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Planning and regulating Europe's gas networks: breaking up with fossil gas

Final report

Authors

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1 Summary

1.1 Introduction

The urgent need to meet climate targets requires a significant reduction in fossil gas demand over the coming years. This has substantial implications for gas grid infrastructure, yet current grid planning in most EU Member States does not adequately reflect the necessary decrease in fossil gas usage.

The aim of this study is to provide insights into how to adapt the regulation of gas grids to meet future energy needs while supporting climate goals. To this end, the study provides comprehensive information on the current state of the gas grid, its development, and the regulatory framework governing it in selected European countries. This includes the identification of current regulatory barriers for the phase-out of fossil gas.

1.2 Persistent gas demand trends despite climate targets

Over the past several years, fossil gas demand has shown little to no decline in most countries included in the study. There is considerable variation in the share of natural gas consumption in total energy demand across the countries, however, ranging from 41.8% in Italy to 12.4% in Denmark.

1.3 Disconnect between gas network planning and climate objectives

The planning of gas networks is predominantly driven by projections of future gas demand formulated by system operators in consultation with a state's regulatory authority. This process often relies on historical consumption patterns and anticipated demand, rather than integrating broader climate objectives or national heat planning initiatives. As a result, there is a significant disconnect between the strategic planning of gas infrastructure and strategic planning related to achieving climate targets. In the countries observed, this disjunction means that while gas networks are being developed or maintained to handle expected demand based on historical patterns, there is little consideration of the need to reduce fossil gas consumption in line with decarbonisation goals. This misalignment poses a substantial obstacle to the transition towards a sustainable energy system and underscores the need for more cohesive and climate-aligned planning.

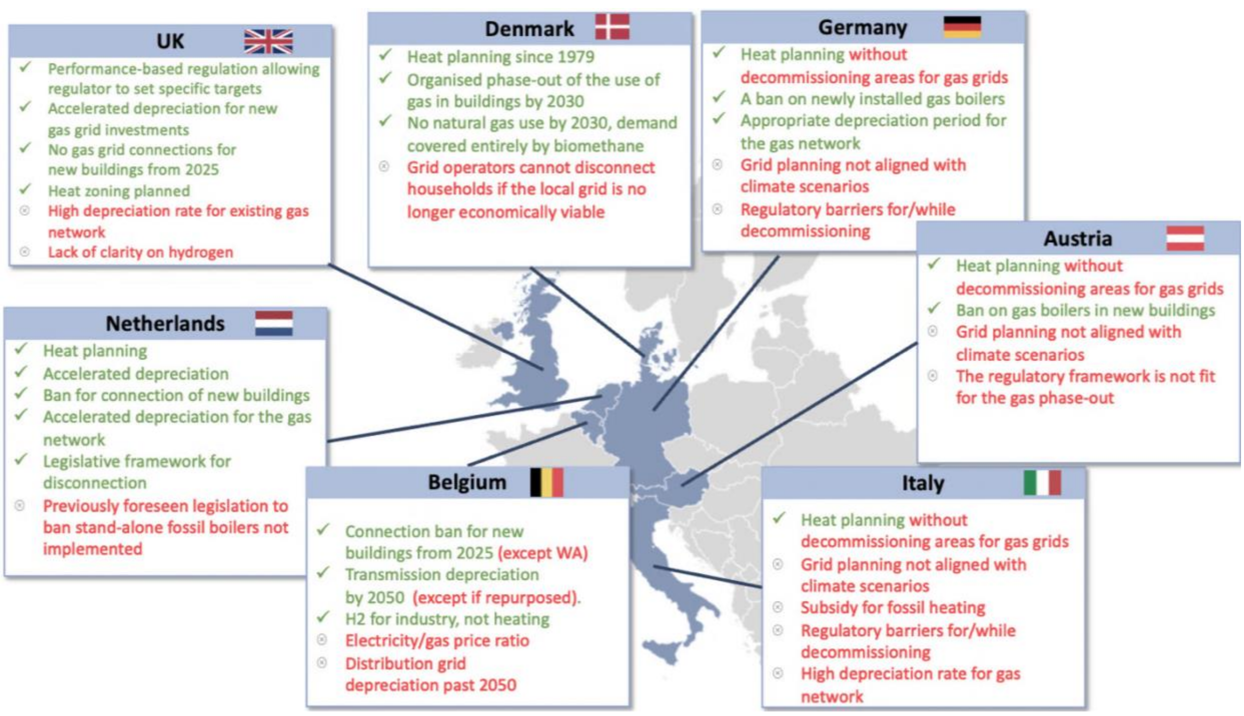
1.4 Regulatory gaps in gas distribution decommissioning

While some countries have taken important steps towards developing a regulatory framework supporting gas grid decommissioning, important gaps remain (see Figure 1).

Regulations in Austria, Belgium, Germany, Italy and the United Kingdom lack clear guidelines for decommissioning gas grid areas in the mid to long term, prohibiting denial of grid access or disconnection of existing consumers unless requested by those consumers. These countries also have long amortisation periods that conflict with climate target phase-out dates; and network charges do not include future dismantling expenditures, preventing costs from spreading over time.

Conversely, the Netherlands has adopted degressive depreciation of infrastructure assets (where a higher amount of costs are recovered in earlier years) and compensates operators for dismantling costs, aligning with anticipated decreases in connection points. In the United Kingdom, while depreciation is not straight-line (with the same amount of costs recovered through energy bills each year), schemes like the Iron Mains Replacement Programme, an initiative to replace old metal pipes, continue to drive network investments. The UK regulator recently decided that investments in new gas grid assets would be fully depreciated by 2050 at the latest, and is considering applying this rule to existing gas grid assets also (Ofgem 2024). Denmark has established a timeline for the phase-out of gas usage in buildings, with the objective of achieving this by 2030. In parallel, the state-owned distribution system operator (DSO) Evida is already planning the related decommissioning.

Figure 1. Overview of country-specific findings on the regulation of decommissioning gas networks



1.5 Insufficient consideration of vulnerable customers

Decreasing gas throughput increases network charges by spreading fixed costs over a smaller sales volume and fewer consumers. This increase raises questions about how costs will be allocated. The discussion surrounding the phase-out of gas (and potential transition to low-carbon heating in particular) has yet to address the issue of protecting vulnerable customers, especially from excessive costs. Although many countries run schemes to financially support energy-poor households, infrastructure planning processes in the countries considered in this study do not explicitly address the concerns of vulnerable energy consumers. Absent consideration of the support needed to transition vulnerable energy users away from the gas network, rising grid charges will fall on the shoulders of those who remain connected, while those who can afford it are more likely to switch to more efficient electric options such as heat pumps. The EU's Gas Package includes a requirement to provide guidance to countries for dealing with this issue.

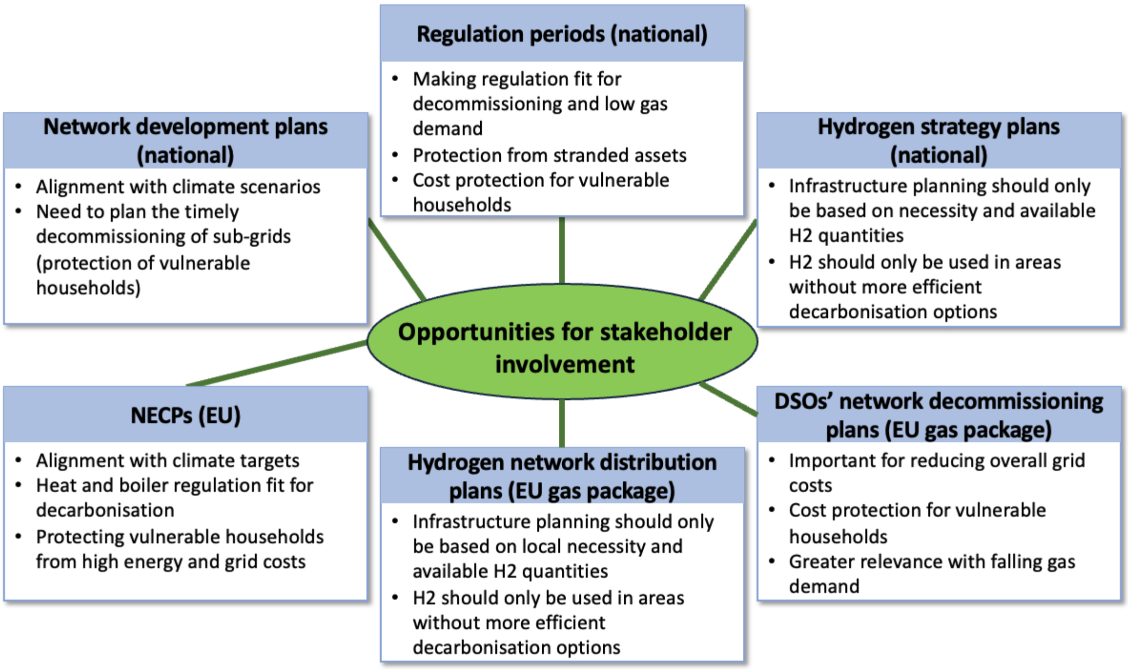
1.6 Insufficient coordination between gas grid and heat planning

Regulations regarding heat planning and boilers have significant impacts on the future development of gas distribution networks. The networks will still be necessary if heat planning relies on hydrogen or biomethane, albeit with lower throughput volumes if extensive demand-reducing efficiency measures are implemented. Should boiler regulations permit the use of technologies that utilise gaseous fuels in proportion, such as hybrid heat pumps or gas combined heat and power (CHP), gas distribution infrastructure will continue to be required. Flow rates through the gas networks may be so low, however, that network operators may question whether they can continue to operate the infrastructure economically. The implications of each scenario will affect both system users and operators, and deserve careful consideration. The analysis indicates that in the countries examined, there is insufficient coordination between heat planning, revised boiler regulations, and gas grid infrastructure planning processes.

1.7 Opportunities for stakeholder involvement

Stakeholders have the possibility to influence the processes surrounding grid planning and the development of grid-related regulations, and ensure alignment with climate goals. Figure 2 highlights key opportunities for involvement in the planning framework and provides suggestions on which elements to take into account.

Figure 2. Opportunities for stakeholder involvement in gas network planning and regulation, and key points to make for appropriate cost-effective infrastructure



1.8 Recommendations for policy and regulation

Provided below is a list of recommendations based on the analysis in this report.

- **Recommendation 1: Adopt national phase-out target and give energy regulators a net zero mandate**

  The current general regulatory focus is on the security of supply and cost control, with minimal attention paid to climate targets. The introduction of an explicit obligation for regulators to support climate targets could serve to align regulatory measures with decarbonisation targets.

- **Recommendation 2: Make the regulatory framework fit for the gas phase-out**

  - Explore regulatory models that incentivise measures aimed at increasing system efficiency instead of primarily rewarding investments.
  - Create a regulatory framework that enables the refusal of new connections to the gas network and the disconnection of existing customers from the network.
  - End incentives for grid expansion (e.g. by concession contracts) and additional customer connections.
  - Enable the claim of costs for the future decommissioning or dismantling of the network as part of current network charges or through financing mechanisms, and set aside those monies to use for the anticipated gas grid decommissioning and dismantling.

- Prevent stranded assets, distribute decommissioning costs evenly over an extended period, and shorten the depreciation periods for infrastructure investments, both past and future, so that they are fully amortised by the time the grid is decommissioned.

- **Recommendation 3: Adopt integrated heat and grid planning**

  The coordination of resources and infrastructure is a fundamental aspect of heat planning. The heat planning aligned with climate targets should consider technical feasibility, environmental impact, cost efficiency and security of supply. It is important to define guidelines for the utilisation of limited resources (e.g. biomass, hydrogen) and to ensure that this is coordinated with infrastructure planning. Technologies such as hybrid heat pumps, which require gas networks but only have a limited throughput volume, should be avoided as they are an obstacle to system efficiency.

- **Recommendation 4: Plan future gas infrastructure based on realistic assumptions about future availability of zero-carbon heating technologies**

  Due to the long investment cycles involved, any new heating system installed today must be compatible with long-term climate targets, favouring electrification and district heating over gas, as the future availability and price of biomethane and hydrogen are uncertain. Infrastructure planning should consider the predicted and necessary reduction in gas consumption, and infrastructure regulation should allow for decommissioning. Delaying decisions on gas network requirements could exacerbate the situation as it could lead to stranded assets, which would increase costs for customers.

- **Recommendation 5: Track and collect harmonised data at the EU level**

  While gas demand is recorded in detail by Eurostat, data on the gas infrastructure at national level is not easy to obtain. To track how gas networks evolve over time, data on gas networks in all Member States should be collected and published. This will allow systematic tracking of whether infrastructure changes are in line with climate targets and an associated decrease in gas consumption in all sectors.

- **Recommendation 6: Protect vulnerable customers**

  The cost of remaining connected to the gas grid will rise as shared charges are borne by a dwindling number of customers. Vulnerable consumers and low-income earners should therefore be prioritised and enabled to switch to sustainable heating solutions at an early stage, without increasing their bills.

2 Introduction

Fossil gas use must plummet to meet Europe's climate goals. Practical decisions about gas infrastructure planning, maintenance and development are not yet aligned with this reality, however. Relevant decisions regarding gas infrastructure are largely made in response to requests from gas DSOs, instead of climate commitments. This reactive paradigm made some sense at a time when gas DSOs were building infrastructure to meet expanding demand. Now, with the climate in crisis, we face a gas system that must rapidly contract. Proactive decision-making is needed to guide this change. Regulators and stakeholders need greater oversight and enhanced transparency in distribution network development to ensure that infrastructure investment is consistent with climate policies and is not used as a barrier to greater system transition.

Considering the anticipated decline in the number of customers connected to the gas network, their interpretation of consumer protection should be redefined. The costs per customer are increasing because of infrastructure upgrades, while the number of consumers bearing these costs is in decline. The remaining customers are required to pay higher prices. Those who are disadvantaged in terms of their energy usage (for example because they are on low incomes, live in poorly insulated buildings, or both) are at an elevated risk of being burdened with the costs associated with an increasingly expensive and unhealthy system. To illustrate, the average gas bill in France increased by approximately 11.7% in July. This rise is largely attributable to the decision of the Commission de Régulation de l'Energie (CRE) to enhance the gas tariff to offset the escalating maintenance costs of the network, which have been exacerbated by a decline in consumption (energynews 11 June 2024).

The revised European Gas Directive mandates that gas distribution network operators develop decommissioning plans for the gas grid when a reduction in gas demand is expected, as specified in Article 57. However, despite this increased recognition of the need for substantial reductions in gas usage, the realities on the ground reflect considerable shortcomings.

The aim of this study is to shed light on gas networks and their regulation in seven countries: Austria, Belgium, Denmark, Germany, Italy, the Netherlands and the United Kingdom. We address the mechanics of the current situation of gas distribution network build-out, including existing planning processes, information transparency, decision-making and stakeholder involvement. With this additional insight, we provide recommendations that address the practical realities facing regulators as they grapple with this transition. In this way, we aim to develop solutions that meet the challenges at hand and to minimise the information gaps. In this initial project, we will review several case studies to draw wider lessons for how to align gas network regulation with the fossil gas phase-out.

This project addresses several themes to fill information gaps:

- **Trends in the gas distribution grid:** Analysis of system expansion or contraction, throughput changes, and shifts in consumer numbers and profiles.
- **Role of alternative gases:** Examination of the impact of alternative gases on current regulatory decisions.
- **Infrastructure decision-making:** Evaluation of how decisions are made regarding maintenance, development and repurposing of infrastructure.
- **Alignment with climate goals:** Assessment of how decision-making aligns with EU or national climate goals and plans.
- **Consideration of vulnerable users:** Investigation into the inclusion of vulnerable user concerns in decision-making.
- **Information sharing and transparency:** Review of how information is shared with regulators and stakeholders.
- **Stakeholder involvement opportunities:** Analysis of opportunities for stakeholder engagement in adapting the regulatory framework to address systemic challenges.

This is the final report of the project, which presents an analytic summary of the case studies prepared for each of the seven countries in question. For further detailed information on a specific country, please refer to the corresponding country reports in the toolkit. Furthermore, this report presents an analysis of the general trends and offers recommendations for regulation based on the results.

