The elephant in the room: How do we regulate gas transportation infrastructure as gas demand declines?

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SUMMARY

The use of gas will decline dramatically as part of the transition to net zero. Modelling at European level shows that by 2050 about 70% less gaseous fuels will be used. Significant regulatory reform is needed to deal with the impacts of this decline on the gas grid.

Fossil gas today serves many end uses, from power generation to residential cooking. In order to transport gas, vast gas grids have been built over the past decades. In Europe, there are now over 130,000 kilometres of gas transmission pipelines – a distance of more than three times the circumference of the Earth. At the more local distribution level there are another 1,800,000 kilometres of pipeline[1]. At the moment, regulation in most European countries treats gas distribution networks broadly as if they are expected to operate in perpetuity though there are some exceptions. But the era of widespread fossil gas consumption will come to an end as the world decarbonises its energy use. This poses a significant challenge for policy makers: if fewer and fewer people use gas, how is the decline of the system managed, who pays for it and how does this work support a rapid energy transition?

Gas in decline

Globally, unabated fossil gas consumption will need to decline by around 80% by 2050 if the goals of the Paris Agreement on climate change are to be met[2]. In Europe, fossil gas makes up 95% of gaseous fuels consumption as of today. Driven by a number of developments, including climate targets at European Union (EU) and national level, energy security concerns after the invasion of Ukraine by Russia, and gas price volatility[3], a steep decline in the use of fossil gas is expected over the next two decades.

A recent impact assessment by the European Commission[4] of the proposed 2040 90% greenhouse gas reduction target (relative to 1990 levels) indicates that total demand for gaseous fuels, including gases such as hydrogen, will fall between 71% and 73% between 2019 and 2050 (Figure 1).

Impact of declining gas demand on final customers

Fuel switching away from gas means that the costs of running gas infrastructure and the amortisation of the sunk network costs will be paid by fewer and fewer customers. Typically, tightly regulated grid fees for remaining gas customers would rise as more consumers decouple from gas grids, for example by switching to a heat pump or district heating.

Analyses of the effects of declining gas consumption on network costs by the British energy regulator Ofgem show that network charges could rise by a factor of 10 within 20 years [5]. Gas grid tariffs in Austria could increase up to fourfold by 2040 under decarbonisation scenarios [6]. Projections for Germany and France indicate a fivefold and threefold increase, respectively [7]. Figure 2 shows the projections for all four countries.

The longer regulation allows for the continued investment into the gas grid without a credible plan for decommissioning, the bigger the problem becomes. Rising gas network fees result in an increased incentive to switch away from the gas grid, resulting more customer switching and even higher network fees. Low-income households, in particular, are exposed to a considerable risk here, as they may not have the means to easily switch away from the gas grid to other alternatives such as heat pumps.

Alternatives to gas grid decommissioning

Gas network operators have promoted the replacement of fossil gas with hydrogen and other low carbon gases as an alternative to grid decommissioning [8]. At first glance, this may seem like an attractive option to policymakers who want to minimise impacts of the energy transition on customers and gas industry stakeholders. Using the existing gas grid for hydrogen transportation is both technically challenging and economically irrational, however.

From a purely technical point of view, an existing natural gas infrastructure cannot simply be used with hydrogen. This is due to the lower energy density, higher flow resistance, making it harder to transport the same energy content, and the corrosive effect of hydrogen. In some countries the gas grid has been upgraded. For example, in the UK old metal gas pipes have been replaced with polyethylene pipes through the iron mains risk reduction programme. However, the UK gas infrastructure would still require further modifications; analysis for the UK government suggested around £22 billion of investment in gas distribution infrastructure, a figure close to the current regulatory value of the distribution infrastructure, would be needed for it to be made suitable for hydrogen[9]. In other countries much of the gas grid would require significant investment.

In addition, hydrogen is produced at great expense, requiring large amounts of green electricity. The use of hydrogen in the heating sector is inefficient and more expensive than alternatives, as more than 50 independent studies have now shown[10]. For example, projected costs to consumers of a hydrogen for heating pathway are almost twice as high compared to electrification and district heating pathways. There is also an associated risk of fossil fuel lock-in if hydrogen production falls short of expectations. That is, in the absence of hydrogen being available, further investments in existing and new infrastructure for hydrogen will lead to overcapacity of such infrastructure, which eventually can only be used to transport and combust fossil fuels.[11].

