Energy transition in Bulgaria

The case for an accelerated switching from coal to gas-fired generation

SUMMARY REPORT – Original version

4 April 2019

Executive summary

- In the transition towards the 2050 objectives set out in the Paris Agreement, stricter emissions standards and emissions targets have been adopted across Europe and coal generation is being phased out in a number of European countries
- Even in countries engaged on ambitious decarbonisation pathways, gas is perceived to have a key role to play in the transition, by ensuring security of supply and electricity affordability as coal power plants retire. Indeed, the properties of gas power plants (dispatchability, ramping rate, start-up time, cost) give this technology a clear advantage to manage the transition compared to existing alternatives. Additionally, the increased use of flexible gas generation enables to integrate and manage more renewables on the system, and as such to pursue the objective of decarbonisation
- This report undertakes a qualitative and quantitative assessment of an accelerated use of gas in the place of coal as a source of power generation in Bulgaria. Such an evolution would enable Bulgaria to make significant progress on the path to the longer term decarbonisation goals, whilst ensuring security of supply and affordability, and maintaining diversity in the generation mix. In addition, it would contribute to development of the Bulgarian gas market and its regional role

- Beyond the EU-wide push for decarbonisation, developments in the Bulgarian market create a favourable environment for a degree of coal-to-gas conversion
  - Bulgarian coal power plants are not compliant with the new standards of the EU Industrial Emissions Directive ('EU IED'); most of them have submitted a request for a derogation and/or are considering a fuel switch to continue operating beyond 2021
  - Bulgaria is likely to benefit from access to an increasing number of gas supply sources, including gas imported through TAP and IGB from the early 2020s and possible domestic production. The increased number of supply sources is likely to increase competition on the gas market in the medium term and may drive prices down
  - In light of significant interconnection investments with neighbouring countries, Bulgaria is positioning itself as a regional gas hub, and increased indigenous demand of gas for power generation would strengthen this position

- Drawing on the lessons highlighted in the country analogues, a successful transition from coal to gas in Bulgaria can be delivered through:
  - a strong political commitment, delivered in conjunction with all stakeholders
  - a particular focus on the trade unions and working with them on a sustainable transition of jobs from coal to other sectors
  - a comprehensive support package that is integrated in design and delivery across both central and local government
  - as a part of an integrated country energy strategy and set of policies pursuing the objective of decarbonisation and facilitating the construction of alternative generation sources such as gas and renewables

Executive summary

- In our assessment, we have brought forward the retirement of three coal plants as compared to the Base case, and assumed that these plants are replaced with new CCGTs
- We estimate outcomes under the Base case and the Accelerated coal-to-gas conversion case, and compute the difference in infrastructure costs, generation costs, security of supply, CO2 emissions and pollution and renewable deployment. We also undertake a high-level assessment of the total amount of support which may be granted to assist the accelerated coal-to-gas conversion and would be re-distributed within the national economy

- Under Reference assumptions, over the 2025-2050 horizon, we find that there are significant benefits associated with an early conversion to gas relating to:
  - Lower carbon costs, as well as health costs and social cost of carbon
  - Avoided CAPEX from coal air quality investments and lower fixed costs of gas power stations

- Overall, we conclude that the societal CBA for an Accelerated coal-to-gas conversion[1] is positive

CBA for a Medium Social Cost of Carbon	NPV (€m)
DIRECT Benefits/Costs	(902)
INDIRECT Benefits/Costs	3,275
Total	**2,373**
Distributional impact - Aid	**2,080**
Million tonnes	
CO2 savings	46

- Indicative estimates show that even the moderate acceleration away from coal such as the one we have modelled is likely to require significant support for the associated socio-economic transition. However, this support is likely to effect a redistribution within the national economy – it will generally lead to a transfer between parties and would not constitute an additional cost or benefit from the coal-to-gas transition reflected in the societal CBA

- Progression towards the 2050 goals will require the phase-out of coal in favour of renewables and gas along the decarbonisation pathway
- Our assessment shows that an accelerated conversion of coal to gas at an early stage is worthy of consideration and provides substantial societal benefits. Based on the study of country analogues, we also provide high-level guidance on the delivery of a successful coal-to-gas transition
- We expect that this study will inform the definition of a long term strategy for Bulgaria's energy mix and form the basis of policy applications, as well as specific investment cases in the future