3 Methodology

A multifaceted approach was employed in this analysis to gain a comprehensive understanding of the gas infrastructure landscape in each country. A fundamental step in this process was an extensive literature review in the countries concerned, with the objective of identifying and comprehending pertinent regulations, data and developments. This research provided the foundation for the analytical framework, enabling a comprehensive examination of the national contexts.

In addition to the literature review, expert interviews were conducted in each of the countries. The focus was on gaining a comprehensive understanding of the status of gas infrastructure and the applicable regulatory framework. These expert interviews facilitated the acquisition of practical insights, clarification of ambiguities and elucidation of subtleties in the disparate national approaches.

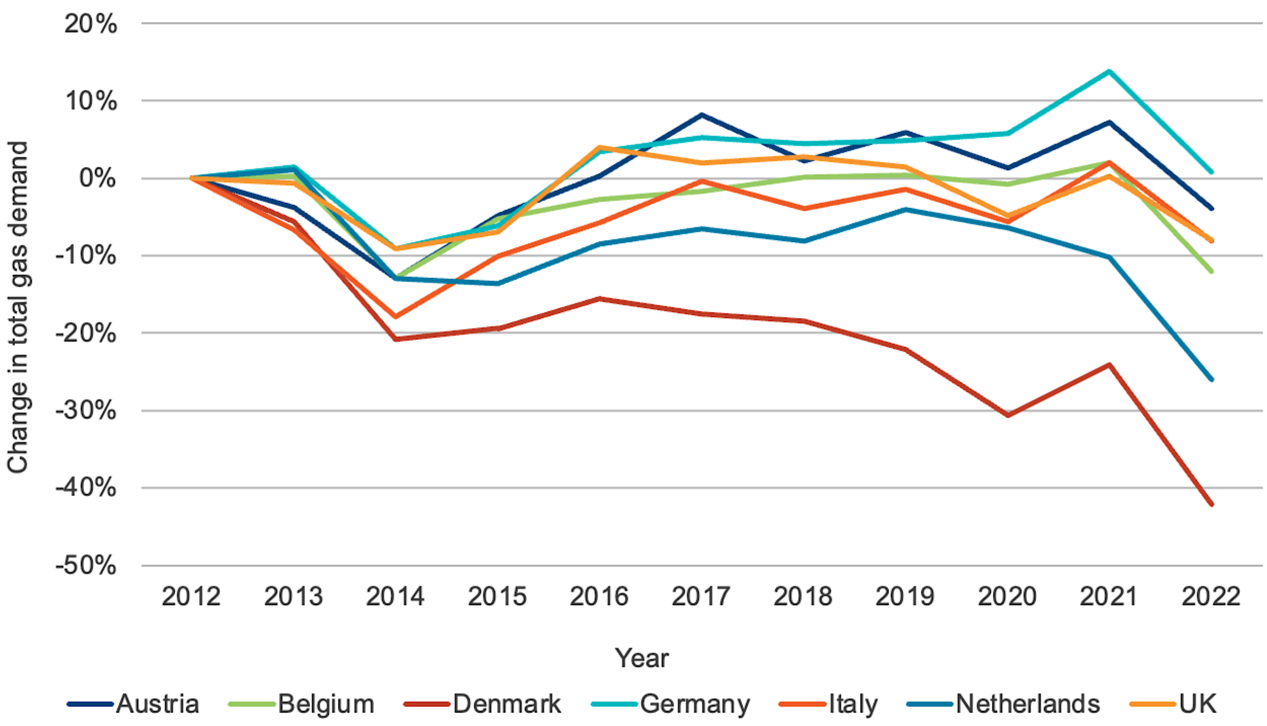
Subsequently, the data was subjected to a systematic analysis. This entailed a quantitative evaluation of statistical information and a qualitative analysis of expert statements and opinions. The combination of these methods permitted an in-depth examination of each national context. A further step was the comparative analysis of the information gathered to identify similarities, differences and potential challenges between the countries. The comparative approach facilitated the detection of patterns and trends, thereby enabling the formulation of conclusions pertinent to the overall assessment.

4 Development of fossil gas consumption and heating sector

4.1 Gas demand: No decline in sight

When allowing for the factors that influence fluctuations in gas consumption (e.g., weather, the Covid-19 pandemic, economic growth), no general trend of a gas phase-out can be detected in Germany, Austria, Belgium, Italy or the United Kingdom to date. Gas consumption has remained high, or even increased (Germany), since 2012. The year 2022, which was exceptional in terms of the energy crisis, shows that consumption significantly decreased within one year, dropping even further in 2023 (AGEB 2023). In the Netherlands, a slight reduction in consumption was observed prior to 2022. In Denmark, consumption had fallen by one quarter of the 2012 level before 2022 began (see Figure 3).

Figure 3. Development of gas demand in case study countries as percentage trend since 2012



Source: Eurostat 2023; DUKES 2023

In recent years, Austria, Belgium, Denmark, Germany, Italy, the Netherlands and the United Kingdom have exhibited divergent trends in fossil gas consumption, reflecting their disparate energy needs and policies. Following a brief period of marginal decline between 2012 and 2016, the consumption of natural gas in Germany and Austria resumed its upward trajectory and has remained at a remarkably high level since 2016. In Germany, annual consumption has averaged approximately 820 TWh, while in Austria it has averaged approximately 80 TWh. In Germany, gas consumption was 14% higher in 2021 than in 2012. In Austria, the consumption of gas in 2016 was 7% higher than in 2012, although there has since been a decline, with 2021 levels of gas consumption approaching those recorded in 2012. It is likely that 2022 gas consumption in all countries under analysis declined in response to the gas crisis precipitated by Russia’s war on Ukraine.

A comparable trend was observed in Belgium, Austria and Italy, where there was a decline in consumption of over 10% by 2014 in comparison to 2012. This was followed by an increase to a level approximating that of 2012 by 2021. However, in 2022 there was a decline due to the impact of the gas crisis.

The total consumption of natural gas in the Netherlands exhibited a slight decline from 2012 to 2014, followed by a period of relative stability until 2021. The reduction in gas demand that occurred in the Netherlands until 2022 resulted in a decrease of 26% compared to 2012.

In Denmark, there was a decline in gas consumption from 2012 to 2014, followed by a period of stability until 2018. Subsequently, there was a resumption of decline. Denmark recorded the most significant decline in gas consumption over the past decade, with a reduction of approximately 42% from 2012 to 2022.

The exclusion of the power sector from the analysis yields a divergent representation of the period spanning 2012 to 2021. The demand for gas in the remaining sectors (households, industry, transport and tertiary) exhibited a level commensurate with that of 2012 in the United Kingdom (+0.3%); while in Austria (+8.3%), Belgium (+9.2%), Denmark (+5%), Germany (13.6%) and Italy (3.2%), it surpassed that of 2012. In the Netherlands, a 9.7% reduction was identified.

There is considerable variation in the share of natural gas consumed in total energy demand (Table 1). The countries with the highest shares are Italy, the Netherlands and the UK, while Denmark has the lowest. These differences highlight the diverse energy profiles and dependencies on natural gas of the European nations in question.

Table 1. Population and natural gas consumption data for selected European countries, 2021

Country	Population 2021	Share of natural gas of total primary energy demand 2021 [%]	Gas demand 2021 [TWh/a]	Gas demand per capita [MWh/a]
Austria	8,955,797	22.7	83.4	9.3
Belgium	11,586,195	24.7	157.8	13.6
Denmark	5,856,733	12.4	25.6	4.4
Germany	83,196,078	26.4	893.8	10.7
Italy	59,133,173	41.8	704.4	11.9
Netherlands	17,533,044	41.5	303.9	17.3
United Kingdom	67,026,292	41.4	806.0	12.0

Sources: (World Bank Group 2023; office for National Statistics 2024; DUKES 2023; 2024; AGEB 2022; Energie Beheer Nederland 2022; BMK 2022; Eurostat 2023; Danish Energy Agency 2022; IEA 2023a; FOD Economie, K.M.O., Middenstand en Energie 2023)

In Austria, natural gas accounts for 22.7% of total energy demand, similar to levels in Germany and Belgium, with a per capita consumption of 9.3 MWh. Belgium has the second highest per capita consumption among the observed countries at 13.6 MWh, with natural gas comprising 24.4% of its total primary energy demand. In 2021, Germany's natural gas constituted 26.4% of its total primary energy demand, with an average consumption of 10.7 MWh per capita. The United Kingdom relies significantly on natural gas, making up 41.4% of its primary energy demand. Italy also shows a substantial reliance on natural gas, comprising 41.8% of its primary energy demand, with a consumption rate of 12.0 MWh per capita.

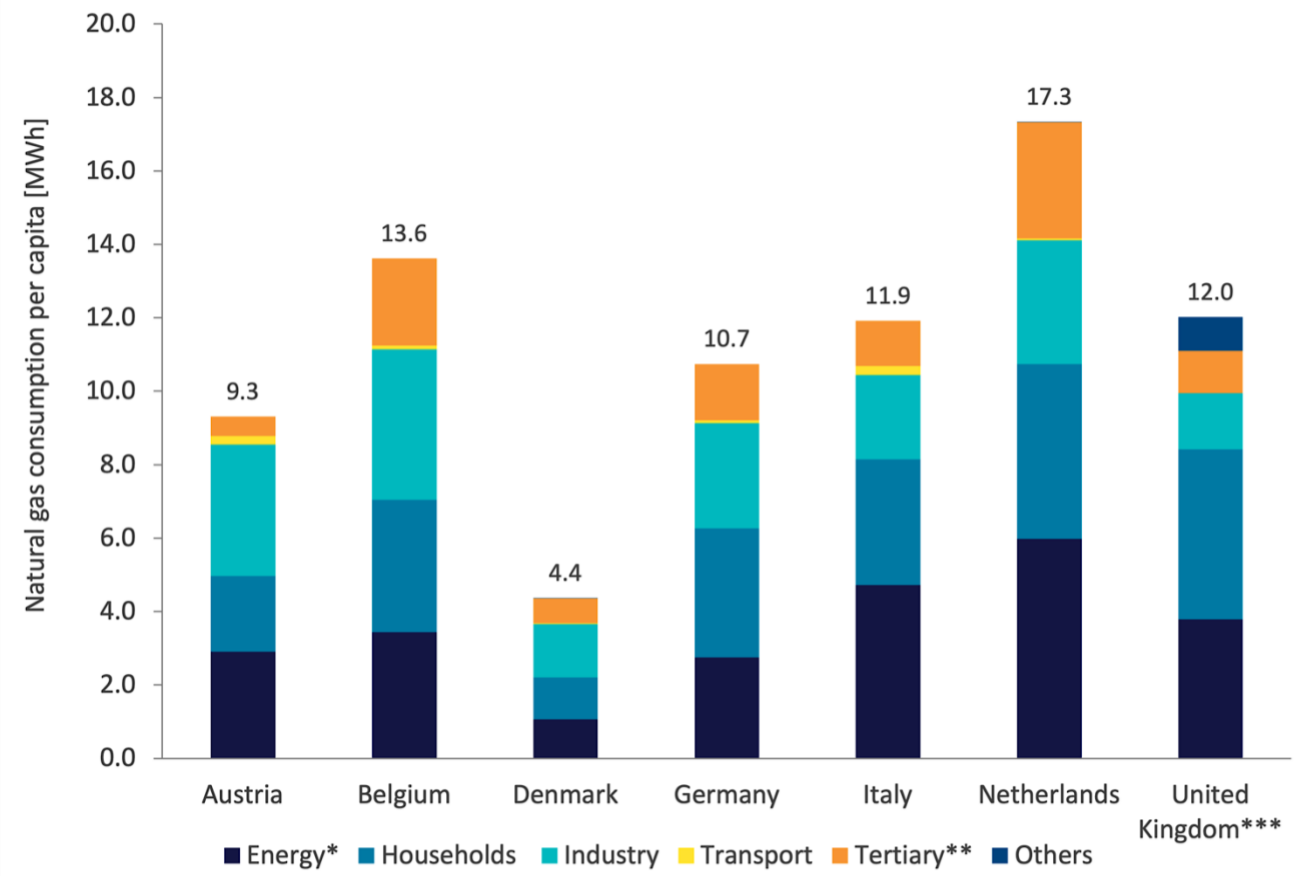
The Netherlands relies heavily on natural gas, which accounts for 41.5% of its total primary energy demand. The Netherlands has a higher natural gas consumption per capita (17.3 MWh per year) than Germany, the United Kingdom and Italy. Historically, the Netherlands has exhibited high energy consumption levels, a trend significantly influenced by its possession of the now defunct Groningen Gas Field, recognised as one of the largest natural gas fields in the world. Its vast reserves have historically empowered Dutch industry and its building sector, making natural gas the backbone of these domains. In industry, natural gas has played a crucial role, especially in refining and chemicals production, where it is a key fuel due to its abundance and cost-effectiveness. Similarly, in the building sector, natural gas has been essential for heating, epitomising the country's reliance on this resource for its energy needs (IEA 2021). However, despite the advantages it offered to the national energy supply, the Dutch government decided to discontinue production at Groningen in

October 2023. This decision was primarily driven by the occurrence of frequent earthquakes, which raised significant environmental and safety concerns (Reuters 2023).

Denmark has the lowest share of natural gas in the primary energy demand of the countries compared, at 12.4%, and a per capita consumption of 4.4 MWh.

The countries exhibit a considerable disparity in their per capita gas demands. The Netherlands has the highest demand, while Denmark has the lowest. This variation in energy consumption patterns is demonstrated in Figure 4.

Figure 4. Sectoral consumption of natural gas per capita, 2021



Source: (Eurostat 2023) *Energy sector = Transformation input – energy use; **Tertiary sector = commercial and public services + agriculture and forestry + fishing; ***Data is for 2019 for the United Kingdom, as Eurostat data for the United Kingdom is only available until 2019.

In Austria, the primary use of natural gas is in the energy and industry sectors, with per capita consumption of 3.6 MWh and 2.9 MWh respectively. Austria also exhibits a relatively elevated proportion of consumption within the transport sector, amounting to 0.2 MWh per capita.

Belgium's highest consumption of natural gas is in the industry and household sectors, which have respective per capita rates of 4.1 MWh and 3.6 MWh.

Denmark has the lowest total demand per capita at 4.4 MWh, with the highest sectoral consumption in industry at 1.4 MWh, followed by households at 1.2 MWh per capita.

In Germany, the primary application of natural gas is for space heating in private housing, with a consumption rate of 3.5 MWh per capita, accounting for approximately 30% of total usage since 2010. Furthermore, Germany has a considerable consumption rate in the energy and industry sectors, with per capita rates of 2.8 MWh and 2.9 MWh respectively.

In Italy, the energy sector accounts for the highest share of natural gas consumption, at 4.7 MWh per capita, out of a total of 11.9 MWh per capita. This is followed by households, which account for 3.4 MWh per capita. The transport sector accounts for 0.3 MWh per capita.

The Netherlands stands out with a high overall consumption of 17.3 MWh per capita, nearly double that of Austria. In the Netherlands, the primary sectoral utilisation of natural gas is in energy production, with a consumption rate of 6.0 MWh per capita. The tertiary sector in the Netherlands exhibits a markedly elevated consumption rate of 3.2 MWh per capita in comparison to other countries.

In the United Kingdom, the primary reliance on natural gas is in households and the energy sector, with an estimated 4.6 MWh and 3.8 per capita respectively consumed in each (see Figure 4). Despite fluctuations in absolute consumption levels, the sectoral shares have remained relatively consistent over the period under review.

Compared to the rest of Europe, gas consumption in most of these countries is high. In absolute terms, Germany, the United Kingdom, Italy, France and the Netherlands have the highest annual gas consumption in the EU-27, while the Netherlands, Belgium, the United Kingdom, Italy and Luxembourg have the highest relative consumption per capita in the EU-27 and the United Kingdom (Eurostat 2023; World Bank Group 2023).

4.2 Gas boiler market and stock

During the past decade, distinct trends in the usage of gas boilers and the adoption of alternative heating technologies have emerged in the countries considered in this study.

Over the past four decades, the Danish heating market has undergone a profound transformation. In 1981, oil boilers were the dominant technology. However, since 1988, district heating has emerged as the predominant heating system, and it is currently connected to over 70% of dwellings. The proportion of oil boilers has undergone a significant decline, falling from over 40% in 1981 to approximately 5% today. Concurrently, the utilisation of gas boilers has increased to 15% of all heating systems, while the number of installed heat pumps has grown to approximately 170,000 systems, or about 6.5% of the market (StatBank Denmark 2024).