Despite the outlook of limited alternative use of the gas grid, there is often a significant misalignment between climate targets and gas grid regulation. Data collected for Europe's largest consumer of fossil gas, Germany, shows that over the last decade the length of gas grid was expanded thanks to increased investment [12]. With the expected decline in fossil gas, and the fact that gas transmission and distribution assets have very long lifetimes, of around 80 years, imply early retirement and potentially stranded assets.

Managing an orderly gas grid decline

Business as usual regulation, with long asset lives and mass disconnections over the coming decades, could potentially lead to a gas grid death spiral with ever increasing network costs encouraging an even more rapid network decline.

The alternative is orderly regulation which anticipates the decline in gas use over the coming decades and provides a framework that allows for gradual decommissioning of the gas grid in those areas where this is the only viable option[6,7,13,14].

The first signs of this happening are already visible indicating a wider shift in regulation: A recently adopted EU directive as part of the hydrogen and decarbonised gas market package requires that "Member States shall ensure that distribution system operators develop network decommissioning plans where a reduction in natural gas demand requiring the decommissioning of natural gas distribution networks or parts of such networks is expected."

In France, gas network tariffs increased in 2023 with the president of the French energy regulator stating that this was a result of declining gas demand and predictions of a shrinking number of customers. The Netherlands provides a good example of making far-reaching changes via a combination of accelerated depreciation and local authority powers. In the current regulatory period (2022-2026), distribution system operators are permitted to depreciate investments in their grids on a cost-reflective basis which recognises a shrinking grid. This is intended to align the costs with the actual use of the network, with connection points expected to decrease in the medium term. Furthermore, gas distribution system operators receive compensation for the costs of dismantling the gas distribution networks and for removing connection points. The Danish government has set up a decommissioning fund to cover costs associated with removing gas supplies from homes, anticipating all homes switching to heat pumps or heat networks by 2030. UK regulator Ofgem has consulted on future network regulation which includes a proposal to accelerate financial depreciation rates and smooth their impacts in line with expected disconnection rates.[15]

This puts the onus on regulators to act and time is of the essence. We propose five steps for an orderly gas grid decommissioning (Figure 3).

Step 1: Integrated planning

Integrated long-term infrastructure planning, beyond gas, is meanwhile needed [13,15,16]. Just as gas grids will see falling utilisation rates, the electric grid faces the opposite challenge: a steep increase in demand, in part driven by the electrification of heating via heat pumps. Analysis by the European Commission [4] models an increase by a factor of 2.8 in electricity demand by 2050. District heating networks will also need to be upgraded and expanded to replace fossil gas heating using low carbon sources of heat such as provided by large heat pumps using ambient heat and waste heat for example from industrial facilities.

In addition to reforming regulation at the national level, much of the detailed infrastructure planning needs to happen at the local level. This is because heat sources and heat demand are highly specific to the location[13]. Take a city for example where industrial waste heat is generated in the industrial district that could be used in buildings in other areas. That is why the recently adopted Energy Efficiency Directive requires municipalities of 45,000 inhabitants or more to develop local cooling and heating plans.

Some countries are further along this path than others. In Germany, the Act on Heat Planning and Decarbonization of Heat Networks, effective January 1, 2024, aims to achieve climate neutral heat supply in line with climate targets by 2045. It mandates that municipalities in Germany with over 100,000 inhabitants must develop heat plans by mid-2026, while those with fewer than 100,000 have until mid-2028, and those with fewer than 10,000 must adhere to simplified planning requirements. Heat planning is seen as instrumental in overcoming inadequate planning for the heat transition, ensuring investment security for renewable energy infrastructure, and aligning consumer expectations. While the Act recommends a planned approach to decommissioning gas distribution networks, it does not mandate it. It does, however, mandate the end of installing new fossil fuel heating systems in the area subject to the plan. The only exception is if those heating systems can also run on fuels such as hydrogen or biogas and the local gas grid operator has a credible plan for introducing these energy carriers to replace fossil gas. It would only be logical to require a plan for decommissioning if that is not the case.

