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The clash with gas: Should it stay or should it go?

Principles to address the changing role of gas in a decarbonised energy system

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Foreword

We are releasing this report[1] at a grim moment in history. As the world was starting to look with hope towards the potential end of a global coronavirus pandemic, Russia invaded Ukraine. Russia's attack has already left millions of Ukrainians without a place to call home. The needless devastation wrought is heart-breaking, and disruptions in food and energy flows threaten economies around the world.

Russia's actions have fundamentally altered the geopolitical landscape. The shifts directly impact, and are often intertwined with, decisions around energy. The need to respond loudly and impactfully to Russia's aggression has caused an exponential rise in support for ending Europe's heavy dependence on Russian oil and gas. This heightened urgency has brought increased attention to solutions that can meet energy needs without reliance on insecure and increasingly unaffordable fossil resources.

This report does not directly address the many ongoing discussions about how to move away from Russian gas – we have covered this question in another report.[2] But the principles we outline for decision-makers are fundamental to those decisions and the shift towards clean energy in Europe. We hope that this report will contribute to the transition to a decarbonised energy system that can resiliently withstand the pressures of change.

Executive summary

Across Europe today, European Union leaders, Member States and citizens face two intertwined fossil gas crises. First is the immediate crisis of gas availability and cost due to Europe's historic reliance on Russian gas. Second, overarching that, is the urgent climate challenge which demands rapid reductions in the use of all fossil fuels, including gas. As governments, utilities, regulators and others work to find answers to these issues, it is critical to lay out the foundational principles for action.

In this study, the Regulatory Assistance Project sets out five essential principles to guide decision-making for the transition away from fossil gas in Europe. These principles are general in nature, due to the breadth of the gas transition, and the numerous policy instruments that governments will need to reform such a large part of our energy economy. To bring the principles into focus, this study examines each one by applying it to current European policy dockets, particularly the Commission's Hydrogen and Decarbonised Gas Market package[3,4] (the 'gas package') and the Commission's and examples of Member States' Hydrogen Strategies (the 'hydrogen strategies').

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[2] Brown, S., Vangenechten, D., Claeys, B., & Lovisolo, M. (2022). *EU can stop Russian gas imports by 2025*. https://www.raponline.org/knowledge-center/eu-can-stop-russian-gas-imports-by-2025

[3] European Commission. (2021a, 15 December). Proposal for a Regulation of the European Parliament and of the Council on the internal markets for renewable and natural gases and for hydrogen (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:804:FIN

[4] European Commission. (2021b, 15 December). Proposal for a Directive of the European Parliament and of the Council on common rules for the internal markets in renewable and natural gases and in hydrogen. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0803

At a broad level, this analysis reveals that Europe's ambitions for the gas transition are only partly reflected in the gas and hydrogen policy files now under way, and are unlikely to be achieved without substantial course corrections. This report provides several actions that could be taken in line with Europe's ambitious and essential gas transition goals.

Five principles for a strategic gas transition

In this report, we have distilled a great deal of analysis and deliberation into the five overarching principles, shown in Figure 1, to guide the transition away from fossil gas. Each of the principles is important, but none of them should be used on a stand-alone basis. Complex decisions require the principles to be considered together, and we do not suggest that there is a hierarchy in the order or manner in which they are presented here.

Figure 1. Principles for a transition away from fossil gas

Principle 1: Implement solution sets that will reduce the greatest amount of greenhouse gases as quickly as possible in both the near and long term.

As policymakers develop solutions for the gas transition, we recommend they keep two aims in mind. First, develop solutions that will reduce greenhouse gases as much as possible, and at as rapid a rate as possible. Second, the transition demands a sustainable system for further reductions, avoiding dead ends that may ultimately limit total reductions in later years. In practice, achieving a balance between rapid reductions and deep, permanent reductions is not an easy task, but policy proposals should be tested against both aims before being put into effect.