The sales of traditional gas and heating oil boilers in Belgium declined by about a third in 2023. In contrast, heat pump sales increased by 140% during the first six months of the year. This growth slowed considerably in the second half of the year, however, resulting in a

23% overall decline in sales of heating systems in Belgium. This equates to a decrease of approximately 60,000 installed units. Nevertheless, over the course of the year, sales of heat pumps increased by 68%, and they now represent 11.8% of the total heating market. However, gas boilers still account for 68% of installed heating systems in buildings, with oil boilers making up 21% of the total. In 2021, heat pumps only had a 1% share of the building stock (Climafed – Belgische federatie voor klimaattechnologieën 15 Jan 2024; FOD Economie, K.M.O., Middenstand en Energie 2022; JRC 2024).

Germany has had a predominance of gas boilers in its heating system market, which held a substantial share of 70% to 80% until 2021, underpinned with consistently increasing sales of gas boilers. Sales fell slightly in 2022 due to the gas crisis, while the spread of heat pumps significantly increased (BDH 2023b). In the existing heating infrastructure, gas boilers still represented two-thirds of all systems in 2022 – and, given their average lifespan of 20 years, they are expected to remain a key component in the German heating market (BDH 2023a).

Austria's scenario is somewhat similar, with steady sales figures for gas boilers (averaging around 50,000 new units annually until 2022, when they dropped to approximately 30,000). Furthermore, natural gas was the primary energy source for 34% of district heating networks. The Austrian market for heat pumps has been on a continuous rise, with sales jumping from just over 20,000 in 2016 to around 60,000 in 2022 (VÖK 1 Mar 2023; 21 Jan 2021; 4 Jan 2022; Lechinger and Matzinger 2020).

The Italian heating market and heating stock are distinguished by a notable prevalence of gas boilers. In the preceding decade, fossil fuel boilers have been the dominant force, accounting for a market share of between 70% and 80%. Notwithstanding the implementation of climate policies, sales of fossil fuel boilers increased from 2015 to 2021. In 2021, over two-thirds of the existing stock of heating systems was comprised by more than 19 million installed gas boilers. Given their lifespan of around 20 years, it seems reasonable to expect that gas will continue to play a significant role in space heating in Italy for some time to come. In that same year, however, the proportion of hybrid systems increased significantly, largely due to the integration of heat pumps with gas boilers. This development presents a challenge for the decommissioning of the gas network, as hybrid systems still require the use of the gas grid infrastructure (ENEA – National Agency for New Technologies, Energy and Sustainable Economic Development 2022; Istat – National Institute of Statistics 2022).

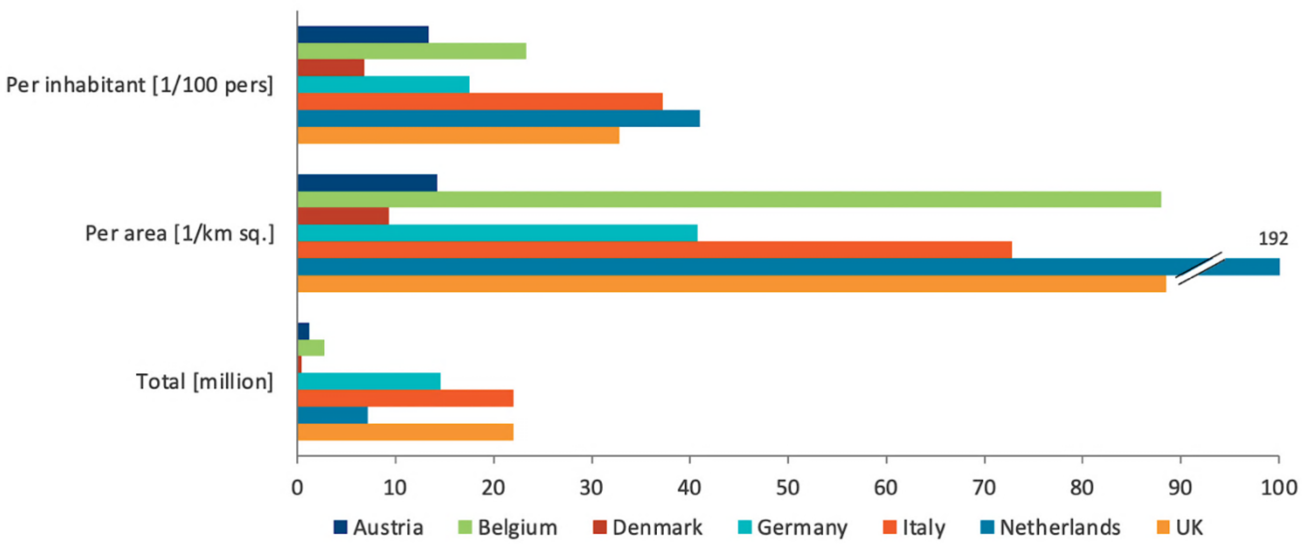
In the Netherlands, despite the challenges posed by high gas prices, the increasing popularity of heat pumps and reduced purchasing power, sales of central heating boilers have remained robust, ranging between 400,000 and 450,000 units per year over the last decade. This trend is mainly attributed to the replacement of older boilers with modern, more efficient models, slowing down the transition to hybrid or fully electric heat pumps. As of now, about 90% of Dutch heating systems are gas-operated (CE Delft 2022b). However, a notable policy shift was agreed in 2022, when the Dutch government stipulated that hybrid heat pumps will become the standard heating system from 2026 (De Rijksoverheid van Nederland 17 May 2022).

Although there has been significant discussion around heating options in the United Kingdom, gas boilers predominate. Heat pumps currently comprise only 3% of heating systems, although sales are expected to increase in coming years. The United Kingdom is also considering using hydrogen for heating, but has deferred a decision until 2026.

4.3 Current state of the distribution network

The following three figures present a comparison of gas distribution network characteristics in the countries analysed in this study. Figure 5 depicts the number of connection points to the national gas networks. The number of connection points per inhabitant is comparable in the United Kingdom, the Netherlands and Italy, with the highest values exceeding 30 per 100 inhabitants, followed by Belgium with around 23. Germany and Austria have values that are approximately half of the highest, while Denmark has the lowest value, with approximately seven connections per 100 inhabitants. With regard to the geographical distribution of connections, the Netherlands has the highest density, with 192 connections per square kilometre. This is followed by Italy, Belgium and the United Kingdom with more than 70 connections each. Germany has approximately 40 connections per square kilometre, while Austria has 14. Denmark has the lowest value, with some 9 connections per square kilometre.

Figure 5. Comparison of gas connection points to national gas grids



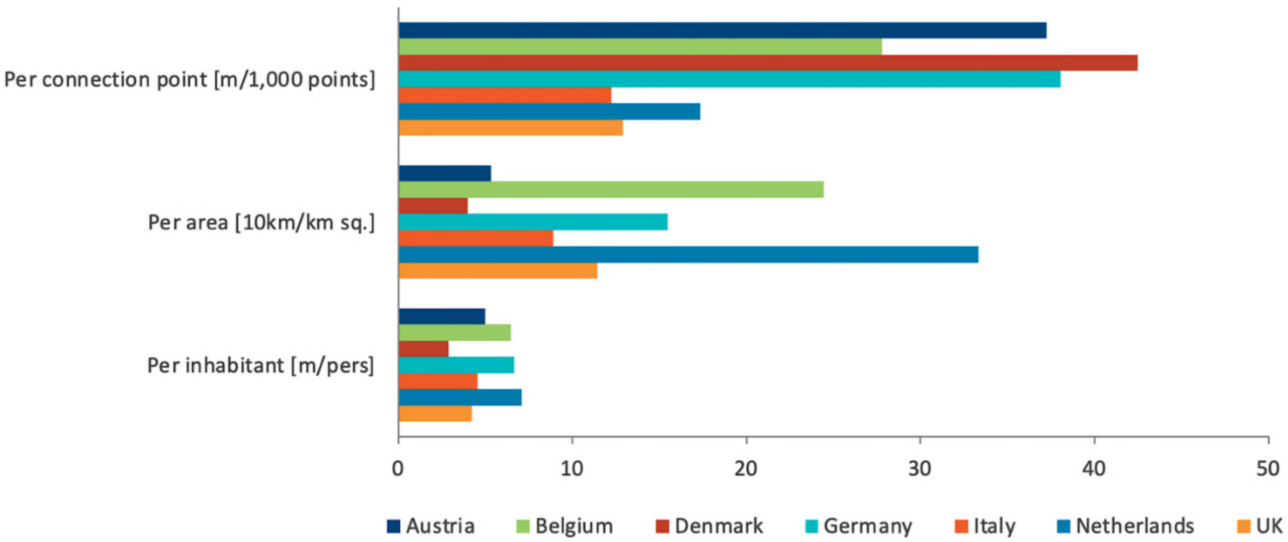
Sources: (World Bank Group 2023; Eurostat 2024; office for National Statistics 2024; E-Control 2023a; DEA 2023c; ARERA 2023a; BNetzA 2023; Netbeheer Nederland; Dodds and McDowall 2013; Ofgem 2023; IEA 2022a)

Figure 6 illustrates the relative sizes of national gas distribution grids, which generally correlate with the size of the respective countries. Germany is home to the largest gas distribution network, with a total length of 550,000 km. The United Kingdom is next with a total length of 284,000 km, followed by Italy with 269,249 km, the Netherlands with 124,600 km, Belgium with 75,000 km, Austria with 44,500 km, and Denmark with 17,000 km.

When considering the length of the gas distribution grid per capita, the figures are relatively uniform across most countries, averaging around 5 m per capita. However, Denmark exhibits a lower figure than the average, with a mere 2.9 m per capita. Conversely, Belgium, Germany and the Netherlands exceed the average, with 6.5, 6.7 and 7.1 m per capita respectively.

A further examination of the average grid length per connection point provides additional insights into network density. Austria and Germany are comparable, with a range of 35 to 40 m per connection point, followed by Belgium with around 28 m per connection point, indicative of a moderately dense network. The Dutch network is notably more compact, with approximately 17 m of network length per connection point, reflecting a highly efficient distribution system. The United Kingdom and Italy have comparable grid lengths per connection point, both around 12.5 m, which also points to a relatively dense network structure. In contrast, Denmark has the longest grid length per connection point, exceeding 40 m per connection, which suggests lower network density.

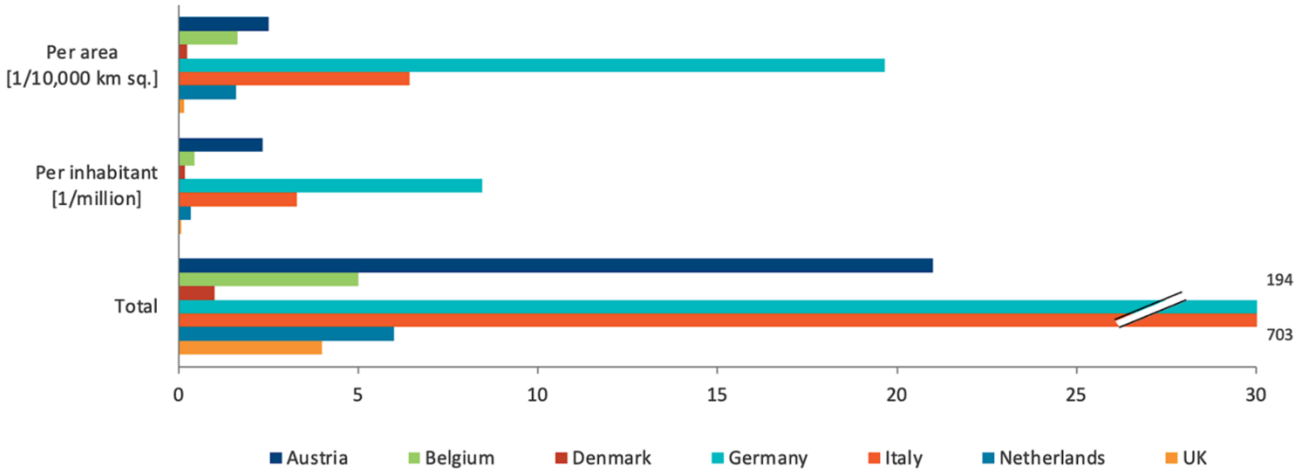
Figure 6. Comparison of national gas distribution network lengths



Sources: (World Bank Group 2023; Eurostat 2024; office for National Statistics 2024; E-Control 2023b; DEA 2023c; ARERA 2023a; BNetzA 2023; Netbeheer Nederland; Dodds and McDowall 2013; IEA 2022a; Synergrid 2023)

The number of DSOs varies between the countries analysed, as illustrated in Figure 7. Germany has the greatest number of DSOs (703), although a significant proportion of these operators are small. This number reflects high densities of DSOs per area and per capita. Italy also has a considerable number of DSOs, namely 194, while the number of DSOs in Austria (21), the Netherlands (6), Belgium (5) and the United Kingdom (4) is significantly lower. In Denmark, the distribution network is operated by a state-owned company.

Figure 7. Comparison of number of national gas distribution system operators



Sources: (World Bank Group 2023; Eurostat 2024; office for National Statistics 2024; E-Control 2023c; Danish Ministry of Climate, Energy and Utilities 2021a; ARERA 2023a; IEA 2022b; BNetzA 2023; Netbeheer Nederland; Energy Solutions 2024; Synergrid 2023)

5 Heat planning and boiler regulations

One challenge in infrastructure planning is a lack of emphasis on the most efficient solutions to meet end uses, and a connection of those solutions with needed infrastructure. For instance, when comparing hydrogen and electrification for heating, hydrogen is significantly less efficient across the board, from production to final end usage. Existing regulation, however, tends to overlook potentially more energy-efficient alternatives such as heat electrification (e.g. through heat pumps or direct electrification), and at the same time allows infrastructure development to proceed that supports the less efficient alternative. The lack of emphasis on efficiency in meeting end uses is thus compounded, as grid infrastructure planning and development occurs without consideration of the infrastructure needed to meet end uses or changing demand. Additionally, some heat planning rules do not take sufficient account of the concept of energy efficiency. Efficiency gains that can be achieved through demand reduction, such as better insulation and electrification of heating, are undervalued. Instead, future regulations should prioritise technologies that optimise overall efficiency and shift the focus from isolated solutions to a more integrated approach. Such an approach would prioritise economically viable demand-side solutions over major investments in energy supply infrastructure.

5.1 Heat planning

Heat planning is a crucial element of energy policy, with a range of approaches and regulations observed across jurisdictions. The strategies applied vary, and reflect the different legal and infrastructural conditions in the individual countries.

In Austria, the planning of heat is integrated into the broader field of spatial energy planning (Energieraumplanung). This is managed at the regional level by individual federal states (Bundesländer) due to the absence of federal regulation. This decentralisation process has resulted in a lack of standardisation across the country. Pilot projects for municipal heat planning are currently being trialled in Styria, Vienna and Salzburg. Although there is no overarching federal mandate, these initiatives are designed to streamline the approach to heat planning and ensure a more coordinated effort in the transition to sustainable heating solutions (Bundesministerium für Nachhaltigkeit und Tourismus and Bundesministerium für Verkehr, Innovation und Technologie 2018; Rehbogen and Strasser 2021).

In Belgium, heat planning is the responsibility of the regional governments, and the approach is different in the three regions.

- Flemish region: The 2025 Heat Plan contains 26 measures to move towards sustainable heating and the greening of energy carriers. The Heat Plan focuses on actions relating to financial support and the optimisation of the effectiveness of that support, various actions to encourage sustainable heating, a minimum share of renewable energy, heating networks, local heat plans, research actions, communication, and subsequent monitoring of the plan. The main source of renewable heat for households is biomass, which, although it is expected to reduce by half by 2030, will remain the biggest. The number of heat pumps is expected to triple between 2020 and 2030 (Vlaamse Regering 2021; Concilliation Committee 2023).

- Walloon region: There is no dedicated heat plan. There are specific plans for district heating and renewable heating (as part of the Walloon region climate and energy plan). There is a focus on biomass (pellets) and biomethane, as well as coal-bed methane. Significant growth (500%) is projected for heat pumps, but they remain the third most popular renewable energy heating technology (Gouvernement Wallon 2023).
- Brussels region: The Brussels Air Climate and Energy Plan for 2030 lacks a specific heat plan. It does, however, include measures designed to reduce greenhouse gas emissions and energy use in buildings. The plan places significant emphasis on energy renovations, with the objective of phasing out the use of oil heating and gas in new buildings. It is projected that the use of heat pumps and biogas will double by 2030, while the use of solid renewable fuels such as wood will decline. Furthermore, research into the potential for spatial planning for district heating using renewable sources is underway (Leefmilieu Brussel 2023).