[1] We have assumed in this study that coal capacity will need to comply with EU emission regulations, without receiving any special derogations from the EC. If we assume that coal capacity does not need to undertake compliance investments, the case for an Accelerated coal-to-gas conversion is stronger because of increased health costs that are avoided by switching to gas. We find that the benefits of the transition are highly dependent on the assumptions for social cost of carbon. However, even with a social cost of carbon of 0, there are net benefits of Accelerated coal-to-gas conversion

Introduction

- Baringa has been engaged to assess the case for an increased use of natural gas in the Bulgarian energy mix, and identify the opportunities and benefits of gas generation replacing coal generation at a faster pace than currently planned. This study is undertaken in a context of increased pressure on Bulgarian coal power plants, due to aging, environmental targets and emissions thresholds rolled out across Europe. These pressures, along with the drive towards decarbonisation by 2050 and the definition of National Energy and Climate Plans, will lead to the phase-out of coal-fired generation in the medium term. A potential coal phase-out would need to address issues of security of supply and broader socio-economic issues associated with the importance of the coal sector in Bulgaria
- Options for coal-to-gas switching involve using the site of decommissioned coal power plants to locate new gas-fired generation or building gas-fired power plants on new sites, as coal capacity is retired. In the former case, elements of the decommissioned coal plant may be partially reused (e.g. cooling installations, steam turbines) or the coal power plant may be demolished but existing infrastructures on the site can be reused (e.g. connection to the electricity transmission network)

- In this study, which is co-funded by Shell, and performed in consultation with EBRD as part of the study process, Baringa seeks to assess the case for an accelerated coal-to-gas conversion in more detail, to facilitate a wider debate with Bulgarian and European stakeholders on this opportunity. More specifically, this discussion would explore how gas can contribute to the achievement of Bulgaria's decarbonisation targets, and improve air quality in urban areas, with significant associated benefits. This assessment is a follow-on to the previous broader Baringa study, which explored the general role of natural gas in the Bulgarian energy mix.*

- This report is organized as follows:
  - First, we present case studies of two European countries – Germany and Spain – which are advanced in the process of coal phase-out, and draw out important lessons for countries which are considering the phase-out of coal generation
  - Second, we outline the current dynamics in the Bulgarian electricity sector. We find that coal generation is facing increased challenges and explore the potential for additional gas generation
  - Third, we provide an overview of our methodology for the assessment of the costs and benefits of the accelerated conversion of a number of coal plants in Bulgaria to gas. We also detail the framework used to identify indicative coal plants which may be suitable for gas conversion
  - Finally, we present our quantitative outputs and the detailed outcomes of the societal CBA for coal-to-gas switching. We also provide a qualitative assessment of potential wider impacts and an overview of any distributional economic effects
- We believe that our report is the first quantitative comprehensive analysis of accelerated coal-to-gas switching in an Eastern European country

*Source: https://www.baringa.com/en/insights-news/points-of-view/bulgaria-role-of-gas-in-decarbonisation/

Case studies – Phase-out of coal mining and generation

In Germany and Spain, EU and government policy has given impetus to the phase-out of coal mining and generation

- An EU-wide political push has resulted in the closure of unprofitable coal mines in both Germany and Spain. While significant redevelopment plans have been undertaken in Germany for the hard coal mining regions, comparable initiatives have not been implemented in Spain