Implementing this principle does not mean that every action must address both goals. It does, however, require a holistic, integrated approach that combines strategies to achieve them. Some high-level European policies, such as Efficiency First[5] and support for the circular economy, foster both short-term and long-term fossil gas reductions.

[5] European Commission. (n.d.). *Energy efficiency first principle*. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-first-principle_en

Other policies, by contrast, appear to be at odds with building a system that can achieve decarbonisation objectives. For example, the focus in the gas package on designing a 'better' gas market is thus far inconsistent with the long-term necessity of creating a radically smaller gas system, with alternative gases serving quite different, hard-to-electrify end uses. Hydrogen, in particular, should be seen as a pathway to a decarbonised energy system, not just as a broad-based substitute for fossil gas.

Principle 2: Elevate solutions that prioritise benefits for low-income and disadvantaged households.

Previous energy policies have created structural inequities that have resulted in disadvantages for low-income, energy-poor and disadvantaged households. The current energy transition not only offers an opportunity to address and ameliorate policies that place a heavier burden on under-resourced communities, but there is also the chance to create a sustainable system that can equitably serve all energy users. Key to doing so is prioritisation of policies that overcome the inherently disadvantaged position of energy users in need, including policies addressing inefficient living spaces and, relatedly, disproportionately high energy burdens (the percentage of household income spent on energy costs).

European Union and Member State policies generally include an overarching goal to address inequity and provide safeguards for energy-poor and disadvantaged households. Provisions to meet this goal, however, are often lacking or are misdirected at short-term solutions. Measures such as social tariffs or energy bill assistance can reduce costs, for example, but they do not address the underlying causes of energy poverty. Nor do such fixes acknowledge that reliance on fossil gas continues to cause environmental degradation and attendant negative health impacts that are often borne more frequently by vulnerable communities. Equitable policies will prioritise solutions that address the root cause of the inequitable outcomes of the past by creating an energy system that is sustainable for all energy users.

Deep housing retrofits and energy-efficiency measures are priority solutions to create a solid foundation for this approach. By reducing total energy demand, these solutions increase flexibility in the energy system. At the same time, they decrease energy burdens and improve physical and mental health outcomes by improving indoor environments. By contrast, solutions that focus on short-term savings – such as replacing gas heating with more efficient gas heaters – only perpetuate disadvantaged and energy-poor households' exposure to rising gas prices. Sustainable solutions that address root causes are especially critical to ensure that these energy users are not left bearing the rising costs of infrastructure and gaseous fuels that will come from a shrinking customer base as gas usage declines. The gas package today does little to address the realities of the coming gas transition for low-income and disadvantaged customers, and hydrogen strategies that include allowances for hydrogen as a solution for heating needs further divert attention from the solutions that can immediately address energy poverty.

Principle 3: Integrate the gas and electricity sectors.

To develop an energy system that can meet greenhouse gas reduction targets, it is essential to integrate the gas and electricity sectors in both planning and operations. The gas transition is not one that merely substitutes new gases for fossil gases. It is a transition to new combinations of resources: electrification, energy efficiency, demand management, and low- or zero-carbon gases in hard-to-reach sectors. This fundamental shift needs policies that create links across the electricity and gas sectors, requiring decision-makers to plan and operate these systems with a focus on decarbonising end uses, not on perpetuating existing service modes. Integrating the gas and electricity sectors requires changes in governance structures, planning requirements and markets.

Ultimately, the gas transition is about meeting energy users' needs effectively, efficiently and equitably. The disconnected nature of current planning processes, which develop solutions within the confines of one sector or another, does not facilitate the development of optimal solutions for end users or for the system as a whole. If, for example, there is insufficient gas supply to meet end-use needs, the current system focuses on increasing the gas supply, not asking whether the end uses could be met in another manner, such as through demand response or electrification. The current system creates a bias towards the means, rather than the goal of meeting the end-use needs of energy users.

