Summary

Low Carbon Options and Gas Infrastructure

Chances of efficiency and renewable energies for gas infrastructure planning and security of supply in Europe

This report reflects the views and opinions of the research contractors which may or may not correspond with the opinion of the contracting authority (The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety).

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1 Introduction

In the coming years, important decisions on the development of European gas infrastructure must be taken. It is important that these decisions are based on solid data and reflect the EU's long-term goal of reducing greenhouse gas (GHG) emissions by 80-95 % by 2050, as well as the aim to limit global warming well below 2 °C, if possible to 1.5 °C, in line with the **Paris Agreement**. Whilst past planning approaches for energy security and network development assumed an increasing European gas demand, European gas demand was in fact declining between 2010 and 2014. Although natural gas is the fossil fuel with the lowest carbon factor, in the long run, a consequent decarbonisation of the European energy system will lead to a decreased gas demand.

A **core question** of this study is, whether demand scenarios and other assumptions that are underlying today's gas infrastructure planning consider this decrease in an appropriate manner. Is it possible to avoid future infrastructural costs if Europe's carbon goals are consistently taken into account in the plans? And how will the European dependency on imported gas be impacted by greater implementation of low carbon options?

The **first step** is to analyse how gas network planning in Europe works today and whether underlying assumptions and scenarios do consider national targets for GHG abatement, renewable energies or efficiency development. This was done by an analysis of the planning approaches at EU and regional and in six focus countries (France, Germany, the United Kingdom, Italy, Spain, the Netherlands).

In the **second step**, pathways describing future gas demand are analysed. This analysis is based on existing scenarios which include energy and climate targets and are different from the scenarios used in network plans. The objective of this step is to evaluate the impact of low carbon options on gas and capacity demand.

In the **third step**, we quantify the possible savings that could be reached by reducing gas imports and analysed savings possibilities on the infrastructure side.

Finally, we compare the risks linked to gas, to the development of renewable energy sources, and to the implementation of energy efficiency measures.

This study considers information available on December 2016. Following this date, only the Ten-Year-Network-Development-Plan 2017 has been complemented. Neither the measures from the European Commission's energy "Winter Package" / "Clean Energy Package" nor the impacts of the decision of the United Kingdom to leave the EU ("Brexit") have been included in the report.

This summary can only highlight the most relevant results. Due to the broad scope of work, the complete study ("Full report") contains many other aspects and is thus recommended to the reader.

2 Analysis of network planning processes at European and national levels

The study analyses existing instruments, processes and scenarios for gas infrastructure planning in Europe with focus on six countries. It aims to find out whether scenarios that are used for gas network planning in Europe consider climate policy goals and low carbon options in an adequate way. Besides, processes and instruments are critically assessed.

Gas infrastructure planning on a European level is largely based on the instruments TYNDP, GRIPs and PCI. Therefore, in the following we present a critical assessment of these instruments:

TYNDP

- The **TYNDP** is an indicative document with the purpose to give a basis for planning of European gas markets and networks. In particular, the TYNDP assesses different levels of future infrastructure development under different demand and supply disruption scenarios.
- The development of the Union-wide TYNDP gives stakeholders many opportunities to engage. The number of stakeholders actively participating in the process is low, largely limited to TSOs and key institutions. Environmental organisations have generally not participated. ACER recommended factoring the results of the public consultation more strongly into the final TYNDP report.
- Consideration of climate policy and low-carbon options within the TYNDP is intimately linked with the process of developing demand scenarios for the TYNDP. In order to ensure proper consideration of climate policy and low-carbon options, the planning process should ensure broader stakeholder participation and consistency of demand scenarios with long term European energy strategy. ACER suggests holding public workshops with key stakeholders, including experts from industry and academia, well in advance of the TYNDP stakeholder process.
- Based on ACER monitoring, the consistency of the TYNDP and the NDP in terms of implementation timelines and listed projects is relatively low. Data on projects is often lacking. (e.g. due to jurisdictional issues). Participation of NRAs in the ACER monitoring process was low. Moreover, the focus of the monitoring process was largely on an assessment of whether the incomplete data in the plans were aligned, as opposed to whether projects within the NDPs are misaligned with European priorities. As such, the more strategic monitoring of the consistency of the NDPs and the TYNDP is left solely in the hands of NRA. This implies that a strengthening of the mandate, resources and tools (e.g. additional modelling capabilities) provided to ACER may be desirable to ensure the proper coordination of gas infrastructure at EU level, as suggested by [Bruegel 2016] and [ECA 2015].

GRIPs

- **Gas Regional Investment Plans** are plans on a regional level in which a group of TSOs from different countries coordinate transmission infrastructure needs for a geographically and functionally determined region over a ten-year period.

