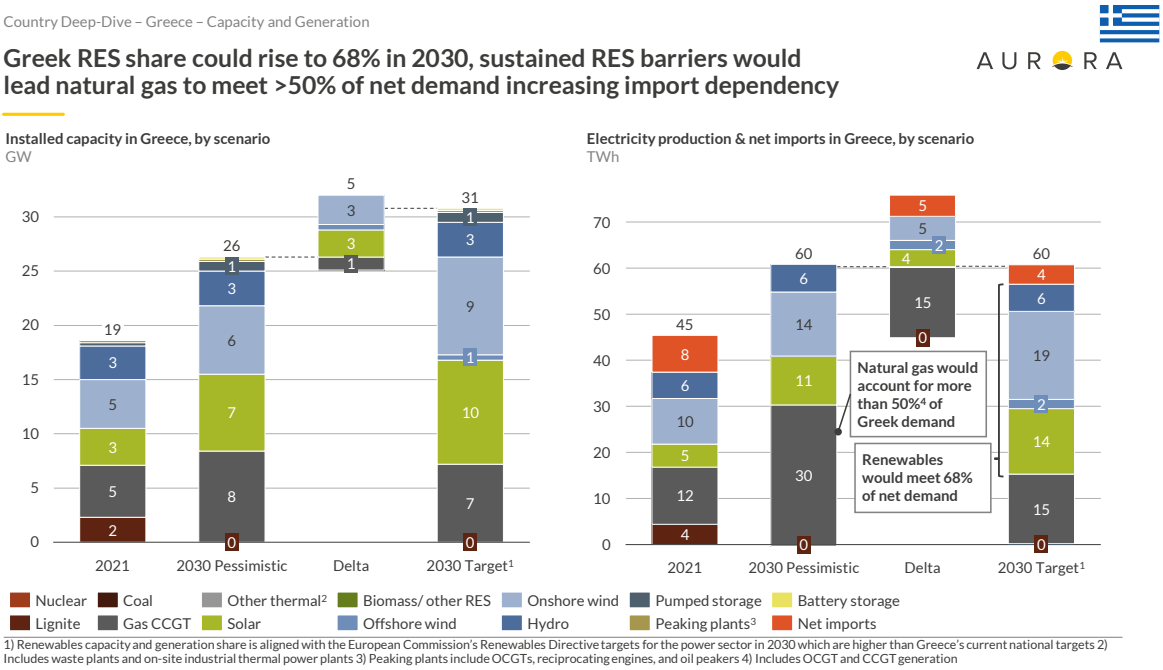
- Wholesale prices would result 36% higher in the Pessimistic Scenario compared to Target Scenario price levels in 2030.
- Compared to Mid-2021 levels, Bulgarian wholesale prices would increase by 55% in a Pessimistic Scenario, mostly driven by sustained high levels of lignite generation required to meet security of supply in absence of sufficient additional gas or renewables capacity. This would further complicate the problem of energy poverty in Bulgaria as wholesale electricity price increases are likely to translate into higher end-consumer electricity bills.
- In case the government enables more market-driven renewables deployment, prices would rise about 13% over 2021 levels in 2030 – still well below levels observed during the European natural gas supply shortage in October 2021 and levels seen in the Pessimistic Scenario in 2030. This increase in the Target Scenario is primarily driven by rising demand and an increased use of more expensive natural gas generation at carbon prices above 40 EUR/tCO2.

Key Takeaways - Bulgaria

- If the Bulgarian government is unsuccessful in supporting renewables and overcoming existing barriers to their deployment, this would lead to:
  - Wholesale prices rising 36% above levels reached in the Target Scenario when comparing 2030 prices. Compared to 2021, prices would increase by 55% until 2030 in the Pessimistic Scenario aggravating the problem of energy poverty due to its effect on end-consumer electricity bills.
  - An increase in the reliance on natural gas as a transition fuel despite Bulgaria's geographically favorable conditions with large amounts of flexible hydro and storage capacity and enough space available for renewables development. Instead, Bulgaria's natural gas generation would more than quadruple to meet a 16% electricity demand increase and lower lignite and hard coal generation (-18 TWh), with CCGT generation covering almost one quarter of net demand in