Restructuring	▲ In Germany and Spain, unprofitable coal mines have undergone significant restructuring since the 1990s ▲ As part of these initial plans, aid was provided to cover production losses and extraordinary charges relating to restructuring while production was being reduced and concentrated over a smaller number of sites ▲ The plans involved early retirement provisions and welfare benefits for miners
Closure	▲ In 2010, it was decided that unprofitable coal mines should be allowed to close and aid was allocated to facilitate the closure in an orderly and socially acceptable manner: a total of €15bn and €2bn were allocated to coal mines in Germany and Spain to finance production losses until closure, as well as to cover the costs of closure and inherited liabilities ▲ Again, plans sought to avoid lay-offs and provided early retirement for miners, welfare benefits and retraining schemes ▲ In both cases, the closure was phased between 2011 and 2018
Re-development	▲ Germany has demonstrated its ability to develop an integrated approach to restructuring entire mining regions through the two multi-billion IBA programmes which have provided significant economic development to the Ruhr and Lusatia regions. A number of coal mines have also been successfully converted in renewable generation sites ▲ Spain has incentivised compliance with the deadline for mine closure through the signature of a contract according to which aid beneficiaries would need to reimburse aid if mines are not closed at the end of 2018. A number of actions have been taken for the redevelopment of sites and of regional infrastructure. However, the financial crisis and successive changes of government, associated with more local action have meant that policies have not generated a significant level of development in the affected regions. The 'Just transition' programme has recently been approved by the socialist government to seek to address some of these aspects

Case studies – Phase-out of coal mining and generation

In Germany and Spain, EU and government policy has given impetus to the phase-out of coal mining and generation

- Germany and Spain have announced their intention to phase-out coal generation in the short- to medium-term

- More than half of existing coal capacity will close in Spain due to the implementation of the EU IED
  - Operators of non-compliant power stations have decided not to undertake the investments required for compliance
  - The government has announced that the closure of the remaining power plants should be expected by 2030
  - Little information is available on support to accompany the closure of coal power plants but the government has committed to leaving no one behind

- In 2015, Germany published the plan for the early decommissioning of 2.7 GW of its oldest lignite power plants
  - Such power plants were shifted to capacity reserve and received a compensation of €1.5bn to 2023, date at which they will be permanently decommissioned
- In 2019, the Coal commission, composed of 28 representatives of public administrations, the civil society and the coal industry, published the roadmap for a total coal phase-out by 2038
  - The plan details the approach for coal phase-out and plans significant support packages for the coal industry and coal workers (negotiated or auctioned), for consumers who will face power price increases (through reductions in system charges) and to mining regions to enable their economic development
  - The plan also gives instructions to ensure security of supply during the transition and to avoid disruptions to the EU ETS mechanism

- Both countries have renewed their commitments to increasing renewables generation
- However, gas is seen as the technology that will ensure security of supply during the transition

Case studies – Conditions for a successful transition

Based on the case studies, we identify a number of enablers for the success of coal phase-out

- The case studies of coal phase-out in Germany and Spain offer lessons for Bulgaria in relation to the restructuring of the coal sector. Adopting an integrated approach, which addresses the various concerns associated with the phase-out of coal, appears to be essential for a successful and socially acceptable transition:

Political commitment to a clear and negotiated phase-out plan

- The definition of the plan requires a clear political commitment to the objective of decarbonisation. Clear announcements, including a detailed roadmap around the planned exit, are necessary to enable operators to plan for the retirement of their capacity
- The definition of the roadmap needs to involve stakeholders from the national, regional and local authorities, as well as unions, representatives of the industry and of the civil society. In this respect, having a clear vehicle such as the Coal commission in Germany, with a clear mandate, facilitates the process. Any support plan also needs to be agreed with the EU and designed in line with EU state aid law

Measures to ensure social acceptability

- Social acceptability is ensured through the negotiation of the phase-out plan with all relevant stakeholders and through the allocation of support such that the impacts of the transition are mitigated and new opportunities are generated in the coal regions
- Aid needs to be allocated to power plant operators for any lost profits and to assist with the costs of closure (including early retirement plans for employees, redundancy packages, welfare benefits and retraining options). Measures should be taken to provide for managed transition of employment
- Measures may be taken to insulate consumers and energy-intensive users from any resulting increases in power prices
- Coal regions benefit from significant support during the transition period to finance the reconversion of the economy towards clean and competitive new industries and to facilitate the regeneration of mining sites. Regional plans for economic and environmental development need to involve regional stakeholders and to account for the specificities of each region. Additionally, retraining for ex-miners needs to be targeted towards new dynamic sectors