- Opportunities for stakeholders' involvement vary between GRIPs and are generally less structured and transparent than for the TYNDP process. There have been limited opportunities for stakeholders to engage, with the exception of post-GRIP consultations.
- The joint development of the TYNDP 2017-2037 and the 3rd GRIPS will help aligning these two processes. As both processes will be jointly developed and data commonly collected, TYNDP stakeholder engagement process will gain in importance for the GRIPs. As the treatment of demand scenarios will also be harmonized, the TYNDP process will also determine the assumptions made about climate policy and low-carbon options for the GRIPs.
- The harmonization of the GRIPs will increase the comparability of the GRIPs reports. The growing harmonization, however, risks making them largely indistinguishable from analysis provided in the TYNDP, thereby reducing their added value for stakeholders. Moreover, due to the mutual timing of the reports it is unclear to what extent the Union-wide TYNDP will take into account the GRIPs, as demanded by EU Regulation.

PCIs

- Projects of Common Interest are an important instrument for the implementation of gas infrastructure under the TEN-E regulation. The projects on the PCI list are supported among others with financing from the CEF.
- None of the PCI priority gas corridors highlight sustainability as a core aim. Projects are not required to contribute to sustainability to receive PCI status. While sustainability is considered in the application of the CBA methodology, a project must only have a net-positive outcome overall in order to qualify.
- The results of the PCI selection process so far reveal that gas projects have thus far been more strongly supported under the CEF Energy calls than electricity and smart grid projects, despite an arguably higher need for support in the electricity sector in order to meet the EU's mid- to long-term energy and climate goals.
- While the Commission formally plays a critical role in the PCI selection process, Member States maintain the power to nominate PCIs, potentially undermining the Commission's ability to guarantee projects are directly linked to EU objectives. The role of the Commission or ACER in the selection and monitoring of PCI projects could be strengthened and stakeholder engagement improved.

Critical assessment of Europe-wide scenarios

- The four scenarios in the TYNDP 2017 are in great part derived from national TSO´s scenarios. There is sparse transparency on the underlying assumptions. Gas demand forecasts in past TYNDPs have overestimated todays demand by far. TYNDPs 2017 scenarios are the first with increasing, stable as well as decreasing gas demand. According to ENTSOG 3 of the four scenarios achieve European energy and climate goals but there is no transparency on the development of GHG emissions. Compared with the trend of a decreasing gas demand in the last years the scenarios still seem to overestimate the future gas demand.
- The TYNDP does not identify single network development projects. A "low" and "high" infrastructure scenario is assessed for the demand scenarios and for different supply scenarios. The need for new investments if gas demand is decreasing and the danger of stranded investments are not assessed.

Conclusions for the national level

Besides the European level this report analyses six focus countries and takes a close look into NDPs and the underlying scenarios for gas infrastructure planning.

- NDPs have widely different timings for the preparation and significant differences in the frequencies in preparing national development plans. While Germany, France, the UK, and Italy have a yearly cycle, the Netherlands' NDP appears in a biennial frequency and a Spanish NDP has not been published since 2008. Germany is changing to a two-year cycle with an intermediate evaluation.
- Stakeholder engagement varies strongly. While stakeholder engagement for the Italian NDP consisted largely of a public consultation in written form on a draft NDP (e.g. IT), the processes in the Netherlands and Germany also include workshops. The UK and Germany both have stakeholder engagement during the scenario development process. The Netherlands strongly involved neighbouring TSO, receiving input from France, Germany and the UK.
- The NRA play a clear role in the NDP process in France, Germany and the UK, while the exact involvement of the NRAs is less clear in Italy and the Netherlands. The Spanish NDP was directly managed by the government. These differences matter since varying levels of involvement in the NDP process may impact the ability of the NRA to monitor the process, including for consistency with the TYNDP and coherence with energy and climate goals.
- Some of the NDP are available in national languages only. Some NDP (DE) offer executive summaries in English. The French, Italian and Dutch NDP are available in their full length in English.

Critical assessment of scenarios at the national level

- All network plans are based on one or more future scenarios. The dominating time horizon is 10 years. Only one scenario per country is binding for the definition of measures.
- In the past, gas demand scenarios that were used for network planning have frequently overestimated the gas demand in most of the focus countries. Looking on the trend of gas demand in the last years it seems that UK and Germany have used the most reliable scenarios. More recently, all of the NDPs reacted to a reduced demand with respective (lower) scenarios. However, a greater validity of gas demand forecasts seems necessary.
- None of the scenarios that are used for the infrastructure planning and definition of measures is completely coherent with governmental goals for GHG emissions reduction targets or low carbon options. Two of the national scenarios (NL, IT) are partially coherent, the others are not.
- Network planning is subject to European law and regulation. Energy policy aims at the functioning of the energy market, security of supply, promoting energy efficiency and the development of renewable forms of energy and promoting the interconnection of energy networks.
- The regulatory authorities are required to discuss the adequacy of network plans with the stakeholders and the consistency with TYNDP of ENTSOG. Adequacy in this context means that the capacity demand in the market can be met safely. Compliance with long term government climate policy goals is not a primary obligation for TSO. However, it can be assumed that realistic demand scenarios would help to avoid an overestimation of infrastructural needs in network plans.
- Thus, network plans in Europe and their underlying demand scenarios are not based on the implementation of all necessary low carbon options to fulfil climate policy goals. Security of supply and functioning of the markets are still the main considerations for infrastructure planning. A discussion about what an adequate level of consideration of climate targets is should be initiated.