2030. This would increase the exposure of the Bulgarian wholesale electricity market to natural gas price volatility as seen during the natural gas supply shortage in Fall 2021.
  - Bulgaria becoming a net importer of 1 TWh of electricity in 2030 as increasing renewables (+3 TWh) and CCGT generation (+ 9 TWh) is not able to meet rising demand (+5 TWh) and retiring coal generation (-18 TWh).
  - Low utilization rates for lignite capacities, implying significant government subsidies will be required to cover power plant fixed costs to prevent them from shutting down.
- If barriers to renewables development were removed to enable construction at a pace in line with generation shares reached under the European Commission's Renewables Directive, this would enable:
  - Wholesale prices remaining at a manageable level just 13% above prices observed before the Fall 2021 gas supply shortage despite a significant demand increase of 16%.
  - Intermittent renewables generation reaching a total 11 TWh (28%), more than three times higher than current levels covering a total of 39% of net demand after adding hydro and biomass generation (15 TWh in total). By 2030 a Target Scenario Bulgarian power sector is more future proof as the country has made significant progress in installing RES capacity which makes further decarbonisation easier as if the country would need to continue from a lower level of deployment.
  - limiting a future reliance on natural gas to just half the levels seen in the Pessimistic Scenario – 12% of net demand in 2030 – up from 7% in 2021 would limit Bulgaria's exposure to future natural gas price volatility. This would happen despite a 16% demand increase (+5 TWh) in the same period and overall lignite and coal generation falling by 10 TWh.
- Bulgaria would see significantly higher lignite generation in the Target Scenario compared to the Pessimistic Scenario despite lower installed capacity. The reason for this is lower carbon prices and low renewables generation which enable more lignite run hours. As opposed to all other EU countries where renewables replace coal and lignite, we expect Bulgarian renewables build-out to be strictly limited to low amounts of market-driven development. Despite a potential slower decline of lignite run-hours, the Scenario still presents a higher ambition for the Bulgarian power sector for three reasons:
  - It leads to lower and more stable wholesale electricity prices
  - The power sector is better prepared for a complete transition to emissions free generation due to its already higher renewables share in 2030
  - A higher utilization for the remaining lignite capacity requires less government support to cover plant fix costs which puts less strains on the governments' budget
- Bulgaria would remain a net exporter of electricity in the Target Scenario despite its increasing demand since significantly higher renewables (+7 TWh) and some additional natural gas generation (+2 TWh) are able to fill the gap left by rising demand (+5 TWh) and lower coal generation (-10 TWh).