Ensuring consistency with wider energy policy

- Phasing over several years gives time to operators to organize the transition and negotiate compensation, and enables to procure required capacity to ensure continued security of supply
- If coal capacity represents a significant share of total generation, a specific plan needs to be implemented to ensure that security of supply is guaranteed throughout the phase-out. This may entail providing incentives such that new dispatchable generation capacity is built
- Coal phase-out is most efficient as a decarbonisation tool if it is supported by high carbon prices and policies facilitating the development of renewable and alternative dispatchable generation on the system

- Although high-level lessons can be drawn, transposing them to Bulgaria would entail adapting them to the elements of context specific to Bulgaria, such as the initial size and importance of the coal sector, the willingness and ability to provide the level of support required for a successful transition and the interaction with existing policies. In the next slide, we present an overview of the electricity sector in Bulgaria, as well as an outlook for the future use of coal and gas

Bulgarian electricity market and outlook for coal and gas

In Bulgaria, coal generation is facing challenges, and there are significant opportunities for an increased role for gas

Market overview

- The Bulgarian electricity market is still largely reliant on coal, which represented around half of total electricity generation in 2017
  - Nuclear and hydro also account for a significant share of the energy mix
  - Solar and wind developed quickly in 2011-12 but the reduction of renewables support has stalled the development of further renewable capacity
- The wholesale market is currently transitioning towards fully liberalised market arrangements
- In spite of being on track to achieve its 2020 targets, stricter EU targets to 2030 and higher EU ETS prices maintain incentives for continued decarbonisation, and put pressure on coal. Additionally, the emissions intensity of Bulgaria is the second highest in the EU
- The Bulgarian government is currently developing its 2030 energy strategy and appears to provide continued support for coal power plants

Outlook for the coal sector

- In Bulgaria, coal power plants currently make a significant contribution to meeting baseload, heat and reserves needs. The reliance on power plants fired by low-quality coal (mostly lignite and brown coal) is associated with high levels of greenhouse gas emissions
- The coal mining sector is a large employer in Bulgaria. It accounts for around 14,000 direct jobs concentrated in two mining regions
- However, the coal sector is under significant pressure since the publication of the emissions standards associated with the EU Industrial Emissions Directive. Indeed, none of Bulgaria's existing coal plants are currently compliant with such standards. For their continued operation, a number of them will submit a derogation request, while others are considering a fuel switch. Together with the end of generation quotas under new liberalised market arrangements, such developments offer the opportunity to consider the potential of gas in Bulgaria's future generation mix

Outlook for the gas sector

- Historically, Bulgaria has purchased its gas under a long-term contract with Gazprom. Following an EU investigation, contract terms have been renegotiated. Prices can now be observed to track, and be related more closely to prices in Western European traded gas hubs
- Additionally, there is spare capacity on the Bulgarian transmission network, and a number of interconnection and regional projects are being developed, which is likely to increase the number of gas supply sources available in the future
- Bulgaria is studying the creation of a regional gas hub and increased national demand, including demand from power generation, would strengthen Bulgaria's positioning as a regional gas hub

The challenges to the future of coal generation and positive outlook for the gas sector create the opportunity to investigate the use of gas for coal-to-gas conversion as well as for new generation capacity that would ensure security of supply as coal generation is being retired.
We now present our methodology for the assessment of an accelerated conversion of a number of coal power stations to gas

Modelling approach

We show the illustrative impact of the conversion of selected coal plants in Bulgaria to gas by comparing outcomes under a Base case and an 'Accelerated coal-to-gas conversion' case, using a societal CBA framework

Wholesale market modelling

Base case	'Accelerated coal-to-gas conversion' case
1 Reference assumptions for Bulgaria including commodity and carbon prices, capacity, demand and interconnection to 2050	4 Same assumptions + Accelerated conversion - 3 selected coal plants (1,380 MW) close before 2025 - 3 CCGT plants (1,200 MW) are built before 2025 instead of being spread on the timeframe
2 Run Baringa pan-European model with existing coal plants in Bulgaria	5 Re-run the model considering an 'accelerated trajectory'
3 Extract results for CBA	6 Extract results for CBA

EU-wide societal CBA Framework

- The costs and benefits of the Base case and the Accelerated coal-to-gas conversion are assessed in the societal Cost-Benefit Analysis ('CBA') framework
- The societal CBA is defined by the balance of costs and benefits of the accelerated coal-to-gas conversion compared to the balance and costs and benefits of the Base case. There is a case for an accelerated coal-to-gas conversion if benefits are higher or costs are lower than in the absence of such accelerated conversion
- To determine this, we compare the difference in costs as measured by our wholesale market model and in other costs:

Δ in total system costs = market impact of coal-to-gas conversion + Δ in other system costs and benefits (those not captured by the wholesale modelling and informed by external cost inputs) → Societal CBA outcome: Is an accelerated conversion from coal to gas beneficial for society?