3 Impacts of low carbon options on gas demand: comparison of NDP with ambitious scenarios

This chapter analyses the potential of energy efficiency (EE) and renewable energy sources (RES) to reduce gas demand and infrastructural needs and thus avoid investment cost. To do this, we compared scenarios underlying existing Network Development Plans with reference and target scenarios as well as more ambitious scenarios regarding GHG abatement. These are our findings:

EE and RES potentials and gas demand: Both at European level and in the focus countries there is clear evidence from the analysed scenarios that a high deployment of EE and RES would lead to a shrinking gas demand. In all analysed countries except Spain scenarios are available in which the use of natural gas would be reduced to a fraction of its current levels (approx. 10 %) or even phased out completely when energy and climate targets are reached or overachieved (e.g. Greenpeace Advanced energy [r]evolution) until 2050. In the medium term until 2030 gas demand stagnates in most references and also in some of the target scenarios with high RES and efficiency gains. However, in scenarios with high efficiency gains (e.g. EE 40) gas demand could already decrease remarkably before 2030.

Comparison of NDP and other scenarios: None of the scenarios underlying gas network plans in the focus countries and Europe as a whole assumes that GHG abatement targets are fully reached. In Europe as well as in most of the focus countries scenarios for gas network planning are the only scenarios that assume an increasing gas demand. Compared to these scenarios, policies already in use (reference scenarios) would lead to a stagnating or shrinking gas demand. Scenarios that reach energy and climate goals by deploying EE and RES have a great potential to further reduce gas demand. This is especially valid for the time after 2030. In very ambitious scenarios there is nearly no (fossil) gas consumption left in 2050 so wide parts of the infrastructure designed to transport conventional gas would be superfluous in 2050. However, it has not been examined how much of the infrastructure might be needed to transport low-carbon gases like biogas or hydrogen.

Consequences on gas capacity demand: A lower (yearly) gas demand leads to a reduced (hourly) gas capacity demand of customers, especially in the long run (after 2030). However, the decline rates of capacity demand are expected to be smaller than those of the (yearly) gas demand. The interrelationship between yearly and hourly demand needs to be examined further. Most of the analysed studies expect a reduction of gas demand in the heat markets. A much broader variety of results can be found, however, for gas used in power generation. There is a high diversity in the reference as well as the targets scenarios about the installed capacities of gas fired power plants – especially in 2050. This makes clear conclusions about the capacity demand more difficult.

Infrastructure demand: A reduced gas capacity demand could make some gas infrastructure investments superfluous, especially projects with the purpose to cover market demand. Other projects might nonetheless be needed. This depends on the main driver of the projects (e.g. market demand, security of supply or others). But before investing in new infrastructure projects potential efficiency improvements and investments should be examined and applied (“Efficiency First”). An integrated view on security of supply and demand forecasts could furthermore reduce the demand for infrastructure and costs, according to a recent study. [Energy Union Choices 2016]

Therefore, infrastructure measures should not only be assessed under high gas demand conditions but also from an “on-track” perspective. Furthermore, more ambitious scenarios should be considered to reflect possible changes in line with the Paris Agreement.

4 Quantification of impacts of low-carbon measures on import dependency, diversity of supply and costs

Gas infrastructure plays a key role for the European energy system. The development of the energy infrastructure is a much-debated issue regarding the future transformation of the energy system. There a lot of different aspects should be taken into consideration concerning future requirements of gas infrastructure, such as the development of capacity demand, flexibility or diversification of import sources. These aspects have been analyzed in chapter 4 of the “Full report”.

The evolution of the **concentration of market power** has been assessed using access to transmission capacities and actual trade volumes and taking planned infrastructure into account. Planned infrastructure projects lead to a greater diversification of import routes but changing gas production trends might increase market concentration and hence lead to respective (possibly more concentrated) gas flows over time. The picture for Europe in terms of import dependence and market concentration is diverse, with the case study countries for this report (Germany, France, the Netherlands, Italy, Spain, the United Kingdom) largely exhibiting high import route diversification, while several, largely central and eastern European member states have a high level of concentration due to being reliant on a sole supplier.

A significant increase in domestic renewable energy production and the adoption of ambitious energy efficiency measures could help to **reduce import dependency** of the European Union by delivering significantly reduced gas consumption and lowering the demand for gas imports. These gas savings are particularly high under scenarios with ambitious energy efficiency measures (e.g. the Commission’s EUCO+40 scenario achieving a 40 % energy efficiency target for the EU28).

Gas demand is not the only aspect determining the construction of infrastructure projects. Other requirements like flexibilization or diversification of import routes have to be considered. In the study (chapter 4.3), a new categorization of projects in the European TYNDP has been used to assess their added-value and achieve a greater differentiation between the types of projects being developed.