Denmark has a long-standing tradition of mandatory heat planning, which is regulated by the 1979 Heat Supply Act enacted in response to the oil crises of the 1970s. In Denmark, municipalities are obliged to plan for both natural gas and district heating, thereby ensuring that these systems do not coexist in the same areas. It is within the purview of municipalities to mandate connections to district heating systems. National and regional actors, including the Danish Energy Agency, provide technical support, although the provision of continuous financial support for smaller municipalities is constrained by limited resources. Furthermore, Denmark is preparing for the implementation of the recast of the Energy Efficiency Directive (EED), which aims to integrate planning for the heating, gas and electricity sectors (Energy Cities 2023; Ministry of Climate, Energy and Utilities 2000).

Germany is striving to have a climate-neutral heating sector by 2045. The country's approach to heat planning is rigorously governed by the recently enacted Heat Planning Act (Wärmeplanungsgesetz; WPG), which mandates all municipalities to develop comprehensive heat plans by mid-2026 or mid-2028, depending on the size of the municipality. Within the heat plan, municipalities need to identify 'prospective heat supply areas,' which can be district heating areas, hydrogen grid areas, areas for decentralised heat supply, or areas for which the future priority supply still needs to be assessed. The allocation is based on four criteria: economic viability, security of supply, implementation risks, and cumulative greenhouse gas emissions (Deutscher Bundestag 2023a).

According to the National Climate Agreement, all municipalities in the Netherlands need to develop local decarbonisation plans outlining gas-free heating strategies for each district. While heat planning is mandatory for municipalities in both Germany and the Netherlands, the legislation does not obligate residents to choose only the preferred technologies identified in the heat planning process. Austria includes heat planning in its spatial energy planning, which is managed at the regional level; federal regulation is currently absent. There is also no mandatory heat planning in the United Kingdom.

Energy planning law has been in force in Italy since 1991. Regional energy plans (Piani regionali) are mandatory for each of the 22 regions, along with local energy plans (Piano Energetico Ambientale Comunale; PEAC) for communities with more than 50,000 inhabitants (Art. 5, 10/1991). Areas for decommissioning the gas grid are not mandatorily designated in this process (Presidenzia del Consigilio dei Ministri 2024c).

The Netherlands, guided by its National Climate Agreement, has set a target to phase out the use of fossil gas in buildings by 2050, with an intermediate goal of converting 1.5 million of the 8 million residential buildings by 2030. Dutch municipalities are obliged to devise local decarbonisation strategies known as 'Transitievisie Warmte' (TVW). These plans entail a participatory process with stakeholders and must encompass detailed neighbourhood implementation plans, designated as 'wijkuitvoeringsplannen' or WUP. The primary criterion for the selection of alternative heating technologies is economic efficiency; the Programme for Natural Gas Free Districts (PAW) provides financial assistance for the transition (CE Delft 2022b; Ministry of Economic Affairs and Climate Policy 2019).

In contrast to this, there is no obligatory heat planning in place in the United Kingdom.

One of the core elements of heat planning is the development of infrastructure, mainly gas distribution, heating, electricity distribution and hydrogen grids. With regard to gas distribution grids, heat planning must take into account both the phase-out of natural gas (and the associated probable successive decommissioning of parts of the current network) and a possible switch to hydrogen.

5.2 Gas boiler regulation

At the European level, the Energy Performance of Buildings Directive (EPBD) has established an essential mandate, namely the elimination of the use of fossil fuels in buildings by 2040. This ambitious requirement has the objective of significantly reducing carbon emissions in the buildings sector, thereby aligning with the European Union's broader climate goals. In order to attain these goals, the directive emphasises a transition to renewable energy sources, an enhancement of energy efficiency, and the incorporation of sustainable practices in building design and renovations (European Union 2024).

At the national level, Austria, Denmark, Germany and the Netherlands have enacted bans on the installation of gas boilers, or regulations to phase out their use. In contrast, the United Kingdom and Italy have not yet implemented policies of this nature.

In Austria, there were discussions in 2023 about phasing out existing gas heating systems by mid-2040. In the end, however, only a ban on the installation of gas heating systems in new buildings was adopted. Instead of a regulatory phase-out, financial support will now incentivise the switch of existing gas boilers to more climate-friendly heating systems (Parlament Österreich 15 Dec 2023).

In Belgium there are different regulations for each of the three regions. Flanders has introduced regulations to phase out the use of gas in buildings, and as of 2021 gas connections cannot be a part of large building projects. From 2022, the cost of gas connections in new buildings are no longer capped, increasing the price from €250 to €1,200. In 2023, requirements for the use of renewable energy and low-temperature heating systems were increased. From 2025, gas connections will no longer be allowed in new buildings, and the cost of all new connections will no longer be capped. In Brussels, gas and oil heating will not be allowed in new buildings or major renovations by 2025. Fuel oil installations will also be excluded from all buildings by 2040, starting with public buildings in 2030. In Wallonia, there are no plans yet to prohibit gas heating (Maron Trachte 30 May 2024; Vlaanderen 2024).

In 2013, Denmark enacted legislation prohibiting the installation of fossil fuel and gas boilers in new buildings. This legislation, known as the 2010 Building Regulations (BR10), updates the previous 2010 regulations. The 2018 regulations (BR18) stipulate the use of renewable heating in district heating areas. Buildings in pre-2013 gas grid areas can still use natural gas, but not fossil oil. It should be noted that existing fossil fuel boilers outside district heating and gas grid areas may continue to be used, although new constructions must meet the latest sustainability standards and utilise renewable energies. In the case of renovated buildings, it is recommended that renewable energy be incorporated into the heating system wherever possible, thus facilitating a gradual shift towards the use of sustainable energy sources (Bygningsreglementet 2018; DEA 2010).

According to the revised Building Law in Germany, all new heating systems must meet a minimum quota of 65% renewable heat. This requirement will come into force as soon as a heating plan is drawn up at municipal level (see above) (Deutscher Bundestag 2023a). Homeowners may continue to install gas boilers until the respective heat planning deadlines in 2026/2028, but will then be subject to a quota for fuels such as biomass/biomethane, or green or blue hydrogen. The quotas are 15% from 2029, 30% from 2035, and 60% from 2040. Moreover, homeowners may continue to install gas boilers if they are hydrogen-ready and the building is located in an area that has been explicitly designated as a hydrogen expansion area by the municipality as part of its heat planning (Deutscher Bundestag 2023b; BMWK 2024).

At the present time, Italy does not have a prohibition on gas boilers planned or in force. Conversely, in addition to subsidies for renewable heating systems, building owners can receive financial support for installing new gas condensing boilers (MASE 2023).

In the Netherlands the connection of new buildings to the gas network has been prohibited since mid-2018. Furthermore, municipalities are entitled to designate areas where no new gas connections are allowed. In 2022, the Dutch government announced that hybrid heat pumps will become the standard heating system for residential buildings from 2026. In 2023, the plans were amended to exclude multi-storey buildings. Nothing is known about the current status of these plans (CE Delft 2022b; De Rijksoverheid van Nederland 17 May 2022).

The United Kingdom aims to phase out new fossil gas boilers by 2035 (Secretary of State for Business, Energy and Industrial Strategy 2021). The country is also considering hydrogen for heating and will make a decision regarding its role in 2026.

6 Gas network planning and alignment with climate scenarios

6.1 Gas network planning

The planning of gas networks is primarily based on assumptions regarding the future gas demand of system operators, in dialogue with the state's regulatory authority. In most cases, there is no direct link between the planning of gas networks and the achievement of climate targets or heat planning in the countries observed.

In Austria, network planning is based on forecasts for natural gas that reflect Austria's climate targets. In this sense, the development up to 2040 is based on a 90% reduction in gas demand for households. However, the plan does not specify to what extent this demand will be replaced by biomethane or hydrogen (AGGM 2022b).

In Belgium, the planning of gas networks is subject to regulation by the three regional authorities. Separate 10-year network development plans exist for the transmission grid of natural gas transmission system operator Fluxys, and for the five distribution system operators. Forecasts for future demand of gaseous fuels, including natural gas, hydrogen and biomethane, are prepared for network planning. The forecasts for natural gas refer to European and Belgian climate targets, but the link is not clear. The current transmission development plan (2023-2032) assumes a natural gas demand in 2030 at about the current level. The plans do not specify to what extent fossil gas demand will be replaced by biomethane or hydrogen (VREG 2024b; Fluxys 2023).

In Denmark, the planning process encompasses both the gas transmission and distribution networks. The objective is to guarantee a secure and efficient supply of natural gas. Evida, the Danish gas distribution company, conducted a study with the objective of identifying areas where parts of the gas network could be decommissioned in a feasible and cost-effective manner. This study resulted in the development of a model for the phasing out of natural gas for residential heating to support Evida's objective of introducing a switch-off obligation for consumers. In addition, the 2022 report by Energinet on the long-term development needs of the Danish gas system identifies the necessity for improvements at the transmission level. These improvements are of critical importance for the export of biomethane and hydrogen, as well as for the transportation of biomethane from production areas to regions with high demand.

In Germany, gas transmission network planning is based on demand surveys of large consumers such as industry and power plants, as well as distribution system operators. This applies to both natural gas and hydrogen. The surveys inquire about the quantities that the distribution system operators expect to need in the future. Planning processes at the distribution grid level also follow demand, and climate targets have only an indirect impact (BDEW Bundesverband der Energie- und Wasserwirtschaft e.V. 2024; EnWG 2017).

Following the related regulation (468/2018/R/gas), Snam, which operates the vast majority of the Italian gas transmission grid, elaborates the national Gas Transmission Network Development Plan (current period 2023-2032). Future gas demand is projected in different scenarios, e.g. the National Energy and Climate Plan (Snam 2023; ARERA 2018).

In the Netherlands, gas transmission network planning is based on future demand assumptions. The objective is to align network development with anticipated demand, particularly in light of the country's climate targets and the transition towards a gas-free buildings sector by 2050 (GTS 2022).

Similarly, in the United Kingdom, gas network planning is also based on future demand assumptions. The strategy entails forecasting future needs and aligning infrastructure development in a manner that ensures the network can accommodate changes in gas usage patterns (NationalGridESO 2023).

The regulations regarding heat planning and fossil fuel boilers have a significant impact on the future development of gas distribution networks. If heat planning relies on hydrogen or biomethane, the networks will still be necessary, albeit with lower throughput volumes (if extensive efficiency measures are implemented to reduce demand). If boiler regulations permit the use of technologies that utilise gaseous fuels in proportion, such as hybrid heat pumps or gas CHP, distribution infrastructure will be required in the future. The gas network flow rates may be so low, however, that network operators may question whether they can continue to operate the infrastructure. The analysis indicates that in the countries examined, there is insufficient coordination between heat planning, boiler regulations and infrastructure planning processes.

6.2 Alignment with climate scenarios

In the countries under study, transmission system operators (TSOs) collaborate with DSOs in long-term gas infrastructure planning based on future gas consumption scenarios. Nevertheless, in the majority of countries, these assumptions diverge from the necessary reductions in gas usage identified in national climate scenarios.

In Austria, the Austrian Gas Grid Management AG (AGGM) oversees the gas market and prepares the Coordinated Network Development Plan (KNEP) and the Long-term and Integrated Planning (LFiP) every two years. The 2022 LFiP predicts a trend towards increasing demand for hydrogen and decreasing demand for methane by 2050.

Belgium has separate 10-year development plans for Fluxys' transmission network and the five distribution network operators. Forecasts of future demand for gaseous fuels, including natural gas, hydrogen and biomethane, are used in network planning.

In Denmark, the TSO (Energinet) and DSO (Evida) are both state-owned entities, resulting in the Danish Energy Agency's projections being aligned with national climate targets. This information is then utilised by grid operators in their planning processes. Consequently, there is no differentiation between scenarios based on climate targets and those based on the views of the gas system operators.

In Germany, the DSOs provide the TSOs with a 10-year gas demand forecast, which serves as the basis for the scenario framework. The network operators define two scenarios reflecting different gas and hydrogen demand developments, updated every two years. There are already several other studies on the future development of gas demand in Germany which consider climate targets. While the demand for natural gas will have to decline sharply, especially from 2030 onwards, the demand for hydrogen will increase slowly in these scenarios.

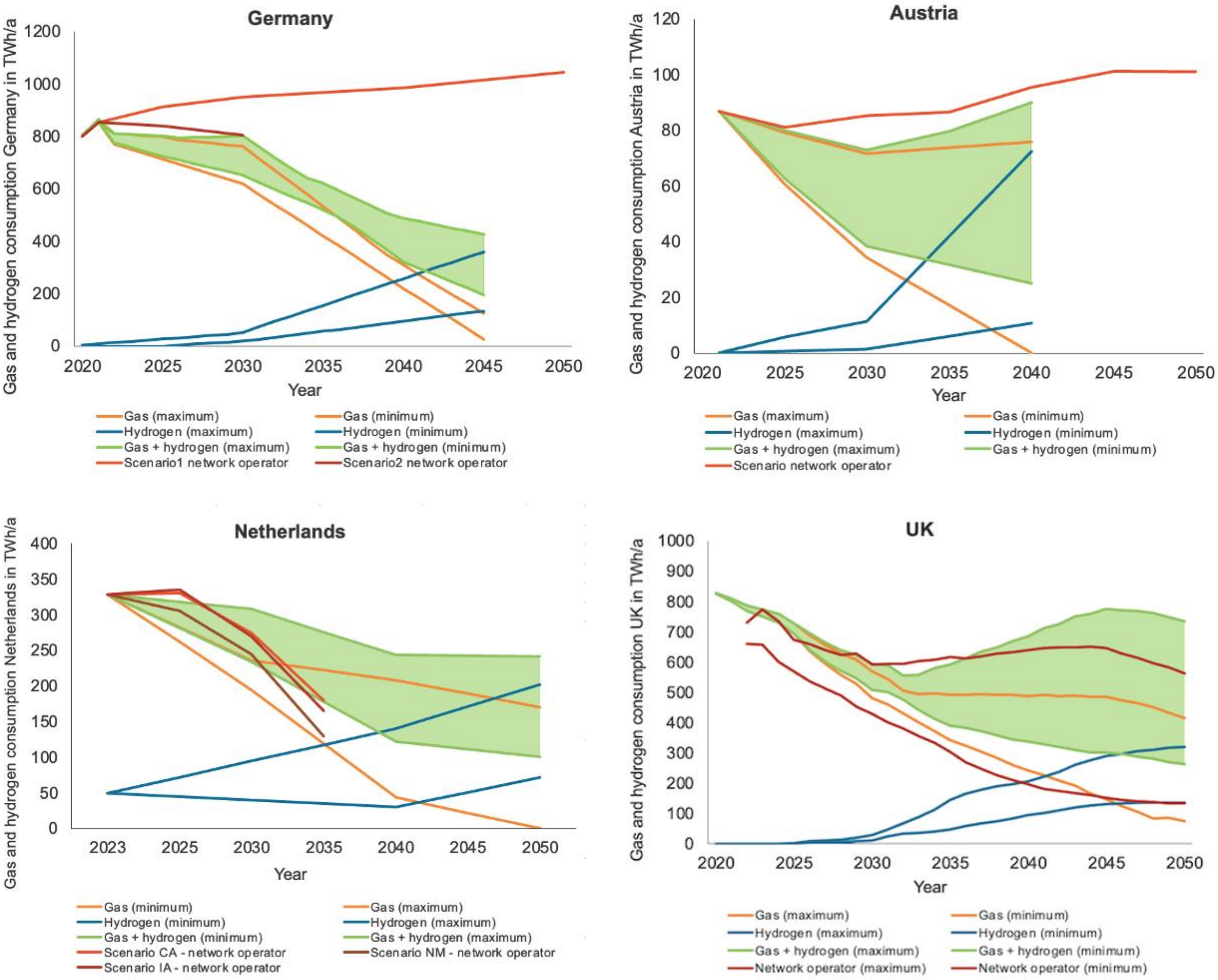
In Italy, the Gas Transmission Network Development Plan is based upon a variety of scenarios, including the Distributed Energy Italy+ (DE-IT+) and Global Ambition Italy+ (GA-IT+). These align with the scenario as defined by the European Network of Transmission System Operators for Gas. Additionally, the gas demand of the National Energy and Climate Plan is considered.