Candidate plants for Accelerated coal-to-gas conversion

Baringa

We identify a diversified sample of coal plants suitable for gas conversion, based on geography and other characteristics. Indicative candidates for coal-to-gas conversion are **TPP Maritsa East 3, Ruse Iztok and Deven.**

Plant names (coal—fired)[1]	General characteristics	Air quality	Technical and commercial aspects	Location	CO2 emissions	Socio-economic impact	Overall assessment
TPP Maritsa East 1 (AES Galabovo)							
TPP Maritsa East 2							
TPP Maritsa East 3							
TPP Varna							
TPP Bobov Dol							
TPP Maritsa 3							
Deven							
Brikel							
Ruse Iztok							
Sliven							
Pernik							

Large
Lignite-fired
High emissions

High emissions
One revenue stream
Close to gas grid
Limited job losses

Access to gas
Considered suitable for gas conversion in previous assessments

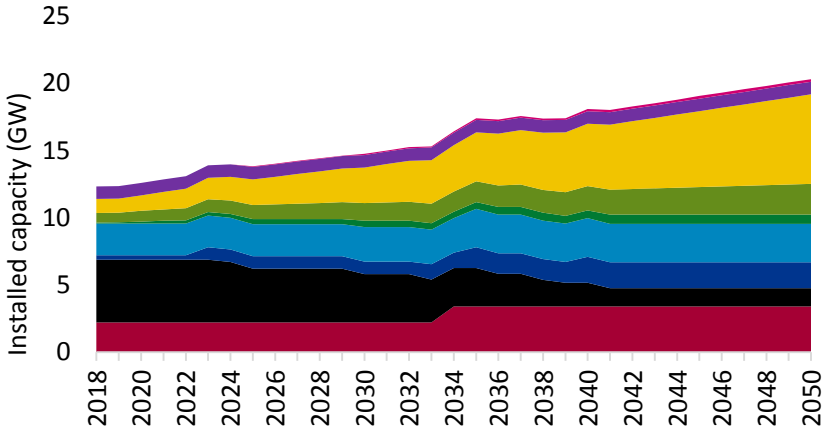
[1]Some plants are currently investigating derogations and fuel switch to ensure compliance with EU IED

Base case vs Accelerated coal-to-gas conversion case

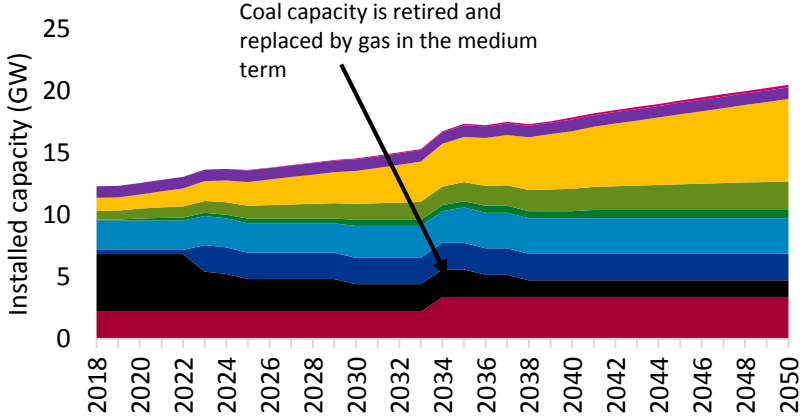
The Accelerated coal-to-gas conversion case relies on an assumption of gas capacity built in the place of retired coal