Infrastructure costs of selected TYNDP projects have also been assessed, classified and estimated using various sources of information. This assessment shows that a large share of projects is aimed at connecting gas transmission systems (especially in eastern Europe) (27 %), installing storage or enabling reverse flow of gas (10 %), or making gas markets more flexible in non-supplier dominated markets (mainly in western Europe) (10 %). These projects generally have moderate to low specific costs and are therefore estimated to make up a moderate share of the overall estimate investment costs but must also be carefully assessed on a case-by-case basis in terms of their medium- to long-term business case. At the same time, a significant number of projects are estimated to be redundant with or run parallel to existing infrastructure (16 %), while making up the largest individual category of overall investment costs. Furthermore, the category ‘big infrastructure projects’ consists of only a handful of large import pipeline projects that risk becoming stranded assets under ambitious climate scenarios compatible with the Paris Agreement, but make up the second highest share of overall investment costs due to particularly high specific project costs. This categorization has to be interpreted carefully: without a detailed modelling of the gas network, it is not possible to validate the need for a given project.

These results underline the need to carefully assess the economic viability of investment projects, in particular where scarce public resources are being invested. The assessment also shows that the investment needed in the gas infrastructure is likely to be much lower than the estimated cumulative cost of the proposed projects. Besides technical requirements, political priorities, economic support and market interests play an important role for the realization of gas infrastructure projects. Overall, there will probably be a frequent trade-off between the goal of achieving a totally flexible European gas network guaranteeing a zero loss of load in any situation, and the need to rationalize and diversify investments into other energy carriers (electricity, renewables) and energy efficiency to ensure an appropriate return of value for money invested.

The estimated investments that would be needed to reach 2030 EU climate targets have been added for comparison purposes. The total **investment** needed to build all the infrastructure projects selected in this study amounts to € 69 billion. 43 % of investments relate to projects belonging to the categories "Big import infrastructure projects" and "Redundant with/parallel to existing infrastructure".

Potential savings from **reduced gas import needs to** vary according to the level of ambition set in target scenarios, as well as to the scenario used as baseline/reference. Taking the scenario EU Reference 2016 as reference and comparing it to EUCO30 scenario, cumulated savings from reduced gas imports over the period 2020—2030 amount to € 63 billion. Taking the scenario TYNDP 2018 Sustainable Transition as reference and comparing it to EUCO+40 scenario, cumulated savings from reduced gas imports over the period 2020—2030 reach up to € 223 billion. This represents 31 % of the total estimated cumulated investments that would be needed to reach 2030 EU climate targets.

Forward looking gas demand scenarios build the basis for network development plans, which in turn are a prerequisite for infrastructure investment. Consequently, it is essential that gas demand scenarios depict the correct gas demand to induce adequate investment and prevent overspending, especially when projects receive public financing. Furthermore, the different network development plans to should show the effects of different scenarios on gas infrastructure needs and take uncertainties into account. The possibility of a long-term decreasing gas demand (e.g. target scenarios) should be considered, to be prepared for different possible developments

5 Risk assessment for EE, RES and natural gas

This section compares key risks associated with scenarios that foresee stable or rising natural gas consumption with those in scenarios that foresee an ambitious deployment of energy efficiency and renewable energy. This assessment provides insights for anticipatory risk management in regard to strategies that promote gas security and decarbonisation through high-RES and EE pathways. While a comprehensive review of all risks related to EE, RES and natural gas is beyond the scope of this report, the assessment provides a broad overview of the most critical risk factors in order to identify key issues that should be further explored and frame a broader discussion about the comparative risks of EE, RES, natural gas.

For the risk assessment, we look at five **risk categories**:

Policy and regulatory risks: Inadequate political ambition or regulatory barriers preventing the achievement of the EU's climate and energy goals

Technological risks: "Disruption" that can occur when an energy source or related infrastructure is exhausted, or production is stopped, especially factors linked to the physical characteristics of the technology itself.

Geopolitical risks: "Disruption" arising from the competition around scarce and valuable resources, and the risk of the owner of a strategic resource using it as a tool for achieving political and economic advantage.

Economic and social risks: Economic and social "disruptions" caused by the overall cost of the energy system, erratic fluctuations in the price of energy products or distributional effects linked to the energy system.

Environmental and health risks: Damage to the environment and health caused by energy production, whether accidentally, during operations or as a result of polluting emissions.

Policy and regulatory risks

Energy efficiency investments will need to be substantially increased in the coming decades to meet the EU's long-term decarbonisation goals, especially in the building sector. However, a number of barriers are impeding efforts to scale up these investments. Meeting the EU's energy efficiency goals will require targeted policies to improve the business case for energy efficiency investments that go beyond the largely voluntary approaches that exist at EU level today, especially in case the political ambition is increased for the medium- to long-term. The expected strengthening of EE policies will be critical in shaping the future deployment of these investments. An insufficiently strong outcome in the upcoming revision of the EED poses a political and regulatory risk in the short- to medium-term.

Increasing the deployment of RES in line with EU's ambitious 2050 targets will require a strong policy investment framework that will likely need to include continued technological support in the short run at least until new business models and improved market rules can improve the bankability of these investments without policy intervention. As such, pressures to weaken existing support measures and insufficiently strong implementing measures for reaching the EU's binding 27 % target pose a policy and regulatory risk towards renewable deployment in the medium- to long-term.