The gas package proposal does not resolve these problems. Although the current proposal recognises the need for system integration and for more integrated planning, most of the problem areas that it sets out to address frame the problem as one of gas decarbonisation, rather than end-use decarbonisation. Similarly, hydrogen strategies are framed in ways that could potentially ignore or even crowd out better options.

Principle 4: Design a coordinated and self-reinforcing policy mix to transform end uses.

The focus of public policy in the gas transition must be on the customer end of the pipe – on the transformation of end uses away from fossil gas. To meet European climate targets, a mix of policies is needed to deliver sustained annual reductions of over 4% per year across millions of customers and end uses, equating to more than 16 billion cubic metres per year. The war in Ukraine has triggered efforts to move away from fossil gas at an even faster rate, with analysis suggesting that reductions of up to 25 billion cubic metres per year could be achieved by accelerating renewable energy deployment, energy efficiency and heat pump rollouts, and electrification in the industrial sectors.[6] Reducing fossil gas consumption at such rates requires two sets of linked policy measures. One set is needed to help customers decrease their energy demands and decarbonise end uses, and a second set is needed to support the substitute energy carriers, principally electricity, that will deliver energy service needs.

No single policy instrument or regulation can drive this process on its own. With the suite of policies encompassed by the Fit for 55 package of legislation, the European Union recognises this fact. Important contributions are expected from multiple policy instruments, including the Energy Efficiency Directive, the Energy Performance of Buildings Directive and the Renewable Energy Directive. Energy-efficiency

[6] Brown et al., 2022.

improvements, including both building renovations and switching to inherently more efficient equipment, are essential to deliver practical solutions that address customer needs. Each of these programmes must be designed with equity and energy poverty alleviation as core design components. Because uptake by building owners and end users is the key to success, and because there are limited investment trigger points, these policies must be designed so that they reinforce one another and provide consistent incentives to accelerate low-carbon end uses.

A wide range of policies can be combined to drive a quicker and more effective transition away from fossil gas. Some of these policies operate at a systemic level, including carbon pricing and reforms of taxes and levies. Other programmes focus on the customer level, on building renovations and end-use equipment investments. These include minimum energy performance standards for buildings and appliances, and a clean heat standard requiring heat and heating fuel suppliers to meet performance standards for lower emissions among heat customers more broadly. The key goal across all of these measures is to ensure that the incentives they provide to end-use customers are in alignment with the ultimate goal of an effective and equitable transition away from dependence on fossil gas. Analysis of the gas package and hydrogen strategies demonstrates that these policies do not fit within the broader set of policies to decarbonise, and may in fact slow those efforts. A system-decarbonisation approach that focuses on using hydrogen and alternative gases to meet hard-to-decarbonise end uses would better serve efforts to meet climate goals.

Principle 5: Increase transparency and use best available data and information.

Integral to any robust public process is the ability of decision-makers to obtain and use the best available data and information. This need is amplified during a time of transition, particularly when that transition requires coordination across sectors that do not have a history of close communication, like electricity and gas.

Transparent public processes are also important for reasons of equity and inclusion. The gas transition directly affects almost every citizen and business in Europe. Stakeholders and the public at large are therefore entitled to review the information that decision-makers are relying upon, and to test the policy ideas being proposed to address emissions reductions.