5.6 Greece



Source: Aurora Energy Research

Figure 19: Modelling Results Greece – Capacity and Generation

Capacity Outcomes

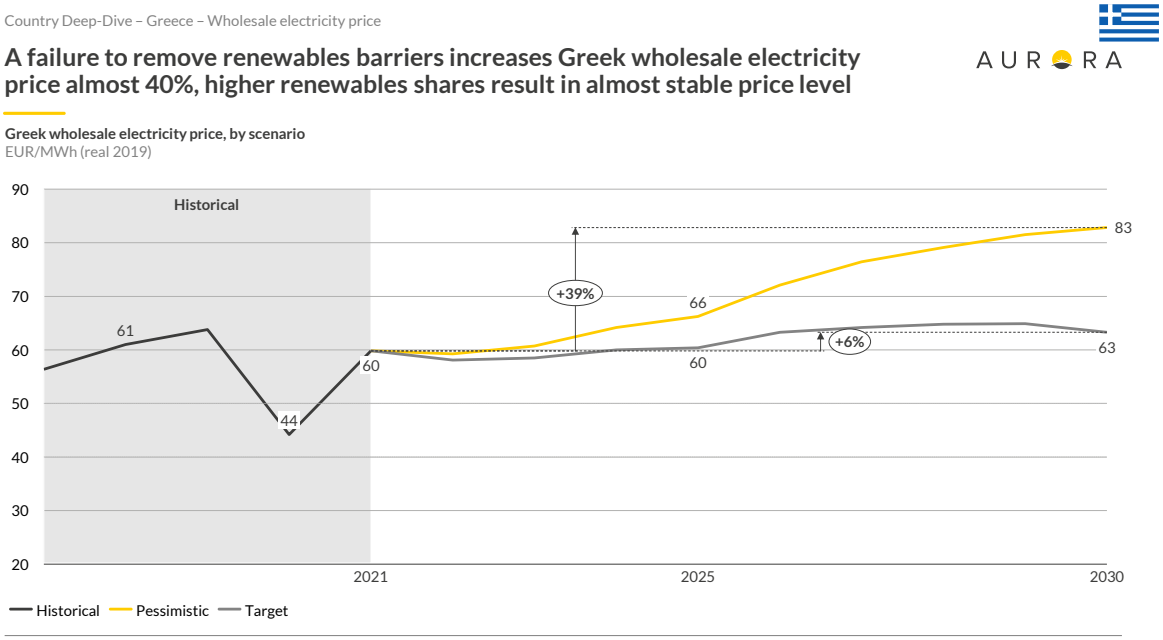
- Intermittent renewables capacity in Greece increases by 142% (>11 GW) until 2030 in the Target Scenario, while under Pessimistic government support it rises by about half this amount or 70% (< 6 GW) in the same time.
  - Target Scenario solar capacity rises most significantly by more than 6 GW, reaching 10 GW in 2030, followed by onshore wind almost doubling from below 5 GW to 9 GW. We assume that about 0.5 GW of offshore capacity will be deployed until 2030.
  - Under Pessimistic government support for renewables, solar increases by 4 GW, and onshore wind by less than 2 GW with no offshore development. For solar and onshore, this reflects sustained complicated permitting processes and banks that prefer financing projects that participate in auctions (which are very limited). Due to a relatively low PPA demand in Greece, the amount of merchant projects with secure revenue streams will be limited as will be the number of banks willing to take on market risks. An additional limiting factor for onshore development is local opposition to development, especially on the Greek islands. Offshore development is still at a very early stage, and delays in a vote on a future legal framework are possible. At the same time, Greece can only develop floating offshore wind which is riskier and more costly being a much newer technology than ground-mounted offshore. These factors combined could delay offshore development until beyond 2030.
- Greek lignite capacity falls to zero in the mid-2020s in the Target Scenario as significant solar and onshore build-out enable a timely retirement.
- In the Pessimistic Scenario, lignite capacity falls by 1.6 GW to about 700 MW remaining in the market mainly due to security of supply concerns under rising demand and continued low levels of additional renewables capacity. However, this capacity generates no further electricity in an average weather year in terms of temperatures as well as wind and solar generation and thus becomes redundant. By definition of the Pessimistic Scenario the remaining lignite plant is forced to

remain in the market to meet security of supply, i.e. in case of future summer heat waves as seen during the summer of 2021. However, it could also be allowed to retire after 2025 if the grid regulator deems it not relevant for security of supply in the future.

- Total natural gas capacity in form of CCGTs rises by about 2 GW in the Target Scenario and 4 GW in the Pessimistic Scenario from a level of 5 GW in 2021. Higher renewables capacities limit the amount of additional natural gas build-out despite exiting lignite capacities and an anticipated demand increase of 33% until 2030.