Natural gas can help support the transition to a low-carbon energy system in the short- to medium-term, in particular by displacing coal and providing back-up power generation to support a significant ramp-up of variable renewable energy sources. However, it remains a fossil fuel that must be limited to achieve the EU's goal of reducing greenhouse gas emissions by 80—95 % by 2050, as well as the goal to limit global warming well below 2°C, if possible to 1.5°C, in line with the Paris Agreement. As such, it can only be a limited tool for achieving decarbonisation. Policy-makers should take measures to avoid locking-in the use of gas through an expensive overbuilding of capacity, as well as a locking-out of renewable energy sources.

Technical risks

Energy efficiency has a very low technical-risk profile and serves as a powerful risk mitigation option. While no technical risks could be identified, energy efficiency provides numerous technical benefits, in particular by increasing the margin of security in peak hours.

Uncertainties about the future technologies and cost of infrastructure investment needed to integrate high shares of renewable energy (ex. grid expansion, battery storage, demand response, etc.) pose a low risk to the development of renewable energy sources in the short- to medium-term. However, high shares of renewable energy (80+%) increase these risks in the long-term. Uncertainties concerning technologies supporting high penetration of renewable energy must be taken into account when considering their potential role in the future energy system. By reducing the demand for infrastructure investments, strong energy efficiency policies can help to minimize these risks.

Natural gas was found to have a relatively low technical risk profile for most of Europe. External technical risks may rise with increased import volumes, but past measures have helped reduce the impact of technical disruptions and current technical risks are largely mitigated by significant overcapacities. Internal infrastructure bottlenecks, however, pre-vent gas from being effectively distributed across Europe. Additional targeted investments may, therefore, be needed to ensure security of supply for those regions most vulnerable to technical supply disruptions from Russia, especially South Eastern Europe.

Geopolitical risks

Energy efficiency is in the unique position of helping to reduce geopolitical risks for both renewable energy and gas, while posing no readily identifiable risks of its own. Some of the countries' most vulnerable to gas supply disruptions from Russia have among the highest potentials for energy efficiency measures.

Geographically varying availability of land and potential for renewable energy development raise the prospect of new trade dependencies developing in the medium- to long-term in a system dominated by renewable energy sources. Large scale centralized renewable energy projects are also likely to play an increasing role in the energy system in the long term, due to advantages of economies of scale and a changing regulatory environment. As a result, the external dimension of low carbon energy security, in particular energy partnerships with new suppliers of electricity and raw materials and the development of new international governance structures should be dealt with pro-actively and at an early stage. Import vulnerabilities linked to imports of biomass and raw materials can be mitigated through diversification of supply, the development of substitutes and resource efficiency measures, including recycling and energy efficiency. Potential vulnerabilities linked to the increased centralization of renewable energy development should be carefully monitored.

Due to declining domestic gas production and resource discovery the EU is at risk of increasing its gas import dependency under BAU over the medium- to long-term, while potentially increasing resource rents for autocratic regimes in oil and gas producing countries. Furthermore, the characteristics of typical natural gas transport and supply contracts in the EU frequently leave gas importing countries exposed to significant risks from unreliable source and transit countries, especially when a supplier is dominant and diversification is low. Scenarios projecting large increases in gas imports over the medium- to long-term can be assumed to bear the highest geopolitical risk (ex. the TYNDP 2017 Scenario 'Blue Transition'). By contrast, early implementation of ambitious demand side measures (ex. EE40 scenario) combined with forward thinking engagement with the EU's energy partners can mitigate import dependency risks, while taking early action on climate change. Member States or national regulators should also monitor long-term contracts to ensure that in aggregate they are in line with medium- and long-term EU and national climate and energy goals.

Economic and social risks

Multiple European Commission assessments conclude that ambitious energy efficiency and renewable energy policies are unlikely to result in significantly higher overall costs to the energy system compared to BAU, while potentially having a positive impact on GDP and import costs. However, distributional impacts may require targeted social and labour policies and distributional measures to ensure public acceptance for low carbon technologies and infrastructure, in particular financial support for vulnerable consumers and job training measures for workers in disadvantaged sectors.

When it comes to investment in new generation capacity, renewable energy sources and especially energy efficiency are among the lowest-risk investments when a broad range of risk factors is taken into account. However, diversification benefits of renewable energy sources may decrease over the long-term.

An increase in net gas imports in the medium- to long-term risks raising the EU's energy import bill and gas prices, as well as potentially increasing the price volatility of gas supplies. Large increases in import costs and extreme gas price volatility could lead to current account deficits and reduced economic competitiveness. Financial instruments can help to mitigate the impact of price volatility. However, demand-side measures provide a more effective method of mitigating import cost risk and reducing the impact of sudden price hikes or supply disruptions on individual investors and the economy.

Access to LNG can help to mitigate import dependency risks, especially for those Member States reliant on a single gas supplier. However, misguided investments into LNG and other new import infrastructure also risk generating stranded assets and competing with low carbon options for scarce public resources. As such, LNG remains a risky and expensive option for reducing geopolitical risks, in particular relative to energy efficiency.

Environmental and health risks

Energy extraction, transformation, transport and use are not possible without environmental impacts. However, energy efficiency measures can play a crucial role in reducing the environmental impacts of all energy generating technologies, including renewable energy technologies and natural gas. In particular, energy savings can reduce the environmental impact of avoided energy throughout its entire life-cycle and contribute to reduced system requirements, generating substantial environmental and health benefits.