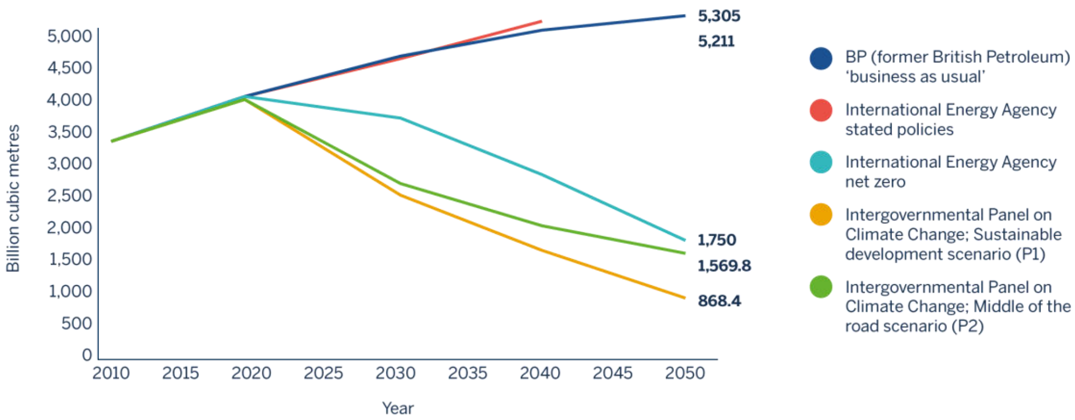
The current gas package proposal does not live up to these principles for transparency and data sharing. Currently, it only requires system operators to share information with specific entities, particularly regulators, market participants and investors, and aims principally at ensuring the efficient operation of the interconnected gas system. These requirements, which focus more on ensuring a well-functioning market and addressing the addition of infrastructure, are insufficient to enable regulators to think about the next steps in a decarbonising system. Data assembly and information requirements, including public processes, need to be revised substantially to serve much broader purposes. These needs include decarbonising end uses, transforming the architecture of the gas grid to serve hard-to-electrify end uses, and ensuring a safe and reliable system as end uses transition.

Introduction: Fossil gas no longer fits

Greenhouse gas (GHG) reduction targets require decarbonisation of the energy system.[7] To achieve that goal, the place for fossil fuels must become smaller and smaller.[8] Member States have recognised the need to move away from coal for some time, and have developed plans and commitments to reduce coal usage.[9] It is also necessary to eliminate dependency on fossil gas[10] to achieve the emissions reductions needed to stem climate change – and, as current events in Ukraine demonstrate, to move away from a geopolitical instability that threatens both lives and energy security.

At a global level, the International Energy Agency's (IEA) *Net zero by 2050* pathway analysis states that unabated fossil gas demand will need to decrease by 55% by 2050.[11] Figure 2 illustrates this average decline of just under 3% per year from 2020 to 2050.[12] Other 2050 decarbonisation scenarios from the Intergovernmental Panel on Climate Change show that even deeper reductions may be necessary to meet climate goals.

Figure 2. Scenarios for global fossil gas demand, 2010–2050



Source: Gaventa, J., & Pastukhova, M. (2021, 8 May). *Gas under pressure as IEA launches net-zero pathway.*

[7] Throughout this report, we use the term 'decarbonise' as shorthand for decreasing all greenhouse gases.

[8] Intergovernmental Panel on Climate Change (IPCC). (2021). Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001. https://www.ipcc.ch/report/ar6/wg1/; Trout, K., Muttitt, G., Lafleur, D., Van de Graaf, T., Mendelevitch, R., Mei L., & Meinshausen, M. (2022). Existing fossil fuel extraction would warm the world beyond 1.5 °C. *Environmental Research Letters.* 17(6):064010. https://www.researchgate.net/publication/360657215

[9] Europe Beyond Coal. (n.d.). *European coal plant countdown coal exit timeline.* https://beyond-coal.eu/coal-exit-timeline