Gasunie Transport Services (GTS) in the Netherlands, which is responsible for managing the national gas transport network, prepares an investment plan every two years in accordance with the Gas Act. This investment plan takes account of uncertainties and is based on climate scenarios. It outlines and justifies upcoming expansion and replacement investments. GTS has formulated three scenarios for estimated gas demand.

Similarly, the National Grid Electricity System Operator (NationalGridESO) in the United Kingdom publishes Future Energy Scenarios, which include gas and hydrogen demand projections up to 2050.

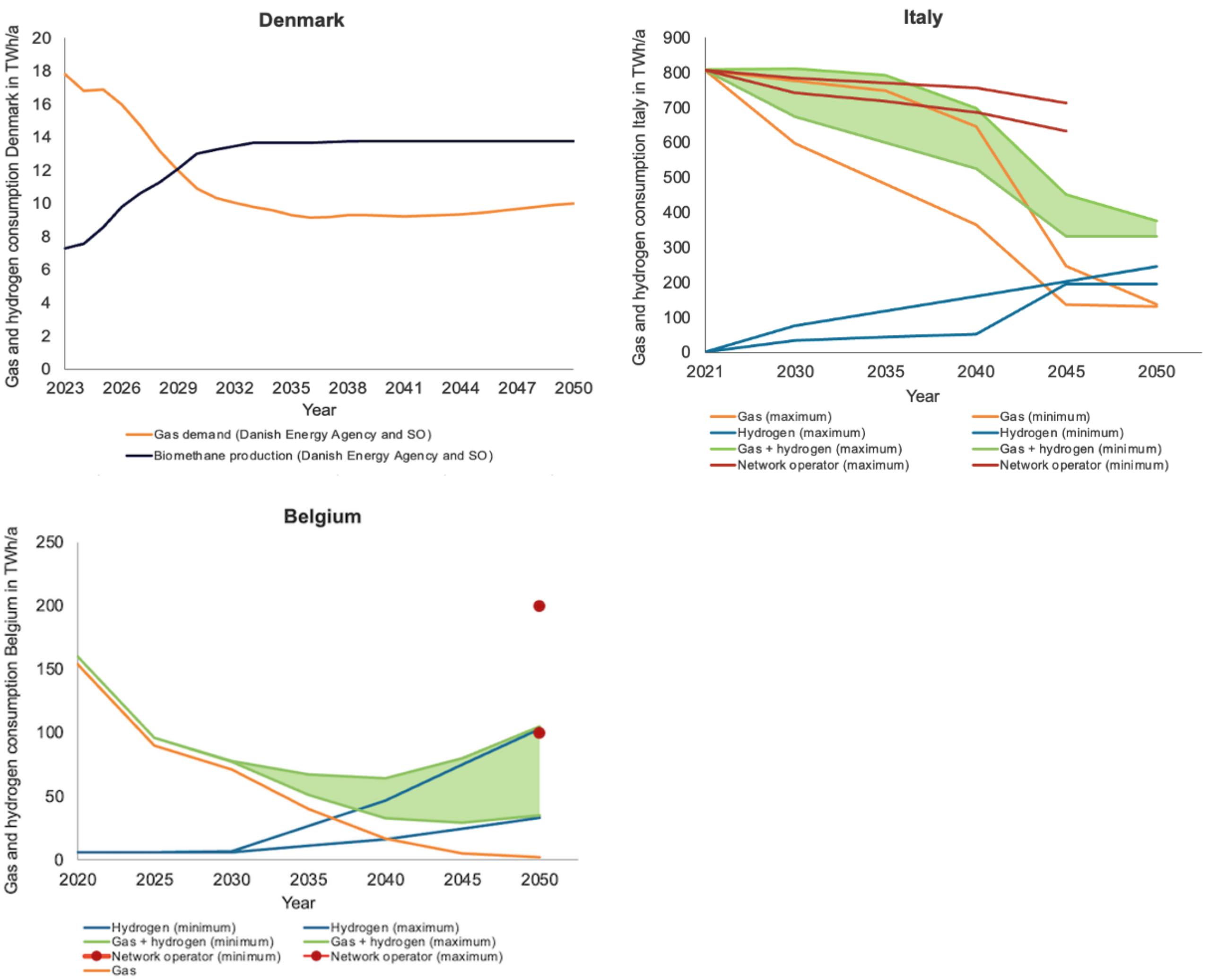
To assess the strategies of these grid operators, a comparison is made with climate scenarios. Figures 8 and 9 below provide a visual representation of this comparison.

Figure 8. Future gas and hydrogen demand in Germany, Austria, the Netherlands and the United Kingdom based on national climate targets and projected developments of gas network operators[1]



[1] All values refer to the net calorific value. The values in the green corridor do not correspond solely to the sum of the maximum values for gas and hydrogen. Instead, the green corridor represents the range of the total sum of hydrogen and gas within the same scenario for different scenarios. Included scenarios: Germany: Agora, dena, BDI, Ariadne Remind, Ariadne REMod, BMWK T45-Strom, BMWK T45-H2, BMWK T45-PtG/PtL (Dambeck et al. 2021; BDI 2021; Fraunhofer ISI; Consentec; ifeu; TU Berlin Fachgebiet E&R 2022; dena 2021) and of the network operators (2020); Austria: AGGM, TUW – Electrification, TUW – Green Gases, TUW – Green methane, TUW – Decentralised green gases, ÖNIP and UBA-Transition (BMK 2023a; Rodgarkia-Dara et al. 2023; Krutzler et al. 2023) and of the network operators (AGGM 2022b); Netherlands: Decentralised Initiative, National Leadership, European Integration, International Trade, Adapt and Transform (Ouden et al. 2020; Netbeheer Nederland 2023; Scheepers et al. 2020) and of the network operators (GTS 2024); UK: Tailwinds, Headwinds, Widespread Engagement, Widespread Innovation, Balanced Net Zero Pathway, Tailwinds (Climate Change Committee 2021) and of the network operators (NationalGridESO 2023).

Figure 9. Future gas and hydrogen demand in Denmark, Italy and Belgium based on national climate targets and projected developments of the network operators[2]



[2]The values in the green corridor do not correspond solely to the sum of the maximum values for gas and hydrogen. Instead, the green corridor represents the range of the total sum of hydrogen and gas within the same scenario for different scenarios. Included scenarios: Denmark: AF22 (DEA 2023a); Italy: I4C and LTS (RSE 2020; I4C 2023) and of the network operators F55+, policy, Reference, GA-IT+, DE-IT+ (Snam 2023); Belgium: Scenarios DG Leefmilieu and Paths2050 (DG Leefmilieu 2021; EnergyVille 2023) and of the network operator (Fluxys 2023) *All values refer to the net calorific value.

There are clear differences between countries:

- In Austria, climate scenarios show significant variation in the projected demand for gas and hydrogen. While some scenarios prioritise electrification, others prioritise the use of green gases and hydrogen to achieve decarbonisation. According to the current network development plan of the network operators, the demand for gas and hydrogen is expected to increase gradually to around 95 TWh/a by 2040, which is slightly higher than the upper limit of the demand projected in the climate scenarios. We can therefore come to a similar conclusion for Austria as for Germany: the network operator's plan is not in line with national emissions reduction targets (see Figure 8 – Austria).
- In Belgium, fossil gas demand dwindles to nearly zero in the climate scenarios developed by the environmental ministry. The demand for hydrogen is projected to stay at the current level until 2030 and then grow rapidly, with significant variation in the climate scenarios. Demand for hydrogen reaches between 33 and 103 TWh in 2050. Projected demand by the gas TSO Fluxys starts at the higher bound of that range, at 200 TWh (this includes other molecules in addition to hydrogen).
- In Denmark, the national plan is to phase out the use of gas in the buildings sector and to produce sufficient biomethane to meet the remaining gas demand by 2030 at the latest. These plans have been formulated in accordance with the findings of climate scenarios and will be incorporated into the long-term planning of the gas network.
- In Germany, network operators have outlined two scenarios for gas and hydrogen demand. The first scenario predicts continuous growth to 1,050 TWh/a in 2050, while the second predicts a slight decline to 850 TWh/a by 2030. However, studies that take climate targets into account indicate a significant decline in fossil gas demand from 2030 onwards. Based on these climate scenarios, gas demand is projected to decrease to 0-135 TWh/a, while hydrogen demand is projected to increase gradually to 135-360 TWh/a by 2045 (see Figure 8 – Germany). This contradicts the projections in the Network Development Plan and indicates a misalignment between current network planning in Germany and national emissions reduction targets. The mismatch could result in stranded assets on the grid side.
- A discrepancy exists between the scenarios presented in the Gas Transmission Network Development Plan for Italy and those indicated by climate scenarios. The projections by system operators indicate a minimal decline in gas consumption up until 2040. By contrast, scenarios that focus on decarbonisation pathways show a significant decline in demand for natural gas without a corresponding increase in demand for green gases. The decline in gas demand forecast in the Network Development Plan up to 2040 is not directly linked to specific climate targets. Instead, these reductions are part of broader energy transition strategies. Unlike the network development plans of other countries, where future fossil gas demand decreases and is replaced by biomethane and hydrogen, the Italian plan does not anticipate a significant decrease of fossil gas.
- Gasunie Transport Services is responsible for managing the national gas transport network in the Netherlands and for planning future expansion and replacement investments. Gasunie has projected gas and hydrogen demand in three scenarios, which focus mainly on the years 2040 and 2050. The scenarios all show an overall decrease in

gas demand and an increase in hydrogen demand, resulting in a lower combined total demand for both gases (GTS 2024).

- In the United Kingdom, climate scenarios and network operator projections show a significant range in the development of gas and hydrogen demand up to 2050. In the climate scenarios, demand for gas and hydrogen ranges from 260 TWh/a to 730 TWh/a by 2050, a difference of more than 2.5 times between the minimum and maximum values. This uncertainty raises questions about the future path. It is unclear whether there will be more reliance on electrification or on hydrogen, biogas or synthetic gases. The network operator scenarios do not align with the climate scenarios; projections for gas and hydrogen demand range from 130 TWh/a to 560 TWh/a by 2050 (see Figure 8 – UK). Gas network operator plans are only consistent with climate scenarios if it is assumed that large volumes of hydrogen (or other low-carbon gases) are used as a like-for-like replacement for fossil gas, which seems unlikely.

7 Regulation

The regulation of gas networks encompasses several topics, including the conditions under which the network operator can make connections, the circumstances under which the network investment costs can be depreciated, the procedures for decommissioning and dismantling networks, and the calculation of network charges.

Regulations concerning gas distribution levels in Austria, Germany, Italy and the United Kingdom do not provide guidelines for the mid- to long-term decommissioning of grid areas. The current regulatory frameworks do not allow for the denial of grid access to consumers in these areas, nor do they permit the disconnection of existing consumers from the grid (unless requested by the customer). In addition, the regulations in Austria, Germany, Italy and the United Kingdom call for long amortisation periods that conflict with phase-out dates derived from climate targets. Additionally, network charges in Germany and Austria are set without adequate consideration of future gas distribution architecture dismantling or decommissioning costs. The lack of clear regulations on factoring foreseeable costs into network charges prevents grid operators from spreading these costs over a longer time period.

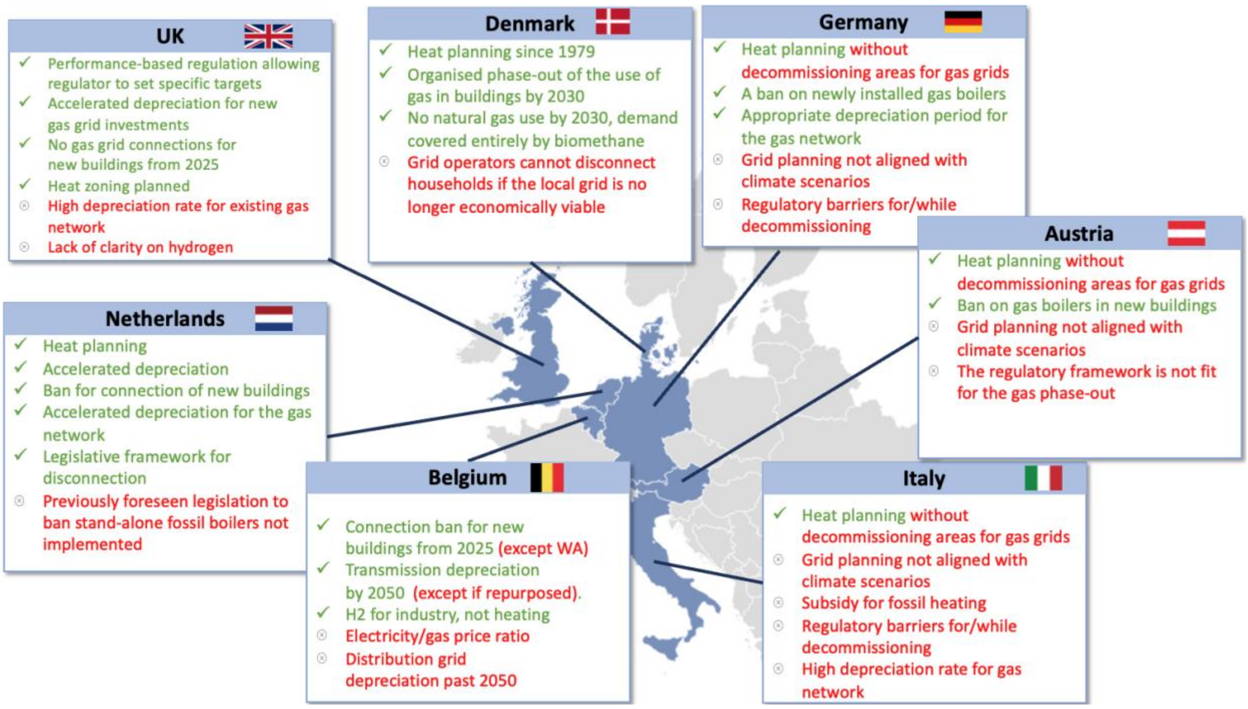
The Netherlands is ahead of Austria, Germany and the United Kingdom in terms of distribution grid regulation. Infrastructure assets are no longer depreciated on a linear basis, but on a degressive basis (a greater amount of the infrastructure investment is paid off in earlier years compared to later ones) while retaining the depreciation periods. This change aims to align the costs with the actual use of the network, considering the expected decrease in connection points in the medium term. The German regulatory authority BNetzA recently published a plan to change how the imputed useful life of and the depreciation methods for natural gas pipeline infrastructure are determined. This is to enable declining balance depreciation, and the earlier passing of network costs to a greater number of customers (BNetzA 2024).

In Denmark, the use of gas for heating buildings will be phased out by 2030, allowing for the majority of the distribution network to be decommissioned. Evida has initiated a planning process to determine which networks should be decommissioned first (Evida 2023). The residual gas demand for industry, energy and tertiary purposes will be satisfied by biomethane. Additionally, gas distribution grid operators in the Netherlands and Denmark receive compensation for the costs of dismantling the gas distribution networks and removing connection points. In the United Kingdom, although depreciation periods are no longer set on a straight-line basis, schemes like the Iron Mains Replacement Programme continue to incentivise – and, in some cases, require – more investment into the network.

A classic example of a disincentive can be found in the cost-plus approach to grid fee regulation, where grid operators typically receive a fixed, or regulated, profit margin on their infrastructure investment. This method prioritises investments in infrastructure over efficiency measures (which may have a neutral or negative impact on overall profits), even where trends demonstrate that demand will decline. To enable the realisation of climate targets, regulation needs to incentivise a system efficiency approach including serving end-user needs in an efficient manner, rather than one which allows infrastructure maintenance or expansion disconnected from future demand scenarios.

A more detailed examination of the regulations of the different countries is provided in the subsequent sections. Figure 10 presents a synopsis of the most significant positive and negative outcomes observed in the countries under review.