A comparison of energy generation technologies over a range of indicators reveals that replacing fossil fuels (including natural gas) with renewable energy technologies offers substantial reductions in the emissions of greenhouse gases and other pollutants, helping to reduce such environmental and health impacts as eutrophication, acidification, particulate matter, smog and other forms of toxicity. Like other energy generation technologies, however, renewable energy sources and their associated infrastructure (ex. transmission grid, storage) produce technology- and site-specific environmental effects that pose environmental risks and trade-offs, including raw material use, water consumption, damage to biodiversity and increased land use. Policy-makers must take these risks and trade-offs into account when planning the policy design for a future low-carbon energy mix. In particular, the use of bioenergy for power generation, transport and heating will have to be carefully weighed against the deployment of alternative technologies, such as electric vehicles and heat pumps. While energy savings and other risk mitigation strategies can help mitigate the environmental impacts in the short- to medium-term, the environmental risks of bioenergy are significantly higher in the medium- to long-term under European Commission target scenarios and thus require careful policy monitoring.

While generally considered less carbon intensive than other fossil fuels when combusted, natural gas is still associated with significant environmental risks along each step of the supply chain. In the European context, particular challenges include environmental risks associated with a potential increase in the domestic production of unconventional gas reserves (ex. water contamination and depletion, air pollution, seismicity, land-use change, health impacts) and the leakage of methane, a GHG far more potent than CO2. As a result, a precautionary approach to environmental risk management becomes particularly important in the application of gas production techniques with uncertain environmental impacts (ex. high-volume hydraulic fracturing) and for supply chains that entail high energy losses and methane emissions (ex. LNG transport, long-distance pipelines). Since the EU imports much of its natural gas, the majority of GHG emissions linked to production and transmission take place outside of Europe. As such, efforts to address the problem of methane leakage must include cooperation with gas producers and transit countries outside of the EU and should furthermore reflect both the scientific uncertainty about methane leakage rates from various source countries, as well as the potentially more harmful global warming potential of methane. CCS technologies could play an important role in mitigating the GHG emissions of natural gas combustion but would likely increase gas consumption and therefore potentially worsen gas import dependence and the environmental impacts in earlier parts of the supply chain (ex. methane leakage).

As a result, the replacement of fossil fuels with renewable energy sources (including electrification and the substitution with renewable gases within environmental constraints), the reduction of fossil and renewable gas consumption through energy efficiency measures, and the reduction of methane leakage through the application of industry best practices offer the clearest opportunity to reduce the environmental risks associated with natural gas, as well as the energy system as a whole.

Conclusions on risks

To sum up, the following key observations can be made in comparing risks across categories.

Energy efficiency

In comparative perspective, energy efficiency is by far the lowest risk energy resource of the three. While distributional effects linked to the cost and impact of EE investments present a moderate risk in the medium- to long-term, only few risk categories with a low or moderate risk level were identified for EE. Furthermore, no significant risks could be identified for the technical and geopolitical risk categories. Overall, the risks associated with ambitious EE scenarios can be considered highly manageable when existing risk mitigation measures are applied.

EE investments and ambitious EE scenarios as a whole produce a range of co-benefits that allow it to play an important role in mitigating risks for both RES and natural gas development across the full risk spectrum. EE measures, including both energy savings and demand response, should be strongly prioritized in mitigating risks for these energy resources through the application of the "efficiency first" principle in energy system planning and investment decision-making.

Renewable energy

Eight risk categories were identified for ambitious RES scenarios, of which most were assessed at a low-moderate or moderate risk level and one at a moderate-high risk level. However, these risks must be viewed against the risk of late action in the context of climate change and carbon assets becoming "stranded" (i.e. unusable) in a decarbonized energy system. Furthermore, a comparison of risks across a broad range of risk factors reveals a lower cumulative risk level for ambitious RES scenarios than for BAU or high gas scenarios, especially for the categories policy and regulatory risks, geopolitical risks and environmental risks.

The temporal dimension plays an important role in assessing risks linked to high RES scenarios, as the extent and nature of the risks depends strongly on the time horizon considered. For example, while some risks represent barriers to getting to high shares of RES and EE (ex. lack of an appropriate policy framework) and require risk mitigation in the short to medium term, others represent risks that appear once higher levels of RES penetration have been achieved (ex. grid integration) and largely emerge in the medium- to long-term. Others yet will see risk decline in the short-run, but increase in the long-run (ex. diversification). Overall, high RES scenarios are associated with greater cumulative risk in the long-term than in the short- to medium-term.

The risk profile of ambitious RES scenarios is highly dependent on the overall energy mix and the mix of RES technologies in the energy system. A system with significant shares of CCS and nuclear will face other risks and challenges than one largely reliant on RES and EE and each renewable energy source has risks that are inherent to its specific technology (ex. environmental impacts). For example, the risk assessment indicates that scenarios with a high share of bioenergy have significantly more risks associated with them.

While some RES risks are associated with traditional risk management strategies (ex. diversification and the development of substitutes to mitigate import dependence), others will require innovative solutions with uncertain outcomes (ex. market design). In this context, energy efficiency (including both energy savings and demand response) and resource efficiency measures represent low risk strategies that should be prioritized to guarantee risk mitigation at the lowest cost.