- We have identified that Maritsa East 3, Ruse Iztok and Deven are candidates for coal-to-gas conversion to facilitate the modelling of a possible accelerated coal-to-gas conversion case
- The 3 plants candidate for Accelerated coal-to-gas conversion amount to around 1,400MW of retired coal capacity
  - We assume that they are replaced by 1,200 MW of CCGT
  - This is a reasonable assumption based on the pace of coal retirement and on other assumptions relating to the deployment of other technologies such as renewables and nuclear over the same period
- However, this selection is indicative and a similar assessment could be undertaken with a different set of coal power plants
  - Changing the selection would only affect the outcome of the assessment through a change in the capacity of coal generation converted into gas
  - This would result in a slight change in the costs and benefits of an accelerated gas conversion due to different wholesale market outcomes (including CO2 emissions) and CAPEX figures

Projected capacity evolution in the Base case



Projected capacity evolution in the Accelerated coal-to-gas conversion



- The next slides present our modelling results and the outcomes of the societal CBA for an accelerated coal-to-gas conversion

Results – Impact on Bulgarian Market

Accelerating the trajectory of coal plant retirement is expected to have a significant impact on the Bulgarian power market, with an increase in power prices and a reduction in generation and net exports

- In the table below, we isolate the impact of the accelerated transition from coal to gas on the Bulgarian power market. These outcomes are for the Bulgarian market only, and therefore a subset of the inputs to our EU-wide CBA

- We find that the accelerated coal-to-gas conversion results in a wholesale price increase, and a reduction in overall generation and net exports as compared to the Base case across the years modelled. Compared to the Base case:
  - Consumers in the Accelerated coal-to-gas conversion case pay 4.4 €/MWh more for their electricity in 2025, going down to 1.7 €/MWh in 2040. As the penetration of renewables in the generation mix and interconnection capacity increase, gas sets the price in a smaller number of periods in the long term
  - As for wholesale prices, the impact of the conversion on Bulgarian generation and net exports is higher in the shorter term
    - Coal and lignite generation is smaller by 1.7 TWh while gas generation is higher by 0.4 TWh in 2040. Net exports are 1.3 TWh smaller in 2040
  - The reduction in generation volumes, the reduction in exports and the increase in prices are due to the fact that generation costs of gas are higher than for coal under Reference assumptions
  - Emissions are 1.7 million tonnes smaller in 2040

Impact of Accelerated coal-to-gas conversion compared to Base case	2025	2030	2040
Price (€/MWh)	4.4	4.0	1.7
Generation from Coal and Lignite (TWh)	(7.6)	(5.8)	(1.7)
Generation from Gas (TWh)	1.4	1.6	0.4
Emissions (million tonnes)	(7.7)	(5.7)	(1.7)
Net exports (TWh)	(6.0)	(4.2)	(1.3)

- CBA results are presented in the following slides

Results – Societal CBA (1/2)

There are significant benefits from Accelerated coal-to-gas conversion

- We have modelled outcomes for all years of the horizon (2025-2050) under Reference assumptions
- Below, we present the difference in costs between the Base case and the Accelerated coal-to-gas conversion (1,380 MW of coal replaced with 1,200MW of gas) for some spot years as well as the NPV over the whole period. A negative difference indicates higher costs from the Accelerated coal-to-gas conversion compared to the Base case, while a positive difference indicates a benefit from the Accelerated coal-to-gas conversion compared to the Base case
- We find that, although CAPEX and generation costs increase in the Accelerated coal-to-gas conversion case, there are significant benefits from avoiding CAPEX for coal compliance, from reduced fixed costs and from the reduction in emissions and associated health impacts

Costs and benefits due to conversion (m€)	2025	2030	2040	NPV
1. CCGT CAPEX (Annuitised)	(76)	(51)	0	**(603)**
2. Gas Infrastructure CAPEX (Annuitised)	(4)	(3)	0	**(33)**
3. Coal decommissioning	(24)	0	0	**(8)**
4. CAPEX for Compliance with EU air quality regulation [1]	19	19	6	**169**
5. Fixed Operation costs	43	29	0	**341**
6. Generation costs (excl. emissions costs)	(268)	(235)	(85)	**(2,226)**
7. CO2 Emissions costs	130	158	49	**1,412**
8. Renewable curtailment	0	0	0	**0**
9. Demand curtailment and unserved energy	0	0	0	**0**
10. System Flexibility	6	4	0	**47**
11. Health Impact (of upgraded plants)	133	133	40	**1,199**
12. Net social cost of carbon (NSCC)	300	224	42	**2,076**
TOTAL	259	277	52	**2,373**