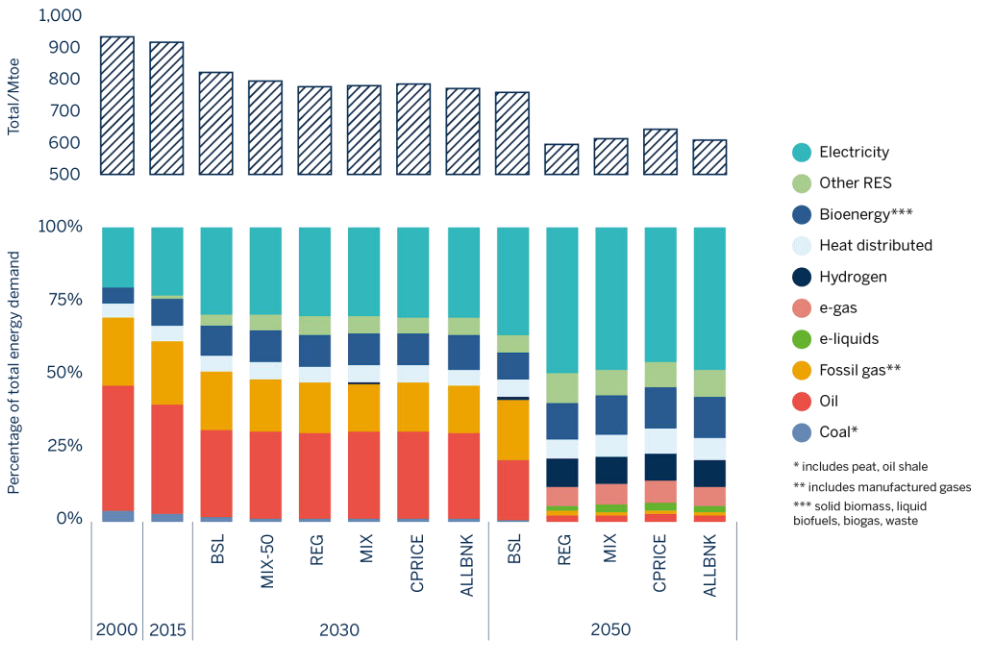
[10] The different kinds of gas that can provide energy services include methane, propane, butane, hydrogen and other heavier gases. Each of these gases can come from different sources or methods of creation. For the past several decades, methane extracted from the ground has been typically referred to as 'natural gas' in many contexts. We find the term 'fossil methane' more accurate and illuminating. Throughout this paper, we use the term 'fossil methane' where appropriate, or more generally 'fossil gas' for gases that are extracted from the ground or otherwise derived from another fossil fuel. When these gases are combusted, greenhouse gas emissions (primarily carbon dioxide) are a byproduct, as well as nitrogen oxides, carbon monoxide, formaldehyde and particulate matter, all of which can be hazardous to human health. Methane itself is also a potent greenhouse gas, and any percentage of methane that is not combusted – either as leakage through pipes or incomplete combustion – contributes to greenhouse gas emissions.

[11] International Energy Agency (IEA). (2021). *Net zero by 2050: A roadmap for the global energy sector*. https://www.iea.org/reports/net-zero-by-2050

[12] Gaventa, J., & Pastukhova, M. (2021, 8 May). Gas under pressure as IEA launches net-zero pathway. *Energy Monitor.* https://www.energymonitor.ai/policy/net-zero-policy/gas-under-pressure-as-iea-launches-net-zero-pathway

Currently in the European Union (EU), 300 million tonnes of oil equivalent (Mtoe) (350-400 bcm) of gaseous fuels are consumed every year, making up around 25% of total EU energy consumption.[13] Fossil gas constitutes 95% of these gaseous fuels.[14] To meet climate goals, fossil gas usage is expected to decline by 66%-71% by 2050, compared to usage in 2015.[15] Modelling undertaken by the European Commission, represented in Figure 3, similarly forecasts that energy efficiency, electricity and alternative gases will almost entirely replace current fossil gas usage.[16, 17]

Figure 3. Final energy demand by energy carrier



European Commission. (2020, 17 September). *Impact Assessment: Stepping up Europe's 2030 climate ambition.*

[13] European Commission. (2020a, 17 September). Commission staff working document: Impact Assessment accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Stepping up Europe's 2030 climate ambition, investing in a climate-neutral future for the benefit of our people, part 1, p. 56; part 2, p. 50. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020SC0176; European Commission. (2021c, 15 December). Commission staff working document: Impact assessment report accompanying the proposal for a Directive of the European Parliament and of the Council on common rules for the internal markets in renewable and natural gases and in hydrogen (recast), Impact assessment report accompanying the proposal for a Regulation of the European Parliament and of the Council on the internal markets for renewable and natural gases and for hydrogen (recast). https://energy.ec.europa.eu/topics/markets-and-consumers/market-legislation/hydrogen-and-decarbonised-gas-market-package_en#documents; European Commission, 2021a.