Natural Gas

Twelve risk categories were identified for high natural gas, scenarios spanning across all risk levels and time horizons, with a particularly high concentration at the moderate risk level. Thus, it can be said that high natural gas scenarios have a comparatively higher cumulative risk level compared with high RES scenarios and a significantly higher cumulative risk level compared with ambitious EE scenarios.

Demand-side measures, such as a high deployment of EE and RES can make a significant contribution to mitigating natural gas risks across the full spectrum of risk categories and should be strongly prioritized in EU and national infrastructure and risk mitigation planning. The European Commission scenario EE40 projecting a strong reduction in net gas imports in the medium-term could make a particular contribution to mitigating risks linked to gas, while also taking early action on climate change.

Numerous studies highlight that the risk mitigation benefits of EE and RES are in part contingent upon the successful completion of supply side measures. For example, while Tóth (2015) assumes the implementation of a significant number of gas PCI projects, Energy Union Choices (2016) assumes varying degrees of gas and power infrastructure investments. As such, these low carbon options do not represent a risk mitigation strategy for natural gas on their own. Mitigation of the full range of risks associated with natural gas will require additional measures, including new gas infrastructure investments. Nonetheless, prioritizing demand-side measures, taking into account long-term climate targets in system planning and targeting supply-side investments can ensure that the costs of risk mitigation are minimized, in particular in the medium- to long-term.

6 General conclusion and recommendations

In October 2014, the European Council adopted targets for reducing EU domestic greenhouse gas emissions by at least 40 % compared to 1990, increasing the share of renewable energy to at least 27 % of final energy consumption and improving the energy efficiency of the EU by at least 27 % by 2030 compared to a baseline scenario. As a consequence to these targets, European fossil fuel consumption is to decrease substantially. Particularly interesting is the role of natural gas: Although it has the lowest carbon factor of all fossil fuels and is - from a climate perspective - preferable to other fossil fuels, a consequent decarbonisation of the European energy system will in the long run lead to decreased gas demand.

Providing the European economy with natural gas to ensure energy security requires widespread and intertwined infrastructure consisting of pipelines, compressor stations, LNG terminals and many other components. Investments to the infrastructure are high and long-term. Some infrastructure investments receive public financing to promote energy security. At national, regional and European level network development plans look ten years into the future to estimate future gas demand, the need for infrastructure investments and identifying possibilities for public financing.

Analysing gas infrastructure planning at European level and for six focus countries (France, Germany, Italy, The Netherlands, Spain and the UK), **Section 2** of this study shows that none of the scenarios that are used for infrastructure planning is completely coherent with governmental goals for GHG emission reduction targets or low carbon options. Instead of basing infrastructure requirements on target scenarios that portray a pathway to reaching climate goals, gas development plans are based on reference scenarios that are not in line with climate and energy targets. Security of supply and functioning of markets are still the main considerations for infrastructure planning.

Gas demand scenarios that were used for network planning have frequently overestimated the gas demand in most of the focus countries. Looking on the trend of gas demand in the last years it seems that UK and Germany have used the most reliable scenarios. More recently, all the NDPs reacted to a reduced demand expectation with respective (lower) scenarios. However, a greater validity of gas demand forecasts seems necessary.

Section 3 of this study analyses **scenarios** incorporating a strong deployment of energy efficiency and renewable energy sources. While some of these scenarios estimate a stagnating gas demand in the medium term, all of them expect a shrinking natural gas demand to reach energy and climate goals in the long run. In all countries except Spain scenarios are available in which the use of natural gas would be reduced to a fraction of its current levels (approx. 10 %) or even phased out completely when energy and climate targets are reached or overachieved. At European level, estimated gas demand in 8 target scenarios is lower in 2030 compared to gas demand estimated in the TYNDP 2017 “Blue Transition”, with estimated savings ranging from 1 % to 43 % compared to TYNDP levels. However, the decline rates of capacity demand are expected to be smaller than those of (yearly) gas demand, depending on the usage of natural gas (e.g. power generation, heating, etc). The interrelationship between yearly and hourly demand needs to be examined further.

Assessing **import dependency, diversity and costs, Section 4** of this study shows that planned infrastructure projects lead to a greater diversification of import routes. However, changing gas production trends might increase market concentration and hence lead to respective (possibly more concentrated) gas flows over time. Import diversification is high for the countries analysed in this study, but low for Central and Eastern European member states that are often reliant on a single supplier. Some of the countries have high potentials for energy efficiency measures. Significantly increasing energy efficiency, especially in the building sector, and renewable energy sources can reduce the import dependency by reducing gas imports.