Figure 10. Overview of country-specific findings on the regulation of the decommissioning of gas networks



7.1 Grid connection

Distribution system operators are generally required to connect customers to the gas grid upon request in Austria, Belgium, Germany, Italy and the United Kingdom. Connection may only be refused if there are valid technical or economic reasons, which must be justified by the grid operator (EnWG 2017; GWG 2011; Presidenzia del Consigilio dei Ministri 2024a; ARUP 2023; Belgisch Parlement 2021). Exceptions in Belgium include Flanders, where gas connections for new buildings have been limited since 2021, with a total ban on connections for new buildings and deep energy renovations from 2025. Similarly, in the Brussels-Capital region, gas connections for new buildings and major renovations will be banned from 2025 (Vlaanderen 2024; Maron Trachte 30 May 2024).

By law, gas distribution system operators in the Netherlands and Denmark are not allowed to connect new buildings to the gas grid. Moreover, municipalities can designate areas where new gas connections are not permitted, such as district heating areas. Owners of existing buildings located in these municipality-designated areas also do not have a legal right to be connected to the gas grid (CE Delft 2022a; Energy Cities 2023; Ministry of Climate, Energy and Utilities 2000).

In all analysed countries, once a connection has been made, DSOs must in principle maintain that connection until it is no longer required by the customer. None of the legislation reviewed allows the connection to be refused based on a building's location in an area where the distribution grid is to be decommissioned, with the exception of the Netherlands. The Dutch parliament recently adopted changes to the legislative framework that allow consumers to be disconnected from the gas grid under certain conditions. In areas designated as gas-free, disconnection is possible after a notice period of eight years.

7.2 Depreciation

Among the countries analysed, the Netherlands has implemented the most significant changes to depreciation rules.

In the current regulatory period (2022-2026), DSOs in the Netherlands are permitted to depreciate investments in their grids on a degressive basis. The objective of this adjustment is to align costs with the actual usage of the network, with a projected decrease in connection points over the medium term. Furthermore, Dutch gas DSOs receive compensation for the costs associated with the dismantling of gas distribution networks and the removal of connection points (ACM 2021).

In Austria, the standard amortisation period is between 30 and 40 years (GWG 2011).

For Belgium, target depreciation rates are applied to the transmission network so that all natural gas transmission assets are decommissioned by 2050 (DNV and Trinomics 2022). At the distribution level, investments are depreciated over 50 years for pipelines and 10 to 33 years for other equipment. In 2023, the residual value of the distribution network in Flanders that will not be amortised in 2050 was estimated at €2.2 billion (Vlaams Parlement 2023).

In Denmark, the depreciation of pipelines is calculated using a straight-line method over a period of 30 years (Energinet 2023; van Nuffel 2018).

In Germany, the depreciation periods for investments in the distribution network historically ranged from 45 to 55 years. Nevertheless, future investments are now constrained to a depreciation period ending in 2045, effectively abbreviating the amortisation period. Past investments continue to adhere to the original 45 to 55-year depreciation schedules, resulting in some investments extending beyond the target year for achieving climate neutrality (2045) (GasNEV 2005). In 2024, the regulator BNetzA published a plan to introduce degressive depreciation for gas network infrastructure (BNetzA 2024).

In the United Kingdom, gas distribution networks currently adhere to a 45-year depreciation period (Ofgem 2011).

In Italy, grid operators apply a period of 50 years to amortise their investments in gas grid infrastructure (Presidenzia del Consigilio dei Ministri 2024b).

7.3 Decommissioning/demolition

Austria, Belgium, Italy, Germany and the United Kingdom treat gas distribution networks more or less as if the infrastructure were designed to last forever. The regulatory framework considers the networks to be permanent fixtures. None of the five countries have explicit regulations for issues such as decommissioning or dismantling the network (or parts of it). Nor are there regulations concerning the conditions under which a distribution system operator may cease gas supply, provisions for future costs of subsequent decommissioning or dismantling of the network, or consideration of these costs when determining grid charges.

In contrast, Denmark and the Netherlands have distinct approaches. In the Netherlands, DSOs receive compensation for the costs associated with dismantling gas distribution networks. Additionally, as of 2024, the costs of disconnecting a building from the gas grid will be socialised; previously, building owners bore this cost, amounting to several hundred euros (ACM 2023b).

In Denmark, the government operates a disconnection scheme that provides financial assistance for removing gas pipes used for space heating in private residences. This scheme is contingent upon the availability of funds and specific eligibility criteria. Qualifying applicants can have their disconnection carried out at no cost (Evida 2024a).

7.4 Grid charges

Regulatory authorities in all countries analysed are responsible for determining grid charges, including cost component, methodology and efficiency elements. Furthermore, they oversee the calculation of grid charges, including the determination of costs for investments and maintenance, along with a limited profit margin; these generally form the basis of the cost-plus approach. Efficiency components may also be included to encourage the most cost-effective management and operation of the gas distribution grid.

The countries analysed have varying grid charges at the distribution network level. In some cases there are also differing charges for the same consumer group within a country.

Due to declining demand and customers, gas throughput in the distribution networks will decrease and cause the fixed costs of the network to be spread over a smaller sales volume. For that reason, future grid charges might increase substantially. Estimates for Germany suggest that grid fees could increase by up to ten times in the event of a gas phase-out (Agora Energiewende and BET 2023).

The Dutch regulator ACM assumes an increase in gas network costs to consumers of 1.4-3.6 times the current rate. However, this estimate does not consider any stranded assets (ACM 2021).

One forecast for the United Kingdom predicted the development of average grid charges from 2014 to 2050, assuming that there would be no changes in the regulations that govern the expansion of the grid and the calculation of costs. This scenario predicts a more than tenfold increase in grid charges. Ofgem has estimated that network charges could reach 1p/kWh by 2040 and 4p/kWh by 2050 (Ofgem 2023).

For Denmark, forecasts indicate that the total costs associated with the gas grid at the distribution level will rise between 2021 and 2030. This is likely due to a reduction in the number of users. In particular, the projected increase in distribution-level grid costs for households is approximately 67%. However, Denmark plans to disconnect all households from gas by 2030, shifting towards district heating and heat pumps as alternatives (Danish Ministry of Climate, Energy and Utilities 2021a).

At present, Austria, Belgium and Italy lack a projection regarding gas grid charges.

If grid charges rise significantly due to a gas phase-out, a discussion should be held to determine who will bear the additional costs: consumers through their energy bills, taxpayers, or both. It is particularly important to protect customers who have no control over their heating system, such as tenants, or those who lack the financial means to switch to more environmentally friendly technologies, such as low-income households.

8 Consumer protection and vulnerable energy users

There are a variety of national regulations to protect gas grid users in the different countries which comply with the requirements for consumer protection as defined in the recently recast EU Gas Directive. The directive includes rules for 'competitive, consumer-centred […] markets for gas' (Art. 3, 4) and 'basic contractual rights' (Art. 10, 11). The directive permits forcible disconnection from the grid (Art. 34, par. 4), but only if users are 'sufficiently informed [in advance]' (Art. 11a) (EP 2024).

The EU Gas Directive also defines the concept of 'vulnerable customers', and Member States must specify measures to protect this group (Art. 4, 25). This may include subsidised gas prices (Art. 3, par. 3) and 'the prohibition of disconnection […] in critical times' (Art. 25, par. 1). When decommissioning gas grids, the needs of vulnerable households have to be considered (Art. 11a) (EP 2024).

According to the European Union Statistics on Income and Living Conditions, vulnerability is defined as having an income below 60% of the national median income. Households with limited financial resources can find high energy costs difficult to afford. Additionally, energy inefficiency, common in older homes and inefficient heating systems, results in higher energy consumption and costs (Eurostat 2022).

Decreasing gas throughput increases network charges by spreading fixed costs over a smaller sales volume. In Germany, projections indicate that grid charges for the remaining customers could increase by up to ten times the current level if demand on the network gradually declines (Agora Energiewende and BET 2023). This increase raises questions about how costs will be allocated. The discussion surrounding the phase-out of gas (and potential transition to hydrogen) has yet to address the issue of protecting vulnerable customers, especially from excessive costs. Moreover, the political discussion has not yet adequately addressed how to in fact prioritise vulnerable customers, by ensuring that they benefit from a transition away from gas – with its attendant indoor health quality concerns (Blair et al. 2023) – and instead can benefit from more efficient electrification of end uses.

During the gas crisis of 2022-2023, many countries implemented policy instruments to protect households against the highly increased gas prices by setting maximum tariffs and offering direct fuel subsidies and subsidy schemes for low-income customers switching to renewable heating systems with higher rates. The focus was often on vulnerable and low-income energy users. Additionally, many countries have programmes to support households experiencing energy poverty. Nevertheless, the countries assessed did not directly link infrastructural planning processes related to the gas distribution grid with potential effects on energy poverty by considering, for example, how to prioritise investment in infrastructure in areas with a high proportion of vulnerable energy users to enable electrification or district heating. The necessity of providing support to vulnerable energy users in order to facilitate their transition away from the gas network is not considered. Consequently, the burden of rising grid charges will increasingly fall on users who remain connected to the gas grid. Those who can afford it are more likely to switch to more efficient electric options such as heat pumps.

In the case of Austria, there are policies in place to protect vulnerable energy consumers against the adverse financial impact of high energy costs. For instance, the subsidy programme Sauber Heizen für Alle provides financial assistance for the installation of efficient renewable heating systems, with subsidy rates of 100% for the lowest 20% income households. Additionally, a temporary reduction in the natural gas levy, or Erdgasabgabe, has been implemented. Nevertheless, the concerns of vulnerable households are not explicitly considered during the process of infrastructural planning (BMK – Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie 2023; BMF 2022).

In Belgium, measures to combat energy poverty and provide social support are an integral part of the federal energy policy. Vulnerable households are entitled to a regulated social tariff for gas, electricity and district heating. This tariff is calculated quarterly by CREG. To further support those affected by fuel poverty, the Gas and Electricity Fund offers assistance through local social services and prepayment plans are available for those who have difficulty paying their energy bills. Strategies to tackle fuel poverty vary from region to region, and there are no quantified targets for fuel poverty reduction. A few specific federal and regional support measures were introduced during the energy crisis in 2022, including a fuel allowance, basic energy package, reduced VAT, additional energy vouchers for customers on social tariffs and a freeze on rent indexation for poor-quality housing (CREG 2018; VREG 2024c; VEKA 2024; KBS 2024). The network regulation does not explicitly include social issues in the decision-making process, however.

In response to the rising costs of energy and grid charges, Denmark has implemented a series of measures designed to protect its most vulnerable energy consumers. In 2022, financial support measures included one-off payments for disadvantaged households, deferral schemes for high energy costs, higher employment allowances, and an improved child and youth allowance (Surwillo and Slakaityte 2023). The government’s gas pipe disconnection programme provides financial support for the removal of gas pipes used for space heating in private households (Evida 2024a). To further alleviate the energy crisis, Denmark has increased subsidies for the disconnection of gas pipes and expanded the district heating fund, as well as implemented measures to improve the supply of wood pellets and subsidies for the purchase of heat pumps. The objective is to convert all 400,000 households from the gas network to district heating or heat pumps by 2030 (The Local 2022). Local authorities may also require buildings to be connected to district heating to ensure efficiency and low costs (DEA 2015).

Germany has implemented policies designed to protect vulnerable households from the financial burden of high gas bills. These include a gas price cap (Gaspreisbremse) and direct subsidies for heating (Deutscher Bundestag 2022; 2023c). Households with an income below €40,000 per annum are eligible for a 30% higher subsidy rate for the installation of renewable energy heating systems, resulting in a total subsidy of 70% until 2028 (BMWK 2024).

Nevertheless, social considerations are not explicitly incorporated into the decision-making processes or regulatory frameworks governing infrastructure development and network operations.

In Italy, approximately 38% of gas consumers receive a gas price which is determined by the Regulatory Authority AREREA based on wholesale prices. These so-called protected tariffs were phased out by July 2024 for all but certain vulnerable consumers. Italy has a White Certificate Scheme which does not focus on savings for vulnerable households. The most powerful relief mechanism is Bonus Energia, a reduction of the gas bill of economically disadvantaged households which is transferred without the need to apply for it. During the gas crisis, the eligibility group for this relief was expanded, supporting 2.4 million households in 2022. Information initiatives include the mandatory provision of advice on gas bills to enable consumers to compare offers. There is also an official comparison tool for energy prices. Furthermore, the help desk and conciliation service handled over 1 million calls in 2021 (ARERA 2023a; IEA 2023b).

In the Netherlands, the decommissioning of gas networks is organised at district level, whereby entire districts are converted into gas-free areas. This approach prevents consumers within a very low connection density area from remaining connected to the gas network. The regulatory framework takes into account the costs for consumers and therefore emphasises the cost-effectiveness of alternatives to gas. By converting entire districts, more comprehensive and efficient solutions can be implemented, making the transition easier both financially and practically (Ministry of Economic Affairs and Climate Policy 2019).

The United Kingdom is addressing vulnerable households with its Fuel Poor Network Extension Scheme, a collaborative initiative led by gas distribution networks in conjunction with various organisations aimed at addressing fuel poverty. The objective of the Extension Scheme is to facilitate the connection to the gas grid of households that are experiencing fuel poverty (Ofgem 2021). Throughout the current price control period, spanning from 2021 to 2026, the gas distribution networks have committed to make ongoing efforts to connect fuel-poor households to their network. These endeavours have been sanctioned by Ofgem, which has arranged the requisite funding mechanisms for these connections. The expenses incurred are socialised among all gas consumers (NEA 2021).

Current national legislations in the countries analysed claim to support consumer protection by making it hard to disconnect gas users from the grid, with the exception of Denmark. Consumers cannot be arbitrarily disconnected from the grid and forced to invest in alternative heating technologies. With the transition of the energy system away from fossil fuels, however, gas grid infrastructure needs to evolve. The revised Gas Directive adds a task for grid operators: decommissioning parts of the grid which are not needed anymore (Art. 40). Member States must now translate the possibility of decommissioning into national regulations and simultaneously protect vulnerable households from unplanned decommissioning. The definition of consumer protection, especially regarding the most vulnerable, must also evolve, however. The focus should therefore be on encouraging the switch from gas to clean heating technologies, away from the gas grid, and providing planning security by considering reduced gas demand in infrastructural planning.

9 Current and anticipated role of alternative gases

9.1 Hydrogen

In all countries assessed, hydrogen today is predominantly derived from natural gas and is used in industrial – mostly chemical – processes. There is, however, a lot of planning regarding the electrolysis of hydrogen; its storage and transport in caverns and pipelines traditionally used for natural gas only; its blending with natural gas; as well as its potential use in everything ranging from power plants and industrial processes such as steelmaking, to smaller CHP units and gas boilers in buildings. Nonetheless, all existing projects are on a small scale. Some planned projects have been cancelled due to excessive costs or local resistance (e.g. projects intended to supply entire villages with hydrogen for heating in buildings, both in the United Kingdom and Germany).

All countries assessed have an official hydrogen strategy and a plan for upgrading parts of their existing transmission gas grids to enable hydrogen transport, which can be achieved by rededicating and upgrading existing pipelines or by constructing new ones. All countries have general visions of hydrogen-only grids linking hydrogen production or import facilities with major industrial centres and power plants. Specific plans for distribution networks do not yet exist, although some DSOs plan to replace natural gas with hydrogen. Table 2 shows the various targets of national hydrogen strategies, including electrolysis capacities, domestic hydrogen production, imports, the length of the hydrogen core networks, and the planned share of gas pipelines diverted to hydrogen.