Ideally, heat plans would provide clear statements on the medium and long-term natural gas coverage of neighbourhoods, enabling fossil gas customers to plan for heating system replacements. This is now happening in cities such as Basel and Winterthur in Switzerland, for example where the city authorities have communicated their plans for the phase out of the gas grid in parts of the city providing customers with much needed clarity. Additionally, this clarity allows natural gas network operators to make informed investment decisions and targeted maintenance efforts. In both cases, the plans have been developed and shared through an open consultation and engaged communication process which is critical.

Step 2: Set appropriate depreciation rates

Under the current regulatory framework, it is typical to recover the investment cost for the gas grid over very long periods of time, e.g. 45 years paid for through consumer bills. But net zero targets for 2050 will need to be met much earlier than that. One option to deal with this is to accelerate depreciation of existing assets. What this means is that more capital investment is paid off early compared to flat-rate depreciation as had been used previously, thereby reducing stranding risk.

Step 3: Define thresholds and criteria for decommissioning

In order to avoid an exponential increase in grid costs for the affected customers in the grid section, but also for all other grid customers, criteria and thresholds should be defined above which the grid operator should be able to no longer supply customers or disconnect them from the grid.

Definition of a tipping point above which the termination of fewer customers remaining in the grid is possible: Potential indicators for defining such thresholds could be, for example, the number of customers per kilometre of line length [number of customers/km], the connected load [MW/km] or sales per kilometre of line length [MWh/km] or corresponding density indicators such as sales per supplied area [MWh/km^2].

Step 4: Minimise capital investment

Further capital investment in gas transportation infrastructure needs to be increasingly carefully considered in light of the risk of asset stranding. Historically, gas assets have been built to last for many decades, but with decarbonisation timelines, assets may have much shorter useful lives than has been assumed historically.

Investment decisions need to take into account safety and performance requirements as the use of gas declines but, continued gas network investment represents a significant potential liability for consumers and taxpayers. Regulators could use modified investment appraisal processes, incentives to extend the life of existing assets and accelerated depreciation of new assets to reflect the forecast decline in gas throughput.

Step 5: Fund disconnections and decommissioning

Customers who want to disconnect from the gas grid often face charges for doing so which can act as a deterrent to switching to low carbon alternatives. Especially low-income customers may decide to remain on the gas grid if they face the prospect of significant fees. This is why the Danish government provides funding to households to cover the gas network disconnection costs.

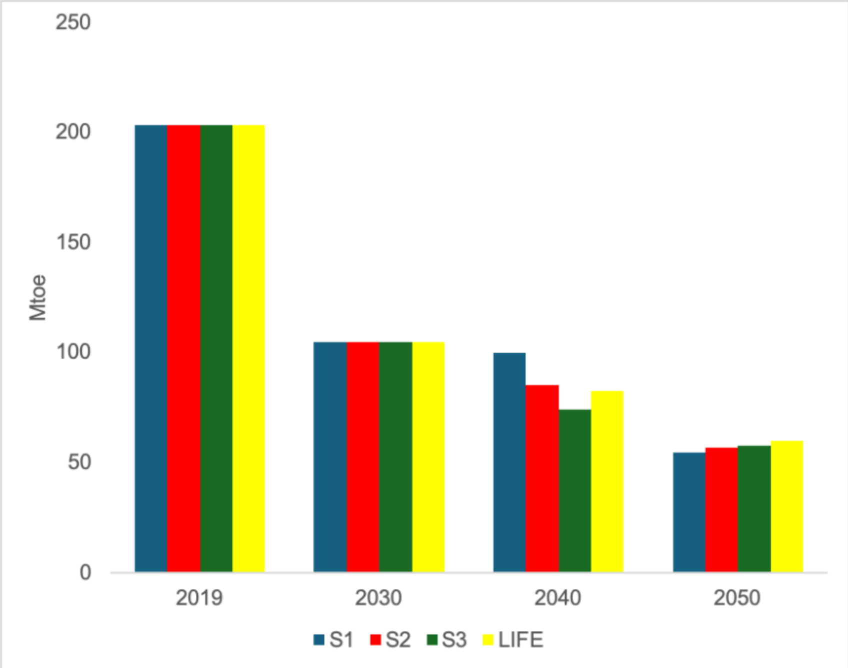
There will also be significant costs associated with the physical decommissioning of the grid to make it safe. For Germany, recent analyses suggest a decommissioning cost between 11.4 billion euros [7] and 24.6 billion euros under a high electrification scenario [14]. Similar analysis in the UK estimates the costs of decommissioning to be up to 25 billion pounds [17], equivalent to about 29 billion euros. Currently, there is no funding earmarked to cover these costs and they therefore represent an additional liability to taxpayers. Regulators should take steps to gain a thorough understanding of the required process and costs of decommissioning the gas grid in order for this risk to be properly considered, for example through setting aside funds for the safe decommissioning of the gas grid.