Generation Mix

- Greek intermittent renewable generation increases more than two-fold until 2030 in the Target Scenario (+20 TWh) to above 35 TWh, 11 TWh higher than generation reached under the Pessimistic Scenario which increases about 63% to reach 24 TWh in 2030.
  - Solar and onshore generation increase similarly, adding 9 TWh each. We expect offshore wind to generate approximately 2 TWh by 2030 in the Target Scenario. In the Pessimistic Scenario, solar adds 6 TWh until 2030. Onshore wind build-out is lower and adds about 4 TWh of generation within the next decade while offshore does not take off until the 2030s.
- Lignite generation in Greece drops to zero already in 2025. In the Target Scenario, all remaining lignite capacity retires by the end of 2024. In the Pessimistic Scenario, high carbon prices together with even higher CCGT generation drive out lignite generation until 2025.
- In the Target Scenario higher renewables and lower lignite generation leads to an increase in more flexible CCGT-generated electricity which reaches 15 TWh, up from 12 TWh in 2021. At the same time the share of gas in the electricity mix drops slightly from 27% to about 25% due to rising electr, limiting or even slightly lowering the exposure of Greek wholesale electricity prices to future natural gas price volatility. The net increase in gas-fired generation is also quite moderate considering an expected demand increase of 33% until 2030. In the Pessimistic Scenario, CCGT generation more than doubles to 30 TWh or above 50% of net demand in 2030, as renewables are not able to meet rising demand and simultaneously replace exiting lignite generation.
- In the Target Scenario Greek net imports are reduced by 50% to 4 TWh. The remaining imported electricity could be replaced by additional renewables build-out, i.e. through developing Greece's offshore wind potential which offers rather stable generation profiles. In absence of this, Greek electricity imports remain slightly higher than in the Pessimistic Scenario, especially in hours where renewables generation is relatively low, demand is high, and Bulgarian lignite plants continue to dispatch at moderate carbon prices in 2030 and in absence of renewable alternatives.
- In the Pessimistic Scenario net imports are reduced to zero, neighboring Bulgaria – which is Greece's largest source of electricity imports – needs to replace lignite – which has become unprofitable due to higher carbon prices – through additional gas generation and lower electricity exports. Due to lower imports from Bulgaria domestic Greek CCGT generation increases, especially in hours with low renewables generation. In this Scenario Greece would exchange its current dependency on Bulgarian lignite generation through an increased dependency on natural gas imports. Higher emissions from imported Bulgarian electricity (mainly lignite) would be replaced through increased price volatility, and security of supply risks as seen during the European natural gas supply shortage in Fall 2021.
- Greek net electricity demand rises 33% from 45 TWh in 2021 to 60 TWh in 2030. Out of the total increase, we expect 1 TWh to come from heat pumps and electric vehicles. An almost 14 TWh or more than 30% rise in the remaining base demand is driven by two factors (beyond the anticipated COVID-19 recovery); strong economic growth expected until 2030, which is particularly pronounced due to economic catch-up effects after reduced demand during the Greek debt-crisis in the early 2010s, and the interconnection of Greek islands with the country's mainland grid which adds 3.5 TWh or 8% of demand compared to 2021 levels.



Source: Aurora Energy Research, entso-e

Figure 20: Modelling Results Greece – Wholesale Electricity Price

Wholesale electricity price outcomes

- Wholesale prices would be 31% higher in 2030 in the Pessimistic Scenario compared to Target Scenario levels in 2030. From Mid-2021 to 2030 wholesale prices would increase almost 40% in the Pessimistic Scenario due to significantly more hours where more expensive CCGTs set the price while pricing in higher carbon prices. This would further aggravate the problem of energy poverty in Greece, as higher wholesale electricity prices would also translate to an increase in end-consumer electricity bills.
- In the Target Scenario, Greek wholesale prices would be very stable with a slight increase of about 6% until 2030 – significantly below levels observed during the European natural gas supply shortage in October 2021. This price increase in the Target Scenario is primarily driven by a 33% demand increase and a more limited availability of previously cheap Bulgarian lignite generation.

Key Takeaways - Greece

- If the Greek government is not successful in supporting renewables and overcoming existing barriers to their deployment, this would lead to:
  - Wholesale prices rising almost 40% above levels observed in the first half of 2021, and 31% above levels reached in the Target Scenario in 2030 further complicating the challenge of energy poverty in Greece.
  - Total 2030 CCGT generation would cover more than 50% of net demand in 2030, shifting the country's dependence on Bulgarian (mostly lignite) power imports to natural gas import reliance. This exposes the Greek power market to a significant risk in terms of future natural gas supply shortages despite Greece's geographically favorable conditions for cheap wind and solar generation. Beyond this, wholesale electricity prices would see an increased exposure to natural gas price volatility likely adding to investor uncertainty. Overall, Greek CCGT generation would increase by 143%, which is necessary to meet a 33% demand increase**Error! Bookmark not defined.** (+15 TWh) and lower lignite generation (-4 TWh).