[14] European Commission, 2020a; European Commission, 2021c; European Commission, 2021a.

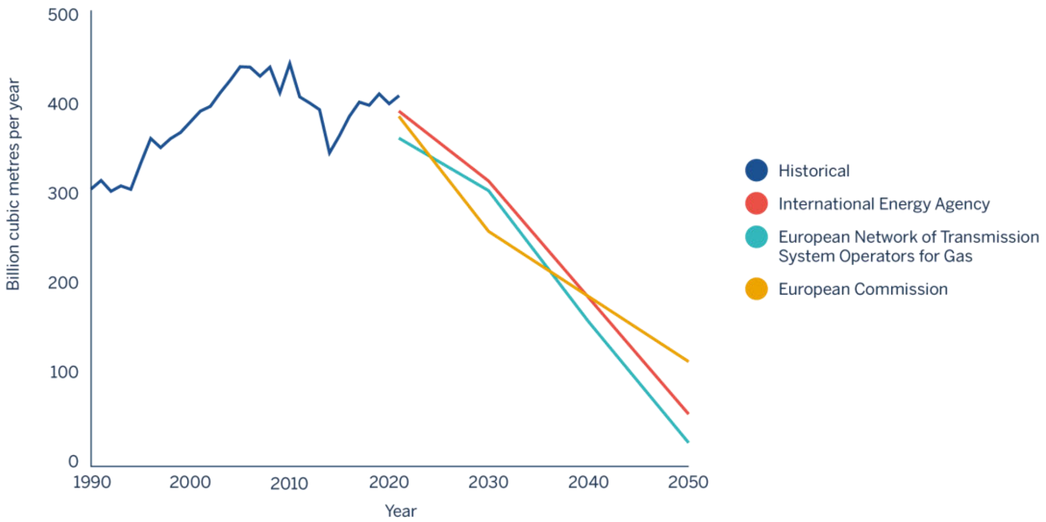
[15] European Commission. (2020, 15 December). Questions and answers: The revision of the TEN-E Regulation. https://ec.europa.eu/commission/presscorner/detail/en/QANDA_20_2393; European Commission, 2020a.

[16] European Commission, 2020a; European Commission, 2021c.

[17] The scenarios are defined as follows: BSL = baseline, achieves existing EU 2030 targets for GHG, renewables and energy efficiency; MIX-50 = increased ambition, achieves at least 50% GHG reductions, combines expanding carbon pricing with increasing the ambition of energy and transport policies; REG = regulatory-based measures that achieve around 55% GHG reductions with high increases in ambition for energy efficiency, renewables and transport policies, but retains scope of EU Emissions Trading System; MIX = a combination of REG and CPRICE that achieves around 55% GHG reductions; CPRICE = carbon-pricing scenario aimed at 55% GHG reductions through strengthened, expanded carbon pricing, while not increasing energy efficiency or renewables policies; ALLBNK = most ambitious GHG reducing scenario, based on MIX, with stronger fuel mandates for aviation and maritime sectors. European Commission, 2020a, pp. 43-44.

Other modelling suggests that a more accelerated phaseout is needed. As Figure 4 below demonstrates, the EU's 2035 target represents a steep decrease in fossil gas use, but it then levels out. Analyses by the IEA and the European Network of Transmission System Operators for Gas (ENTSO-G) show slightly later decreases, but those reductions are deeper and more sustained.[18]

Figure 4. Historical consumption and future scenarios for EU-27 fossil gas



Source: Inman, M., Langenbrunner, B., & Zimmerman, S. (2022). *Europe gas tracker report 2022.*

Although modelling shows that alternative gases[19] may remain in the system, unabated fossil gas must be phased out of the power sector by 2035 and out of industry and buildings by 2040.[20] How fossil gas will be replaced will vary by sector. As is shown in Figure 5 below, for example, fossil gas in the buildings sector will be replaced largely by energy efficiency and electrification.[21] Alternative gases will play a role in system decarbonisation, but their role will be very different to that of gas today.