Outlook

Regulators across Europe have started to look at how to deal with the challenge of significant gas demand reduction and the implications for the gas grid. This includes major economies like Germany, France, the Netherlands and the UK. Meeting this challenge will require a critical evaluation of requests for additional gas infrastructure within the context of whether such expansion is in line with the decarbonised system set out in EU policy. In addition to ensuring any additional spending on the gas grid is aligned with the decarbonisation pathway, regulators and governments will need to allow for gradual decommissioning of the gas grid. The sooner issues of asset stranding and decommissioning costs are managed, the lower the risks for taxpayers and the climate.

Figures

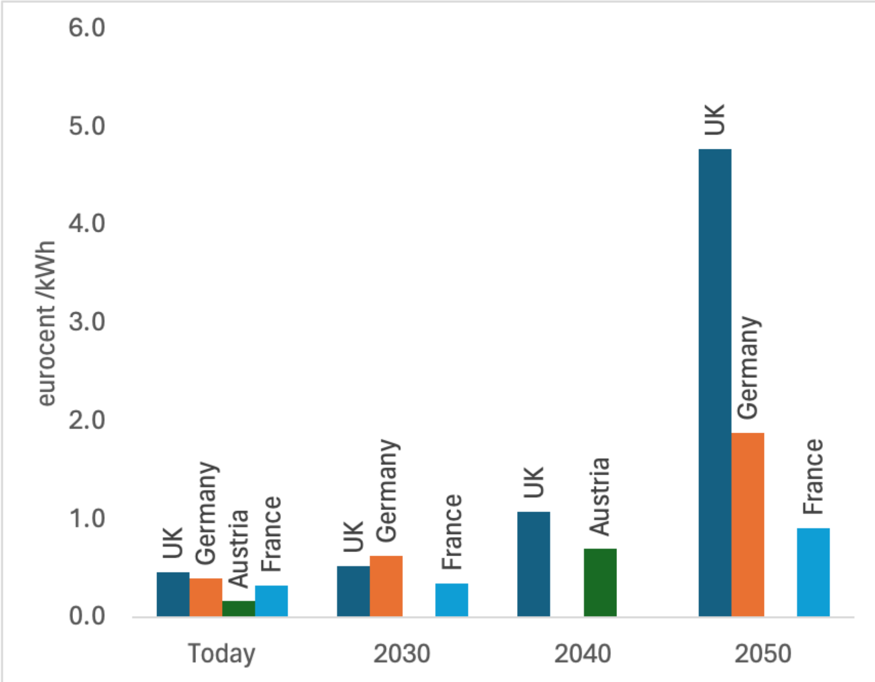
Figure 1: Consumption of gaseous fuels in the EU under different scenarios



Mtoe = millions of tonnes of oil equivalent; S1-3 and LIFE are different scenarios is available in the impact assessment by the European Commission[4]:

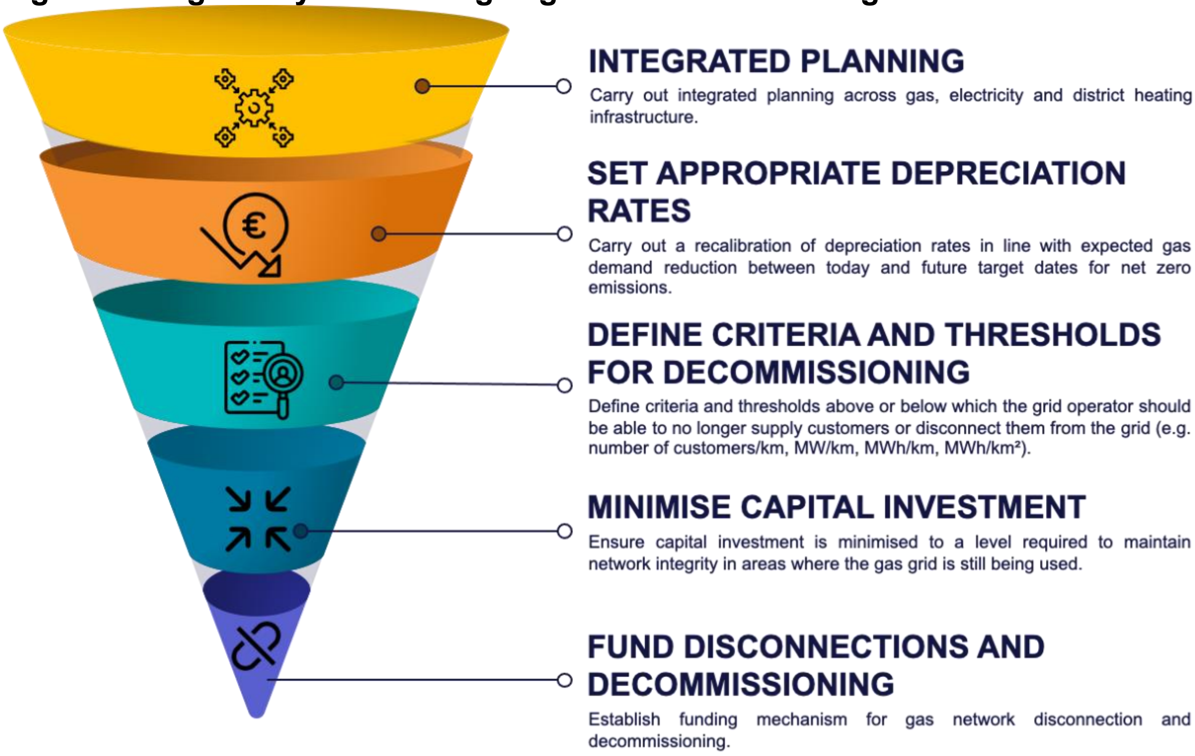
- S1: up to 2040, this scenario delivers a target in 2040 that is the linear reduction path of net greenhouse gases between 2030 and 2050. It does not assume specific mitigation of non-CO_2 emissions beyond their default evolution within the current framework, for instance in agriculture, or in the land use, land-use change, and forestry sectors.
- S2: to reach a reduction of at least 85% by 2040, this scenario combines the energy trends reflected in S1 with a further deployment of carbon capture and efuels as well as substantial reductions of emissions in the land sector, including non-CO_2 emissions in the agriculture sector and carbon removals in the land use, land-use change, and forestry-sectors.
- S3: to reach a reduction of at least 90% by 2040, this scenario builds on S2 and relies on a fully developed carbon management industry by 2040, with carbon capture covering all industrial process emissions and delivering sizable carbon removals, as well as higher production and consumption of e-fuels than in S2 to further decarbonise the energy mix.
- LIFE looks at the sensitivity of the analysis to key societal trends related to more sustainable lifestyles, resulting from changes in the consumer preferences, from circular economy. measures related to the use of energy and materials, as well as from changes in mobility and the food system.

Figure 2: Gas grid charges under decarbonisation scenarios



UK: used average projected grid charges based on [5] from three decarbonisation scenarios (Consumer Transformation, Leading the Way, System Transformation); Germany and France: based on [7]; Austria: based on [6]

Figure 3: Regulatory levers for gas grid decommissioning.



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