  - Greek net imports would drop to zero at the cost of higher reliance on domestic CCGT generation and emissions. The reliance on previously imported Bulgarian electricity (mainly lignite) would be replaced through increased price-, and security of supply risks as seen during the European natural gas supply shortage in Fall 2021.
- If barriers to renewables deployment were removed to enable construction at a pace in line with the renewables shares targeted in the European Commission's Renewables Directive, this would enable:
  - Wholesale prices to be at about the levels seen in Mid-2021 (+6%) before the European natural gas supply shortage despite significant demand increases and well below levels observed in October 2021.
  - Intermittent renewables generation reaching a total 35 TWh (59%), more than two times higher than current levels covering a total of 68% of net demand with renewable electricity after adding hydro generation (total 41 TWh). This would allow a significant futureproofing of the Greek electricity mix and prepare the country for further decarbonisation in the 2030s.
  - Limiting an increased reliance on imported natural gas in form of CCGTs to one quarter of Greek net demand in 2030 (instead of over 50%), slightly lowering the power market's relative exposure to natural gas price volatility compared to 2021 levels (27%). A small increase in CCGT generation from 12 to 15 TWh is still required until 2030 due to Greece's significant demand increase and retiring lignite capacity.
- Greece would reduce its net electricity imports by 50% until 2030, reaching 4 TWh in the Target Scenario, with electricity coming primarily from Bulgaria in the form of mostly lignite and some hydro generation in hours with low wind and sun intensity but likely falling quickly with additional onshore and offshore generation in the 2030s.

5.7 Comment on the Czech Republic

This study puts a particular focus on EU countries that were-, or are still relying to an important degree on hard coal or lignite fired power generation. In this context, readers may ask themselves why the Czech Republic was not covered in detail given its' high share of lignite-fired electricity generation. The reason is the important role that lignite combined-heat-and-power (CHP) plants play in the Czech power sector. While Pessimistic Scenario assumptions would have relied on mainly aged-based retirement of lignite CHP plants, and fit into our general scenario definition, the creation of a Target Scenario for the Czech Republic would have required an in-depth analysis of different heat decarbonization pathways. In terms of consistency with our EU-level Target Scenario and considering the scope of this study this was not possible. Therefore, – although Czechia was part of the EU modelling scope – no detailed power market results for the Czech Republic were published. Despite this study's limitations, we can extract a list of key takeaways from our EU-level analysis and our country-specific market knowledge for the Czech Republic:

- Under Pessimistic Scenario assumptions, Czech power prices would develop in similar ways as seen in other countries with high coal and lignite generation resulting in a significant increase of wholesale electricity prices over Mid-2021 levels until 2030. This would threaten the competitiveness of the Czech industrial sector and aggravate the challenge of energy poverty due to the combined effect of higher carbon and wholesale electricity prices on end-consumers' heat and electricity bills. Natural gas-fired generation would likely play a slightly smaller role in wholesale price formation than in other countries since a minimum amount of lignite generation driven by heat demand would lead to lower CCGT run hours.
- Target Scenario outcomes would in general see lower wholesale electricity prices but depend to a great degree not only on the amount of renewable generation in the system, but on the deployment of carbon-free heat supply which is required to replace the existing fleet of lignite-CHP plants.
  - In absence of alternative sources of heat, lignite-CHP plants would continue to operate, especially driven by industrial and winter heat demand, even in hours where renewables generation is high and wholesale market price signals would not motivate their dispatch.
  - This underlines the importance for the Czech government to combine removing barriers to renewables deployment until 2030 with a comprehensive decarbonisation strategy for Czech heat-supply. Combining these two would enable the country to reach a decarbonisation of its power and heat sector while preserving competitive wholesale electricity prices and its domestic industry.