Linking yearly gas demand to capacity demand and ultimately natural gas infrastructure costs is complex. A detailed modelling of the gas network is necessary to ultimately decide over infrastructure investments. To understand the order of magnitude of monetary savings related to lower gas demand, a rough estimation has been made concerning savings in infrastructure expenditure and natural gas imports. The **sum of infrastructure expenditures** for advanced FID and PCI projects amounts to €69 bn, only a minor share of this is public money. Out of this sum, €30 bn (43 %) relate to expenditures categories "Big import infrastructure projects" and "Redundant with / parallel to existing infrastructure" which might be superfluous if target scenario were used for network planning. More importantly, **fuel import savings** associated with lower gas demand are ranging from €63 bn to €223 bn for the time period from 2020 to 2030. In comparison, investments needed to reach European climate and energy goals in 2030 are estimated to be €38 bn annually over a time period from 2011 until 2030 by the European Commission, translating to €722 bn of cumulated investments over the time period from 2011 to 2030. To sum up, significant infrastructure investment savings are possible when relying on target scenarios. Even higher fuel cost savings can be expected when gas demand is reduced in line with target scenarios.

Finally, **Section 5** of this study compares **key risks** associated with renewable energies, energy efficiency and natural gas usage in terms of different risk categories. Risks associated with energy efficiency are regulatory risks resulting from inadequate political ambition, economic and social risks associated with distributional effects and health and environmental risks stemming from a deployment of new materials. Renewable energies are associated with, among others, regulatory risks resulting from inadequate political ambition, technical risks concerning uncertainties in technical potential and grid integration, geopolitical risks in terms of electricity import dependence, economic and societal risks resulting from distributional effects and environmental risk resulting from higher land use. Natural gas is associated with the largest quantity of risks in all risk categories, varying from a regulatory risk such as a gas lock-in, technical risks in terms of supply disruptions, geopolitical risks such as import dependence and long term (take or pay) contracts, economic risks associated import costs and stranded assets and environmental risks linked to the extraction of gas. Member States or national regulators should monitor long-term contracts to ensure that in aggregate they are in line with medium- and long-term EU and national climate and energy goals.

Replacing fossil fuels (including natural gas) with renewable energies offers substantial reductions in the emissions of greenhouse gases and other pollutants, helping to reduce such environmental and health impacts as eutrophication, acidification, particulate matter, smog and other forms of toxicity. However, renewables also produce technology- and site-specific environmental effects that pose environmental risks and trade-offs, including raw material use, water consumption, damage to biodiversity and increased land use, which need to be addressed. Energy efficiency measures can play a crucial role in reducing the environmental impacts of all energy generating technologies, including renewable energy technologies and natural gas. In particular, energy savings increase the margin of security in peak hours and reduce the environmental impact of energy use throughout its entire life-cycle and contribute to reduced system requirements, generating substantial environmental and health benefits. Meeting the EU's energy efficiency goals will require targeted policies to improve the business case for energy efficiency investments that go beyond the largely voluntary approaches that exist on EU level.

Distributional impacts may require targeted social and labour policies and distributional measures to ensure public acceptance for low carbon technologies and infrastructure, in particular financial support for vulnerable consumers and job training measures for workers in disadvantaged sectors.

As a **general conclusion** gas network development processes need to take target scenarios into consideration if climate and energy targets are to be taken seriously. Current scenarios used in network plans do not reflect gas demand savings associated with renewable energy and energy efficiency measures appropriately. Natural gas can help supporting the transition to a low-carbon energy system in the short- to medium-term by displacing coal and providing back-up power generation to support a significant ramp-up of variable renewable energy sources. However, it remains a fossil fuel which use needs to be reduced to achieve the EU's goal of reducing greenhouse gas emissions. Monetary savings associated with lower gas demand result from avoided infrastructure investments and gas import savings. It is highly recommended to assess the risk of stranded investments, in particular where infrastructure projects receive public financing.

To achieve this, the following **recommendations** are given to policy makers and stakeholders:

- Network development plans should **show the effects of different scenarios** on gas infrastructure needs, and better consider the possibility of a decreasing gas demand, to be prepared for different possible developments. NDPs and their underlying demand scenarios are, in their current state, not based on the implementation of all necessary low carbon options to fulfil climate policy goals. Security of supply and functioning of the markets are still the main considerations for infrastructure planning.

- None of the **PCI** priority gas corridors highlight sustainability as a core aim. Projects are not required to contribute to sustainability to receive PCI status. In order to improve the adequate level of public spending stakeholder engagement in the selection and monitoring of PCI projects should be improved, especially for what concerns redundant or big import infrastructure projects in order to avoid stranded-investments.

- A strengthening of the mandate, resources and tools provided to **ACER** may be desirable to ensure the proper coordination of gas infrastructure at EU level. To ensure proper consideration of low-carbon options, the planning process should ensure earlier and broader stakeholder participation, and consistency of demand scenarios with long term European energy strategy.

- **Uncertainties and risks** associated with scenarios need to be considered in network development planning. Even though a high usage of natural gas is termed as a reference case, it is associated with large environmental, societal and geopolitical risks. Policy-makers should take measures to avoid locking-in the use of gas through an expensive overbuilding of capacity, as well as a locking-out of renewable energy sources. Uncertainties concerning technologies supporting high penetration of renewable energy must be considered when considering their potential role in the future energy system. By reducing the demand for infrastructure investments, strong energy efficiency policies can help to minimize these risks.

Imprint

Low Carbon Options and Gas Infrastructure

Chances of efficiency and renewable energies for gas infrastructure planning and security of supply in Europe

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