	2025	2030	2040	Total
Difference in EU CO2 Emissions (million t/year)	(4.4)	(3.7)	(1.1)	(45.8)

Higher CAPEX due to investment for Accelerated coal-to-gas conversion

Avoided CAPEX for EU IED compliance

Higher total generation costs (including emissions costs) as gas is less cost competitive than coal under Reference assumptions

High benefits from pollution reduction

High benefits. NSCC is high due to low EUA price

Reduction in EU-wide CO2 emissions due to coal to gas conversion in Bulgaria

[1] We have assumed that coal capacity will not receive any derogations in relation to the EU IED. However, the societal CBA for an accelerated conversion to gas is also positive if we assume that coal plants do not need to undertake investments to ensure compliance with EU directives. In this case, the societal CBA of an accelerated coal-to-gas conversion is actually higher than our current estimates, as the continuation of existing coal power plants without enhancements would result in significant emissions and health costs, which are avoided with an earlier conversion to gas.

Results – Societal CBA (2/2)

The net present value of the overall benefit from Accelerated coal-to-gas conversion is highly sensitive to the social cost of carbon

- We compute the net present benefits over the 2025-2050 horizon considering a discount rate of 4% (the social discount rate recommended by EC) and with a social cost of carbon of 100 €/tonne (in line with the previously used figures by the EC)

CBA for a Medium Social Cost of Carbon	Societal CBA results of accelerated coal-to-gas conversion (NPV in €m)
DIRECT Benefits/Costs	(902) – Net cost
INDIRECT Benefits/Costs	3,275 – Net benefit
Total	**2,373 – Net overall benefit**

- We find that there are net benefits from Accelerated coal-to-gas conversion
  - Savings in health cost and in the social cost of carbon are an important source of benefits of Accelerated coal-to-gas conversion, followed by savings from CAPEX to ensure compliance of coal power plants, reductions in fixed costs and increases in flexibility
  - The increase in benefits from Accelerated coal-to-gas switching is sufficient to compensate for the increase in CAPEX costs associated with decommissioning the coal power plant and building the additional CCGT capacity

- We find that the benefits of the transition vary significantly depending on the assumptions on social cost of carbon, through changes in emissions costs. Therefore, we determine the benefits of an Accelerated coal-to-gas conversion for different values of the social cost of carbon
  - When the net social cost of carbon is high, the Accelerated coal-to-gas conversion results in high emissions cost reductions and in increased benefits for society

Sensitivity to Social Cost of Carbon Assumption	Social Cost of Carbon (€/t)	Societal CBA results of Accelerated coal-to-gas conversion (NPV in €m)
No Social Cost	0	297
Low Social Cost	80	1,657
Medium Social Cost	100	2,373
High Social Cost	120	3,089

- Results also vary with different EUA carbon price assumptions, through changes in generation costs
  - With high EUA prices, gas is more cost-competitive compared to coal generation. Therefore, an Accelerated coal-to-gas conversion results in a net reduction in total generation costs (including fuel, VOM and emission costs) compared to the Base case, which reinforces the case for an Accelerated conversion
  - Under Reference carbon price assumptions (low/moderate carbon prices), gas is less cost-competitive than coal and there is a net increase in total generation costs under the Accelerated coal-to-gas conversion. As the table above indicates, even with moderate carbon price assumptions and a zero social cost of carbon, we see a net benefit of conversion of €297m over the modelling horizon, when all CBA components are taken into account

Results – Support packages for the Transition

The Accelerated coal-to-gas conversion may require additional subsidy or public expenditure, as has been done in other countries to support a successful transition

- The decommissioning of coal-powered generation capacity in Spain and Germany has been supported, in both countries, by public aid going primarily to coal regions, to the workforce being impacted and to plant owners.[1] Using our analogues, an indicative estimate of the total amount of public aid required in Bulgaria is as follows