> "In the new reality, the EU's gas consumption will reduce at a faster pace, limiting the role of gas as a transitional fuel." ~ European Commission

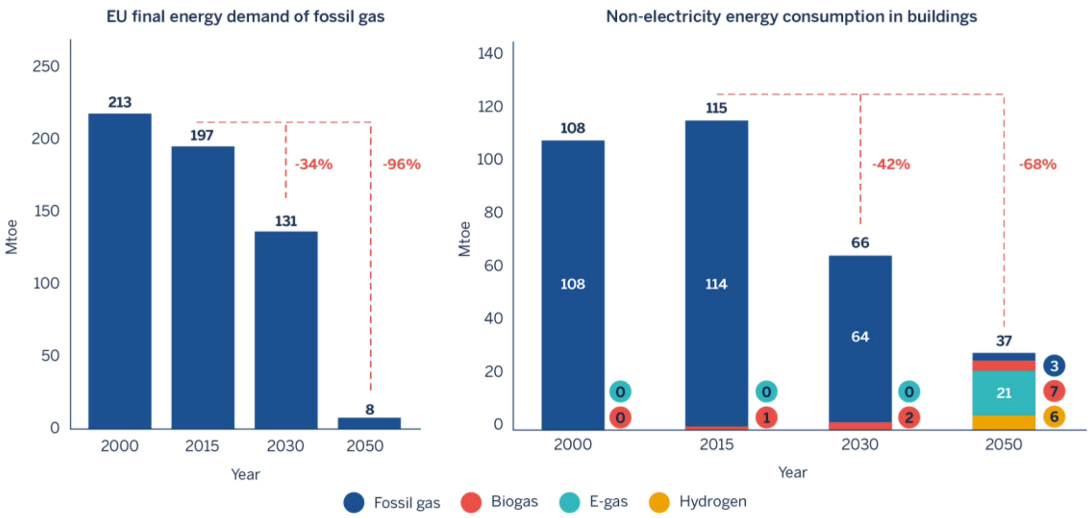
[18] Aitken, G., Langenbrunner, B., & Zimmerman, S. (2022). *Europe Gas Tracker Report 2022*. Global Energy Monitor. https://globalenergymonitor.org/report/europe-gas-tracker-2022

[19] This report uses the term 'alternative gases' as a reference for gaseous fuels other than fossil gas itself, such as green hydrogen, blue hydrogen (made from fossil fuels, but not itself fossil gas) and biofuels.

[20] Buck, M. & Dusolt, A. (2021). *Preparing the necessary phase-out of fossil gas in Europe – Benchmarks and recommendations for the Fit for 55 package* [Presentation]. Agora Energiewende. https://www.agora-energiewende.de/en/publications/preparing-the-necessary-phase-out-of-fossil-gas-in-europe

[21] Flis, G., & Deutsch, M. (2021). *12 Insights on hydrogen*. Agora Energiewende. https://www.agora-energiewende.de/en/publications/12-insights-on-hydrogen-publication

Figure 5. Total consumption of gases and gases in buildings in European Commission's MIX scenario



Source: Flis, G., & Deutsch, M. (2021). *12 insights on hydrogen.*

Russia's invasion of Ukraine has amplified the need for an accelerated transition away from fossil gas. With its REPowerEU strategy, the Commission recognises that it is the clean energy transition that will allow for reduced dependence on Russian fossil fuels.[22] REPowerEU sets out a plan to fast-forward the transition to a clean energy system, building on its Fit for 55 proposals by frontloading the deployment of energy efficiency, renewable energy and electrification.[23] Analysis by RAP and others shows that, by 2025, Russian gas imports could be reduced by two-thirds with clean energy, electrification and energy efficiency — without additional gas import infrastructure.[24] As the Commission itself has noted, "In the new reality, the EU's gas consumption will reduce at a faster pace, limiting the role of gas as a transitional fuel."