6. Conclusions

Outlook for a Pessimistic renewables and coal Power Scenario across Europe:
▪ If EU governments fail to overcome barriers to renewables build-out, 2030 carbon prices could rise almost 80% above Mid-2021 levels, while wholesale market prices may result on average 44% higher[11] in 2030 than in a case where barriers for renewables are removed.
▪ Both high EUA prices and high wholesale electricity prices would threaten the competitiveness of European Industry and exacerbate the problem of energy poverty, especially in Eastern and South-Eastern European countries where wholesale electricity prices account for a large share of end-consumer prices.
▪ Low renewables build-out increases Europe's dependency on imported natural gas with some countries meeting between 44-50%[12] of their net demand from natural gas generation. This increases the exposure to future natural gas price volatility which affects industrial and private consumers.
▪ In absence of accelerated renewables build-out, all countries will see increasing gas generation, some of which is enabled through building additional gas capacity. This delays an inevitable transition towards a renewables-based power sector.
▪ Coal plants that remain in the system until 2030 as suggested by current government plans or for security of supply reasons would face significantly lower run hours (except for Bulgaria)[13] in the latter half of the 2020s, likely requiring strategic reserve payments from governments to recover their fixed costs.
▪ ***If Poland decided to follow through on its Energy Policy for 2040 targets for coal generation*** in combination with Pessimistic Scenario assumptions, carbon prices would rise a further 20% above levels observed in the Pessimistic Scenario, reaching more than twice the level observed in Mid-2021. This would require significant amounts of direct subsidies for mostly unprofitable coal generation in 2030. Besides possible legal challenges due to state-aid regulation, the Polish government would likely be criticised for risking the competitiveness of European industry for the sake of extending the life of the Polish coal industry for a few years.

[11] Refers to the comparison of 2030 arithmetic means of Target and Pessimistic Scenario wholesale electricity prices across six focus countries. The overall price increasing trend would apply to all other European countries even though individual country results might deviate from this average.

[12] Refers to Poland (44%), Italy (45%), and Greece (50%) under Pessimistic Scenario assumptions in 2030

[13] The only exception is Bulgaria, where lignite is likely to play a role in 2030, unless the government allows for a renewables deployment higher than seen in the Target Scenario, or high carbon prices as in the Pessimistic Scenario drive a switch to more expensive gas generation, causing a more than 50% wholesale electricity price increase over the next decade.

Outlook for a Target Scenario with accelerated renewables build-out across Europe:
▪ If governments remove existing barriers to renewables deployment and enable a market-driven retirement of coal and lignite plants, both electricity and carbon prices would stabilise or even fall below currently observed levels for all focus countries we have analysed in this report. This would limit negative impacts on industrial competitiveness as well as on energy poverty. Since the same carbon price applies to all EU countries, this general trend can be expected to be mirrored by other EU power markets that were not analysed in detail in this study.
▪ The EU's dependency on natural gas imports would decrease for the power sector until 2030 despite rising electricity demand and coal phase-outs. This reduces power market exposure to future natural gas price volatility and puts member states in a better position for a further reduction of emissions, natural gas imports and generation throughout the 2030s.
▪ To reduce project LCOE and minimise the costs of renewables build-out, financing risks could be reduced through mechanisms such as CfDs or market premium schemes that reduce electricity price risk exposure for investors.
▪ Still, beyond the goals of preserving industrial competitiveness, and decarbonising the EU's power and industrial sectors, governments may want to pursue an overall stable EU ETS and power price level for two reasons: First it keeps the cost of subsidy payments low, especially if they are indexed to market prices i.e. via two-sided CfD schemes and second it sends important signals to investors that rely on stable and predictable carbon and electricity markets.
▪ Finally, Target Scenario levels of renewables deployment combined with allowing for a market-driven retirement of coal plants put the EU on a more realistic pathway towards achieving net zero emissions in 2050. The main reasons are a more future-proof European energy mix in 2030 with higher renewables shares and lower emissions, as well as lower wholesale electricity and carbon prices that maintain the competitiveness of European industry and don't aggravate the challenge of energy poverty.