Public Aid – Plant closure costs

- Description: This is the aid granted to cover the costs associated with the closure of power stations and mines, including social costs and environmental costs such as site rehabilitation. We determine the aid relating to plant closure costs by applying simple ratios and metrics to the data available from a limited number of precedents, to make it applicable to the Bulgarian transition
- The review of precedents led to a cost assumption of €161k/pers for an impacted workforce of 4,200
- We find that aid for the Accelerated coal-to-gas conversion may amount to a total of €680mn over the transition horizon

Public Aid – Lost profits

- Description: In a number of precedents, plant owners have been compensated for their lost profit of continuing operating the plant over a few additional years. This is calculated considering projected earnings [profit + finance cost + amortisation] lost because of the closure of the plant, for 10 years
- The lost earnings are assumed to be equal to €100mn/GW per annum
- We find that total aid relating to lost profits of power station operators from an Accelerated coal-to-gas conversion may amount to a total of €1.4bn over the transition horizon

- Aid may also be granted to residential and commercial electricity users to compensate for the small increase in electricity prices from the Accelerated coal-to-gas transition, as is planned in Germany. This would limit the impact of the transition on household bills and on the competitiveness of Bulgarian businesses
- These costs/benefits are not accounted for in the CBA because they are a transfer of funds between parties which results in a distributional effect – as opposed to a net increase in costs or benefits. The level of this aid is calculated using publicly available data and simplified proportional metrics, but is not based on a Bulgarian precedent. Therefore our estimates should be considered as highly indicative
- The bulk of any aid package would need to be provided by the Bulgarian State and cleared with the EU according to EU State Aid Law. Furthermore, precedents have shown that EU funds may contribute to a transition in Bulgaria, favouring such a public policy development, but for a fraction of the envisaged amount

[1] Our assessment does not include an indicative estimate of aid for coal regions because the power stations identified for gas conversion are not geographically concentrated.

Conclusions

- In the transition towards the 2050 objectives set out in the Paris Agreement, stricter emissions standards and emissions targets have been adopted across Europe and coal generation is being phased out in a number of European countries
- In the context of the definition of Bulgaria's National Energy and Climate Plan for Bulgaria, we have undertaken a qualitative and quantitative assessment of an accelerated use of gas in the place of coal as a source of power generation in Bulgaria. Our analysis shows that there are significant benefits associated with an early conversion to gas, and a number of risks associated with the absence of such conversion

Benefits of an accelerated conversion	▲ Total net benefits amount to around **€2.4bn** over 2025 – 2050. Benefits include: – A **reduction in CO2 emissions** of 46 million tonnes, associated with **lower costs** (EUA and net social cost of carbon) – The **avoidance of significant health costs** associated with pollution from coal power plants – Avoided **CAPEX** for the compliance of coal power plants with the UE IED and lower **fixed costs** of gas power stations ▲ Additionally, an accelerated coal-to-gas conversion facilitates the **deployment of renewables** on the system due to the high flexibility of gas generation
Risks of status quo	▲ Our quantitative analysis shows that costs would be higher in the absence of an accelerated coal-to-gas switching ▲ None of Bulgaria's coal power plants are currently compliant with EU emissions norms: they are relying on significant investments, a derogation or a fuel switch to continue operating and may be required to close in 2021. Additionally, the continued use of coal without a degree of gas conversion would delay the achievement of Bulgaria's decarbonisation objectives. As the decarbonisation agenda becomes more pressing, enforcement actions may be taken at the EU level to drive policy changes ▲ Due to relatively low levels of domestic gas demand, Bulgaria may find it challenging to strengthen its position as a regional gas hub without an increase in domestic gas demand from power generation

- Drawing on the lessons highlighted in the country analogues, delivering a successful transition from coal to gas requires a strong **political commitment**, the **involvement** of the industry, unions and local authorities, a comprehensive **support package** and a consistent **framework of energy policies**

In the medium term, the delivery of such transition in Bulgaria is largely dependent on the political willingness to embark on the path of decarbonisation. Such commitment may be explicitly made in the upcoming National Energy and Climate Plan and form the basis of an initial discussion with stakeholders