Table 2. Official government targets/plans for hydrogen by 2030

		AT	BE	DK	DE	IT	NL	UK
Amount of H_2 used in 2030	TWh/a	24	6	2-3	95-130	2% of final energy demand	*Not specified*	5-40
Total electrolysis capacity	GW	1	Target of 0.15 in 2026	1-7	10	5	3-4	up to 10
H_2 production at home	TWh/a	*Not specified*	*Not specified*	5	*Not specified*	*Not specified*	22.2	*Not specified*
H_2 imports	TWh/a	*Not specified*	20 in 2030, 200-350 in 2050, half for export	Exports from 2030	45-90	*Not specified*	100-167	*Not specified*

		AT	BE	DK	DE	IT	NL	UK
Length of core hydrogen network	km	1,050	*Not specified,* start with 100-160 km in 2026	350	9,700	*Not specified*	1,200	*Not specified*
Share of rededicated pipelines planned (predominantly transmission)	%	64	Not quantified, expected to be major part	*Not specified*	60	*Not specified*	84	*Not specified*

Sources: National hydrogen strategies (BMK 2023a; AGGM 2022b; Energinet and Gasunie 2023; Danish Ministry of Climate, Energy and Utilities 2021b; State of Green 2023; BMWK 2023b; BMWK 2023a; BMWK 5 Dec 2023; Vereinigung der Fernleitungsnetzbetreiber Gas e.V. 2023; IEA 2023b; MASE 2023; Hynetwork Services 2023; Ministerie van Economische Zaken en Klimaat 29 Jun 2022; Secretary of State for Business, Energy & Industrial Strategy 2021; NationalGridESO 2023; FOD Econ 2022; EnergyVille 2024)

The United Kingdom is the only country which has set itself a deadline for deciding on (1) the usage of hydrogen for heating in buildings, and (2) a hydrogen blending target for gas distribution networks (possibly 20% by 2030). The decision is to be taken in 2026. Austria sets a separate target of 80% green hydrogen usage in industrial processes by 2030. The Dutch plans for hydrogen consider the Netherlands as a future hydrogen trading hub. This explains the high imports predicted for 2030 (see Table 2), of which considerable amounts will be exported again, especially to the industrial centres of north-western Germany. In the future, Denmark intends to export the majority of its hydrogen production from around 2030 onwards. To date, the Italian government has not yet defined the hydrogen network in concrete terms.

Belgium also wants to transform its gas hub to a hydrogen transit hub. Its hydrogen strategy does not aim for high installed capacities of electrolysers in the country, except perhaps linked to Belgian offshore wind. No major role for hydrogen is foreseen at the distribution level.

9.2 Biomethane

The landscape of biomethane is more diverse than that of hydrogen. Biomethane is currently employed by all countries examined, albeit mostly to a limited extent. Total gas grid-relevant biomethane consumption ranges from around 0.01 TWh in Belgium to close to 13 TWh in Germany, with the Netherlands and the United Kingdom at intermediate levels. Denmark, however, has a particularly high level of biomethane usage, where it accounts for 38% of gas demand (see Table 3). Denmark produces 8 TWh, despite the country and population being smaller than Germany, for example.

The amount of biomethane currently in use is dwarfed by the amount of fossil natural gas, and the number of biomethane plants per country is more or less proportionate to the amount of biomethane consumed. The average amount of biomethane produced per plant is lowest in

Belgium, with around 5 GWh per plant annually, followed by Austria with 10 TWh and the Netherlands at 33.8 GWh per plant. Biomethane plants in the United Kingdom, Germany and Denmark produce an average of 52-54 GWh per year. Italy has the highest production levels per plant, at around 70 GWh. Whether these differences stem from differing plant sizes or different usage hours has not been assessed here.

Table 3. Status quo of biomethane parameters

		AT	BE	DK	DE	IT	NL	UK
Total biomethane consumption	TWh	0.14	0.01	8.0	12.8	6.0	2.4	6.2
Total biomethane as % of total fossil gas consumption	%	0.2	0.01%	38	1.6	0.9	0.8	0.8
Biomethane plants	-	14	3	150	238	85	71	119
Avg. biomethane production per plant	GWh	10.0	5	53.3	53.8	70.6	33.8	52.1
Biomethane consumption per person	kWh/per person	16	0.9	1,366	154	101	137	93
Biomethane consumption per area	MWh/m^2	1.7	0.3	186.4	35.8	19.9	57.8	24.9

Sources: (AGCS Gas Clearing and Settlement AG 2023; BMK 2023b; Danish Ministry of Climate, Energy and Utilities 2021a; Energinet 2024a; DEA 2023a; 2023b; BNetzA 2023; REF Ricerche 2023; Nederlandse Gasunie NV 8 Feb 2023; Centraal Bureau voor de Statistiek (CBS) – Statistics Netherlands 2022; 2021; DESNZ 2023; NationalGridESO 2023; SERV 2023)

A comparison of countries' per person and per area biomethane consumption shows that Denmark has the highest level of both. There are some country-level differences in the intensity of biomethane usage but, in relation to total fossil gas consumption, biomethane does not currently play an important role in the majority of countries, with the exception of Denmark.

All countries studied, except for Germany and Belgium, have an official biomass strategy (the German one is under development and is expected to be published shortly). Austria, Italy and the Netherlands have set very ambitious targets for future biomethane usage (see Table 4).

In Austria, the government aims to increase the amount of biomethane production and consumption more than fiftyfold, to 7.5 TWh by 2030. In the Netherlands, the target is more than eight times current levels (19.5 TWh annually by 2030). Denmark wants to increase production from 8 TWh to 13 TWh, although that number exceeds the biomethane potential calculated by Guidehouse (2022). The UK biomass strategy sets a more moderate target of 8 TWh in 2030, an increase of only 29%. Both the Austrian and Dutch targets for 2030 also surpass the biomethane potential assessed by Guidehouse (2022).

Table 4. Official government targets/plans for biomethane by 2030

		AT	BE	DK	DE	IT	NL	UK
Official biomethane production target for 2030	TWh	7.5	*No target*	13.0	*Yet to be published*	100	19.5	8.0
Guidehouse (2022): biomethane production potential	TWh	6	7	9	78	55	14	45

Sources: (BMK 2023b; DEA 2023a; REF Ricerche 2023; Nederlandse Gasunie NV 8 Feb 2023; DESNZ 2023)

Whether or not some of these very ambitious government targets for 2030 can be achieved remains to be seen. As the Guidehouse (2022) study shows, there still is some untapped potential for biomethane production. Yet it is very important to note that none of these potential levels of biomethane production are anywhere near the amount of fossil gas used today, except for Denmark. In fact, they represent less than 10% of fossil gas consumed today.

10 Transparency of information and opportunities for stakeholder involvement

10.1 Public information and transparency

In the majority of the countries under analysis, network operators publish regular reports on the development of the gas infrastructure and operating data. Such reports serve to enhance transparency and facilitate informed decision-making by stakeholders. Furthermore, these reports frequently include the most recent information on investment plans and future strategies. This ensures that stakeholders are kept informed about forthcoming developments in the gas sector.

- Austria:

  Every year, the Austrian Gas Grid Management AG (AGGM) develops two key plans for the country's gas network: the Coordinated Network Development Plan (KNEP) and the Long-Term and Integrated Planning (LFiP). These plans serve as the basis for Austria's future gas infrastructure and include strategies for improving the existing infrastructure and ensuring security of supply (AGGM 2022b; 2022a).

  In accordance with the Renewable Energy Sources Act (EAG), the Federal Ministry for Climate Change, Environment, Energy, Mobility, Innovation and Technology (BMK) is initiating the preparation of an integrated Austrian Network Infrastructure Plan. This plan provides a comprehensive perspective on the country's future energy infrastructure requirements and serves as a strategic instrument. It forms the basis for the expansion and transformation of the energy transmission infrastructure by 2030 and the achievement of climate neutrality by 2040. The BMK aims to synchronise the expansion of renewable energies with the expansion of the grid, as well as storage and flexibility solutions, by simultaneously considering overarching aspects of energy transport for electricity and gas, including hydrogen (Österreichisches Parlament 2021).

  According to §61 of the Gas Industry Act, distribution system operators are obliged to advise end users connected to their network on general energy-saving measures and specific opportunities for gas saving and efficient use (GWG 2011). Maintenance work is communicated on the individual DSO pages, which provide information on the entire managed network. Reference is made to the network development plan of all network operators in cooperation with AGGM and the transmission system operators. This collaborative approach enables a comprehensive review and planning of the gas infrastructure, and considers the different network segments and responsibilities (Wiener Netze GmbH 2024; Gas Connect Austria GmbH 2024).

- Belgium

  Every two years, TSO Fluxys and the gas DSOs publish their investment plans and vision documents. Nevertheless, comprehensive data regarding the gas grid are less readily available. For example, the depreciation rates and timelines for the gas distribution networks in Flanders were only obtained through parliamentary inquiries (Vlaams Parlement 2023).

  It is extremely challenging, if not impossible, to find data on the size of the network or the customer breakdown. In contrast to the electricity TSO Elia, Fluxys does not publish long-term scenario analyses (Fluxys 2023).

- Denmark

  The two state-owned network operators, TSO Energinet and DSO Evida, make information about annual gas prices, forecasts and the current proportion of biomethane available on their websites. Furthermore, they disseminate reports on the long-term development requirements of the Danish gas system and the prospective hydrogen network (Energinet 2024b; Evida 2024b; DNV 2022; Energinet 2022).

  In accordance with the relevant legislation, gas network operators are obliged to publish a range of data on a regular basis. This includes metered consumption data, quality and pressure conditions within the distribution system, and any changes or notifications regarding suppliers and consumers, including billing methods (Danish Utility Regulator 2023).

  Furthermore, Evida has developed a model for the gradual replacement of natural gas for residential heating, which has been published in a report. Evida is requesting the authority to impose a switch-off obligation on consumers within two years, with the objective of enabling the partial decommissioning of unprofitable parts of the grid (Evida 2023). The Danish Energy Agency and the Ministry of Climate, Energy and Utilities have direct access to this model. Other stakeholders must negotiate access with Evida.

- Germany

  In Germany, a network development plan is published every two years by the 16 transmission system operators, detailing planned gas network construction projects for the next ten years under the supervision of the Federal Network Agency. The Federal Network Agency publishes an annual monitoring report covering all gas network developments, such as investment in new networks, maintenance and repair expenditure, network length, number of operators, and consumption trends (EnWG 2017; FNB Gas 2020; BNetzA 2023).

  According to ENWG §23c (6), gas distribution network operators are obliged to publish key network data. This includes information on gas quality. In addition, operators must publish the rules for connecting other installations and networks to their network, and the rules for access to their network. The publication should also include standard load profiles applicable in the local distribution system and a schematic map showing the areas within a municipality connected to the local gas distribution system (EnWG 2017).

- Italy

The regulatory authority ARERA (Autorità di Regolazione per Energia Reti e Ambiente) publishes an annual monitoring report that includes detailed information about the gas grid (ARERA 2023b). Additionally, a regional gas distribution register provides publicly accessible data, contributing to transparency in the sector (ARERA 2020). To facilitate consumer awareness and decision-making, there is an official comparison tool for energy prices, which is promoted on every gas bill alongside advice on how to use it. This integrated approach aims to enhance the availability of information and support consumers in making informed energy choices (ARERA 2023a).

- Netherlands

In the Netherlands, the management of the gas transport system is overseen by a national transmission system operator, Gasunie Transport Services B.V. (GTS), and six regional distribution system operators. Each year, these network operators publish information on the updated network tariffs, thus ensuring transparency for consumers.

The map of the network areas where gas is distributed are open to the public. In addition, each network operator publishes their respective investment plans, providing an insight into the planned developments and improvements within their specific network. This approach aims to keep stakeholders informed about ongoing activities and future initiatives in Dutch gas distribution infrastructure (GTS 2022).

- United Kingdom

Despite the wealth of information provided by Ofgem, finding relevant documents is not straightforward, and it is difficult to effectively navigate the Ofgem website. This presents a hurdle for those attempting to gather information without a clear understanding of the specific document they are looking for. Information relating to individual price controls, for example, is not readily available on Ofgem's website and, when located, may lack necessary details or not be consolidated in one place (Ofgem 2024b). Finding more general data about the network, such as its size or customer breakdown, is an arduous if not near-impossible task.

While Ofgem's consultations provide an avenue for stakeholder input, they do not necessarily provide sufficient data to facilitate meaningful contributions. Comments received are collated but not aggregated, making it difficult for stakeholders to gauge the overall sentiment or impact of their collective feedback. Furthermore, it appears that gas network operator GDN submissions are not accessible on Ofgem's website, limiting their availability to GDN's own platform. This lack of transparency raises concerns about the accessibility of key information and the ability of stakeholders to fully engage with the regulatory process. Improving the accessibility and organisation of information on Ofgem's website could therefore improve transparency and encourage more meaningful participation in the regulatory discourse (National Grid Gas Transmission 2022).

10.2 Opportunities for stakeholder involvement

Stakeholder engagement is important in the context of effective gas network planning and regulation, with a close link between the two and the evolving climate targets and socio-economic considerations. This is of particular significance in the context of several key documents that provide guidance on policy and infrastructure development.

For instance, national grid development plans should be closely aligned with climate scenarios, while anticipating future energy needs. In this context, environmental groups and consumer representatives can provide valuable insights into community needs and expectations. It is also essential to ensure the timely decommissioning of sub-grids in order to protect vulnerable households from high energy costs.

The National Energy and Climate Plans also play a role in aligning national energy policies with climate targets. The involvement of stakeholders, such as industry representatives and environmental organisations, is crucial for ensuring that heating and boiler regulations effectively support the decarbonisation process and protect vulnerable households from the potentially high costs of continued grid usage.

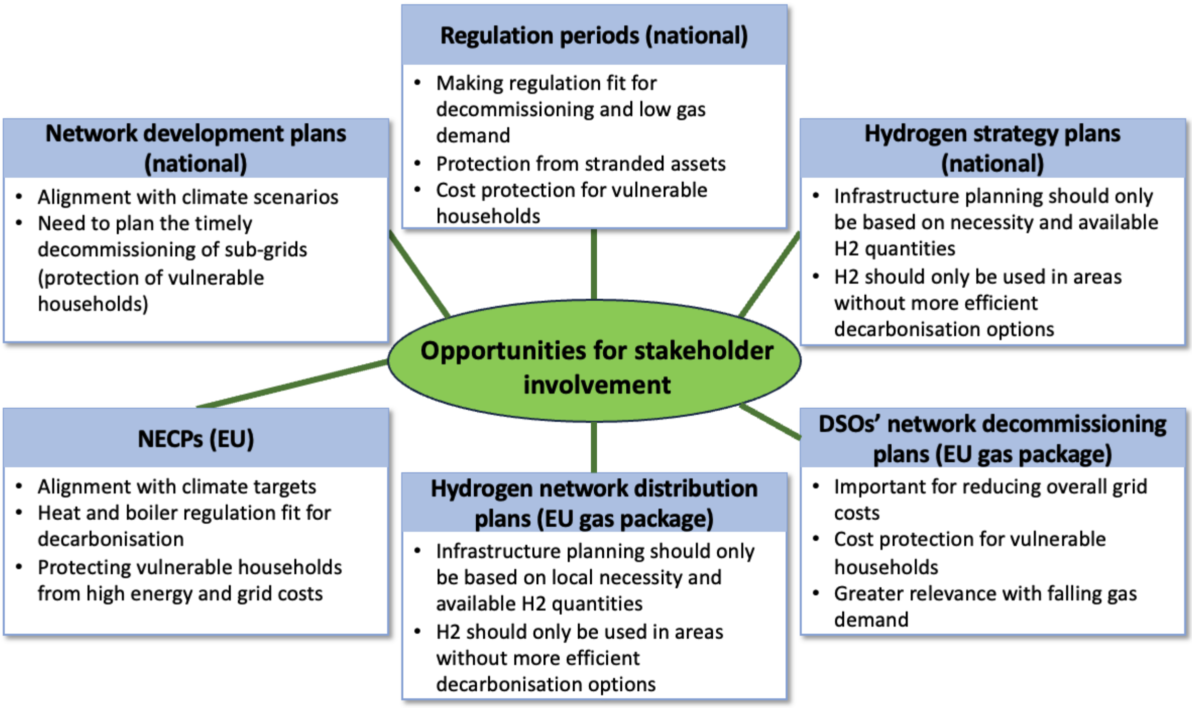
The plans for hydrogen distribution networks as part of the EU hydrogen and gas decarbonisation package, or gas package, necessitate meticulous planning to optimise the utilisation of local hydrogen resources. Local communities and energy experts can exert influence over infrastructure decisions, ensuring that they are made in a manner that is both efficient and cost-effective. Furthermore, stakeholders could only advocate for the use of hydrogen if there are no more efficient alternatives to decarbonisation.

The plans of DSOs to decommission networks as part of the gas package are of great importance, as they will help to reduce overall costs and avoid the creation of stranded assets in the face of falling gas demand. Consumer groups and regulators have a pivotal role to play in safeguarding vulnerable households during this transitionary period.

The national regulatory periods are an important time for stakeholders to exert their influence and adjust the regulatory frameworks. These modifications are necessary in order to meet changing energy trends, particularly with regard to decommissioning management and low gas demand. Stakeholders could advocate for regulation that prevents investment in stranded assets while protecting vulnerable households from energy price volatility.

Figure 11 summarises the general options for stakeholder participation in gas grid planning and regulatory processes. Targeted stakeholder engagement can help to increase the robustness and fairness of gas network planning and regulation. By promoting measures to accelerate decarbonisation and achieve international climate targets, protect vulnerable households from energy poverty and high costs, optimise infrastructure investments and adapt regulations to the changing energy landscape, a sustainable and fair energy future can be achieved.

Figure 11. Opportunities for stakeholder involvement in gas network planning and regulation and key points to make for appropriate, cost-effective infrastructure



Additional country-specific information on the possibilities for participation is as follows:

- Austria

  The next gas tariff regulation period starts in 2028 (E-Control 2022). It is therefore advisable to make the recommended adjustments to the network regulation before then, with a focus on adapting the regulatory framework to facilitate the phase-out of gas. Integrating heat and grid planning as well as basing future gas infrastructure plans on realistic assumptions about the availability of zero-carbon heating technologies should be prioritised. In addition, assumptions on biomethane production and injection need to be reviewed to ensure that targets and assumptions are reasonable.

- Belgium

  To ensure the optimal development of the fossil gas network, the federal regulator CREG, in conjunction with regional regulators VREG, Brugel and CWAPE, engages in consultations pertaining to investment plans and tariff methodologies as and when required. These consultations are public, but staying informed and providing relevant input requires close involvement. The comments received during the consultations are collated and summarised. Monitoring the progression of decisions pertaining to hydrogen regulation is a more protracted and challenging process. Nevertheless, this may be subject to change following the appointment of CREG as the hydrogen regulator under the recently enacted hydrogen law. A lack of an integrated cross-sectoral strategy and planning strategy is a notable shortcoming of the Belgian approach. The division of responsibilities between the federal and regional governments introduces a further layer of complexity to the process (CREG 2024; VREG 2024a; Brugel Brussel 2024; CWaPE 2024).

- Denmark

Stakeholder involvement in Denmark's gas sector is evident in two primary areas. Firstly, the annual determination of grid fees by the regulatory authority allows stakeholders to influence through recommendations. Secondly, the Danish Energy Agency prepares annual projections for gas demand and biomethane production, where stakeholders can similarly contribute with recommendations and support.

The planned phase-out of gas for buildings by 2030 requires the gas grid operator to be able to disconnect gas connections following notification. This approach would facilitate the targeted decommissioning of specific sections of the gas network, enabling cost-effective implementation. The recommendation for decommissioning to support this transition can be made at any time.

- Germany

The next regulatory period of the Federal Network Agency is scheduled to commence in 2029. Until then, stakeholders are afforded the opportunity to become involved in the regulatory process, with a view to ensuring that their recommendations are integrated into the development plans. Engaging at an early stage enables stakeholders to influence the strategic direction and regulatory framework governing the gas networks after 2029 (ARegV 2017).

- Italy

In June 2024, ARERA started a stakeholder process for defining the scenarios for the new transmission network development plan (ARERA 2024). The creation of regional and local energy plans also includes the involvement of stakeholders (Bianconi 2021; Buratti et al. 2001).

- Netherlands

System operators disseminate data on revised network tariffs annually, thereby ensuring transparency for consumers. Stakeholders can engage in the process by offering recommendations and advocating for specific topics to be addressed in the plans.

In addition, each network operator publishes its investment plans, which offer insights into planned developments and improvements within its specific networks. This practice not only ensures that stakeholders are kept informed about ongoing activities and future initiatives in the Dutch gas distribution infrastructure, but also provides the opportunity to influence the direction of these investments by offering feedback and suggestions. This approach facilitates multiple avenues for stakeholder engagement, enabling active participation in shaping the Dutch gas distribution landscape (GTS 2022). In the Netherlands, the next regulatory period will start in 2027, by which point the main recommendations need to be addressed (ACM 2023a).

- United Kingdom

Ofgem frequently consults on the price control framework for gas networks through its website (Ofgem). To ensure a robust and inclusive regulatory process, Ofgem established a RIIO Challenge Group (Ofgem 2020). Tasked with providing independent scrutiny of proposed network company business plans for all sectors under RIIO-2, the Challenge Group focuses on affordability, consumer protection (especially for vulnerable customers) and sustainability, including environmental impacts and the transition to low carbon. Members of the Challenge Group also participate in public hearings organised by Ofgem.

The current members of the Challenge Group are listed on the Ofgem website. There are several additional working groups that contribute to Ofgem's decisions on gas network regulation, covering both gas distribution and gas transmission (Ofgem 2019a; 2019b). Individuals interested in attending upcoming working groups are encouraged to contact RIIO2@ofgem.gov.uk for more information. This structured approach allows stakeholders to engage actively in the regulatory process and influence decisions that shape the gas network framework.

11 Recommendations

This analysis has shown that the current trends regarding gas use and infrastructure are not in sync with decarbonisation pathways. Realigning gas policy and regulation with climate goals is far from trivial, however, and will require a range of significant changes to the status quo.

Drawing on the country-specific assessments in this report and other recent analysis (Rosenow et al. 2024), we make the following recommendations:

Recommendation 1: Adopt national phase-out target and give energy regulators a net zero mandate

Energy regulating authorities like BNetzA, Ofgem or ARERA typically prioritise two goals: reliability of supply, and keeping costs down for consumers. While regulators increasingly consider the implications of regulation on decarbonisation, an explicit mandate that tasks them with developing regulation that delivers on climate goals is often missing. In the United Kingdom, the energy regulator Ofgem has been given a net zero duty through the Energy Bill. Similar mandates and duties for regulators in other countries can provide the basis upon which regulatory decisions are made.

Recommendation 2: Make the regulatory framework fit for the gas phase-out

The regulatory framework for gas distribution grids needs to be revised to permit the option of complete withdrawal from the gas supply. In several countries, the regulatory framework for gas distribution grids implicitly assumes that the gas grids are a permanent infrastructure. As a result, regulations are focused on expanding and maintaining the grids rather than decommissioning them (partially or entirely). Therefore, significant modifications are necessary. Gas DSOs should be able (and where appropriate obligated) to shut down specific sections or entire networks. To achieve this, several regulatory elements must be considered. They include:

- Exploring regulatory models that incentivise measures aimed at increasing system efficiency instead of primarily rewarding investments.
- The possibility of refusing to connect new customers to the gas network and disconnecting existing customers from the network (whereby it must be regulated whether and in what form compensation is paid, who bears the associated costs, and how energy/heating needs are met).

- Ending incentives for grid expansion (e.g. by concession contracts) and additional customer connections, especially for vulnerable customers, and prioritising means to shift vulnerable customers to more sustainable and efficient heating solutions.
- The possibility of claiming foreseeable costs for the decommissioning or dismantling of the network today as part of the network charges or through financing mechanisms, and to set aside those monies to use for that future decommissioning and dismantling (this approach would spread the respective financial burden and safeguards so as to protect the last remaining consumers from excessive costs).
- Preventing stranded assets and distributing decommissioning costs evenly over an extended period, shortening the depreciation periods for infrastructure investments, both past and future, so that they are fully amortised by the time the grid is decommissioned.

Recommendation 3: Adopt integrated heat and grid planning

The aim of heat planning should be to achieve an efficient, effective and equitable heat supply that is aligned with climate targets. To accomplish this goal, heat planning should include clear assessment criteria. Potential solutions, including gas-based and electrification options, should be evaluated based on their ability to meet the assessment criteria, which should include technical feasibility, environmental impact, cost-efficiency, supply security, and any risks that an option may not be realised. Overarching guidelines are necessary, particularly regarding the availability and allocation of limited resources such as biomass, biomethane or hydrogen.

Heat planning must also be coordinated with infrastructure planning, so that infrastructure planning can be orientated to and support heat planning. Regulations regarding the replacement or use of heating systems should take into account the potential long-term impact on gas networks. Technologies such as hybrid heat pumps, which will require a gas distribution network but require very limited throughput volumes, should be avoided as they act as a barrier to system efficiency.

Recommendation 4: Plan future gas infrastructure based on realistic assumptions about availability of zero-carbon heating technologies

Due to the lengthy investment cycles, it is necessary for every new heating system installed today to be compatible with long-term climate targets. In the long term, gas-based heating systems will need to be operated using biomethane or hydrogen. Due to the uncertain future availability and price of these fuels, however, investing in a gas boiler today would be a risky decision and should be avoided if possible.

This has implications for gas distribution networks. Infrastructure planning should primarily consider the technology portfolio that is currently available and reliably serves climate targets, specifically the electrification of heat supply and district heating, and anticipate the decline in gas sales. Infrastructure regulation should allow for decommissioning. There could be allowance for decommissioning to be done in such a manner that it allows for individual sections to be revitalised at a later date, if alternative gases became the most efficient option.

Delaying important decisions about gas networks will potentially exacerbate the problem. At best, it will leave less time for managing the transition from gas to other energy carriers. At worst, it will unnecessarily create stranded assets, adding to costs borne by customers.

Recommendation 5: Track and collect harmonised data at the EU level

European climate goals under the Green Deal require full decarbonisation by 2050 or earlier. All EU scenarios indicate a steep decline in gas demand, which is tracked in detail by Eurostat. Data on gas infrastructure is not easily obtained at national level, let alone at EU level, however. The collection and publishing of data on gas networks in all Member States would allow systematic tracking of whether infrastructure changes are in sync with climate targets, alongside the associated decline in gas use across all sectors.

There is another gap in data on consumption of gas by end use (space heating, domestic hot water, process heat etc.). Data availability is still very patchy across the EU; this research only found such data in Germany.

Recommendation 6: Protect vulnerable customers

In the past, consumer protection in relation to gas grids ensured grid connection and suppression of gas prices through liberalised energy markets and regulation of natural monopolies. With a declining number of customers connected to – and paying for upgrades to – the gas grid, this interpretation of consumer protection should be redefined. Customers remaining on the gas system will face higher prices to meet heating, cooking and other needs. Without intervention, energy users who cannot withdraw from the gas system as quickly as others risk being stuck with the costs of an increasingly expensive and unhealthy system.

Vulnerable consumers and those on low incomes should be prioritised and enabled to transition to sustainable heating solutions early, while ensuring that their bills do not increase. Programmes that connect vulnerable energy users to the gas grid should be adapted to favour electrification and district heating.

Country-specific recommendations

Austria

The next gas tariff regulation period starts in 2028. It is therefore advisable to make the recommended adjustments to the network regulation before then, with a focus on adapting the regulatory framework to facilitate the phase-out of gas. Integrating heat and grid planning should be prioritised, and future gas infrastructure plans should be based on realistic assumptions about the availability of zero-carbon heating technologies. In addition, assumptions and targets on biomethane production and injection need to be reviewed to ensure that they are realistic. In Austria, changes to regulation should consider the following points:

1. Enable the ability to refuse new connections as well as disconnect existing customers from the gas network.
2. Shorten depreciation periods for past and future infrastructure investments to avoid stranded assets and to spread decommissioning costs evenly over a shorter period, ensuring full payback by the time the network is decommissioned.
3. Cover foreseeable decommissioning costs through network tariffs or funding mechanisms, while building up a reserve for future decommissioning to spread the financial burden and protect consumers from excessive costs.
4. Interlink (gas) infrastructure planning with municipal heat planning.
5. Incorporate climate scenarios into infrastructure planning to avoid unnecessary costs and investments.

Belgium

New legislatures at the federal and regional levels begin at the end of 2024 (pending government agreements). It is recommended that the proposed adjustments to network regulation be implemented before these new legislatures start. The specific recommendations for Belgium are:

1. Develop a unified vision on gas use. All levels of government should coordinate on a unified vision for the future of fossil and alternative gases. The vision should clarify the role these gases will play, especially at the energy distribution level.
2. Implement a socially equitable depreciation plan to avoid stranded fossil gas infrastructure assets. This plan can be inspired by the targeted depreciation rates used for the transmission network, with the aim of full depreciation by 2050.
3. Shift taxes and charges from electricity to fossil fuels to create a level playing field for alternatives to gas heating. Such a shift has been included in the agreement for the incoming Flemish regional government. It should be expanded to the other regions and the federal level. This strategy should include measures to support vulnerable households in the transition to new energy systems.

4. The phase-out of gas connections in Wallonia should include clear guidelines on the timetable for phasing out new gas connections in new buildings. This clarity is needed, especially as other regions in Belgium have already set a target of no new gas connections from 2025.

Denmark

The planned and prepared phase-out of gas for buildings is set to occur by 2030. However, to implement this cost-effectively, it is necessary to make it possible to disconnect gas connections (after notification) to allow for the targeted shutdown of parts of the gas network. The demand can be made at any time. It is therefore recommended that Denmark:

1. Enable targeted decommissioning of gas distribution networks by allowing gas connections in local network areas to be disconnected by Evida, with prior notice.
2. Protect vulnerable people from high energy costs through targeted decommissioning and prioritised support enabling this group to switch to heat pumps and district heating.

Germany

The next regulatory period of the Federal Network Agency (BNetzA) is scheduled to commence in 2029. Until that time, stakeholders could become involved in the regulatory process with a view to ensuring that their recommendations are integrated into development plans. It is important that these stakeholders engage at an early stage, to exert influence over the strategic direction and regulatory framework that will govern the gas networks in the upcoming period. For Germany, the country-specific recommendations are as follows:

1. Enable the refusal of new gas connections, and disconnection of existing customers. Infrastructure planning should be linked to municipal heating planning.
2. Adapt the depreciation period to reflect the actual usage time of the gas networks, as now planned by the regulatory authority.
3. Adapt infrastructure planning to realistic climate scenarios and the resulting gas demand.
4. Include the designation of gas-free areas and the decommissioning of gas network infrastructures in municipal heat planning.

Italy

In order to enhance the regulatory framework for gas infrastructure in Italy, it would be advisable to consider the following recommendations:

1. Implement policies that permit gas network operators to refuse new connections and disconnect existing customers, where appropriate.
2. Reduce depreciation periods for both past and future infrastructure investments. This will help avoid stranded assets and distribute decommissioning costs over a shorter timeframe, ensuring full repayment by the time the network is decommissioned.

3. Finance foreseeable decommissioning costs through network tariffs or funding mechanisms. Establish a reserve for future decommissioning to spread financial burdens and protect consumers from excessive costs.
4. Ensure that gas infrastructure planning is closely coordinated with municipal heat planning for better alignment and efficiency.
5. Use climate scenarios in infrastructure planning to avoid unnecessary costs and investments, ensuring that plans are sustainable and aligned with climate goals.

Netherlands

In the Netherlands, the next regulatory period will start in 2027; any recommendations would need to be addressed by then. These include:

1. Consider hybrid heat pumps as a transitional technology and not as a final solution, as grid infrastructure would still be needed despite the lower throughput. This would significantly increase specific costs. In addition, more alternative gases (such as biomethane and hydrogen) would be needed, although these are urgently needed in other sectors that have few alternatives to decarbonise.
2. Improve the consistency between climate scenarios and infrastructure planning regarding gas demand.
3. Introduce programmes to protect the last consumers in a timely manner.

United Kingdom

The next UK gas distribution price control review is expected to start in April 2026. Due to the significance of this decision for gas regulation, Ofgem has proposed that long-term risks associated with the use of the gas grid could be managed through depreciation rates or asset lives, with the potential for 're-openers' allowing the option to modify the price control. Alternatively, Ofgem has suggested that the price control framework could be delayed, perhaps by two years. Both options protect the gas network owners but offer limited upsides for consumers. Delay leads to an increase in potential stranded assets and increases the financial exposure of UK citizens, not just to gas network costs but also to energy insecurity and climate change costs. To address this, we suggest these recommendations to the UK government:

1. 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.
2. Provide opportunities for Ofgem and the UK Department for Energy Security and Net Zero to work together and with other parties to develop a plan which equitably allocates the multi-billion-pound risks associated with stranded gas assets and decommissioning, evolutionary regulation and renationalisation.
3. Implement the recent Ofgem decision to allow for accelerated depreciation ensuring new gas grid investments are fully paid off by 2050 and, as currently considered, extend accelerated depreciation to existing gas grid assets.

4. Consider whether the Iron Mains Risk Reduction Programme continues to offer consumers value for money as a major capital investment programme – and, if not, intervene as soon as is practicable.
5. Ensure that approaches to heat and local area energy planning – and wider clean heating policy – are coordinated with the issue of gas grid decommissioning, and that consumer protection is central.

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