In addition to the overarching risks of climate change and political instability, a greater awareness of the safety and public health risks and environmental impacts caused by fossil gases – from extraction to end uses – is raising concerns about continued reliance on these fuels. These concerns have led to greater investment in clean alternatives, and advances in technology and system integration are facilitating an overall shift towards more sustainable solutions. Options are now available that result in fewer carbon emissions and more efficiently and effectively meet consumer end uses, including energy efficiency, end-use electrification and low- and zero-emission gaseous fuels to serve hard-to-electrify sectors. For example:

- Energy efficiency measures such as building envelope insulation and deep building renovations reduce total energy demand, allowing for efficient

[22] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, REPowerEU Plan, p. 1. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483; European Commission (2022b, 18 May). *REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition* [Press release]. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131.

[23] European Commission, 2022a.

[24] Brown et al., 2022.

transitions away from gas-powered end-use equipment, such as heating and home appliances.

- Electric end-use equipment is declining in price, increasing in efficiency and improving in quality. Electric appliances, especially those equipped with grid-connected technology, can also provide valuable flexibility benefits to the power system, including demand-side flexibility, storage and ancillary services.[25]
- Alternative gases, such as 'green' or carbon-free hydrogen and biogases that have lower GHG impacts, will be needed even in a decarbonised system for hard-to-electrify sectors, such as certain industries, shipping and aviation. Given that these gases currently face significant hurdles of supply and infrastructure, and questions about whether they meet environmental, health and safety concerns, their contribution to meeting climate goals remains limited.

As the need and the possibilities for transitioning away from fossil gas are increasing, the reality of implementing this seismic shift looms large among the barriers to decarbonisation. The gas system consists of a network of infrastructure, serving end uses from power generation to residential cooking. This infrastructure criss-crosses Europe's land and seas with over 130,000 kilometres of gas transmission pipelines – a distance of more than three times the circumference of the Earth – and around 1,800,000 kilometres of distribution pipeline, equivalent to about two-and-a-half trips to the moon and back.[26] Also entrenched are the numerous entities tasked with delivering fossil gas to consumers. As Europe powers end uses in new ways, regulators are faced with the challenges of repurposing and decommissioning a system, one that may not even be fully depreciated, and addressing system operators that may resist a transition.

This transition away from gas poses several combined challenges for policymakers, regulators and other stakeholders:

- Breaking the inertia of 'business as usual.' Meeting this challenge will require considering requests for additional gas infrastructure within the context of whether such expansion is in line with the decarbonised system set out in EU policy.[27] On the transmission side alone, additional gas pipelines already under construction in the EU will cost around €18 billion and will increase import capacity although there is an urgent need to reduce the size of the system (see

[25] Electric hot water heaters provide a good example of the value that can be offered to the grid. Not only can aggregated hot water heaters provide demand-side flexibility and storage, but they can also be controlled to follow and respond to frequency regulation signals. Yule-Bennett, S., & Sunderland, L. (2022). *The joy of flex: Embracing household demand-side flexibility as a power system resource for Europe.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/joy-flex-embracing-household-demand-side-flexibility-power-system-resource-europe; Tennbak, B., Ryssdal, M., Fiksen, K., Ådnanes, O.-K., Christiansen, C.-H., & Rode, W. (2021). *Value of flexibility from electrical storage water heaters.* Thema Consulting Group AS, Danish Technological Institute, NVE. https://nemitek.no/nve-rapport-varmtvannsberedere-viktige-for-framtidens-kraftsystem/144193

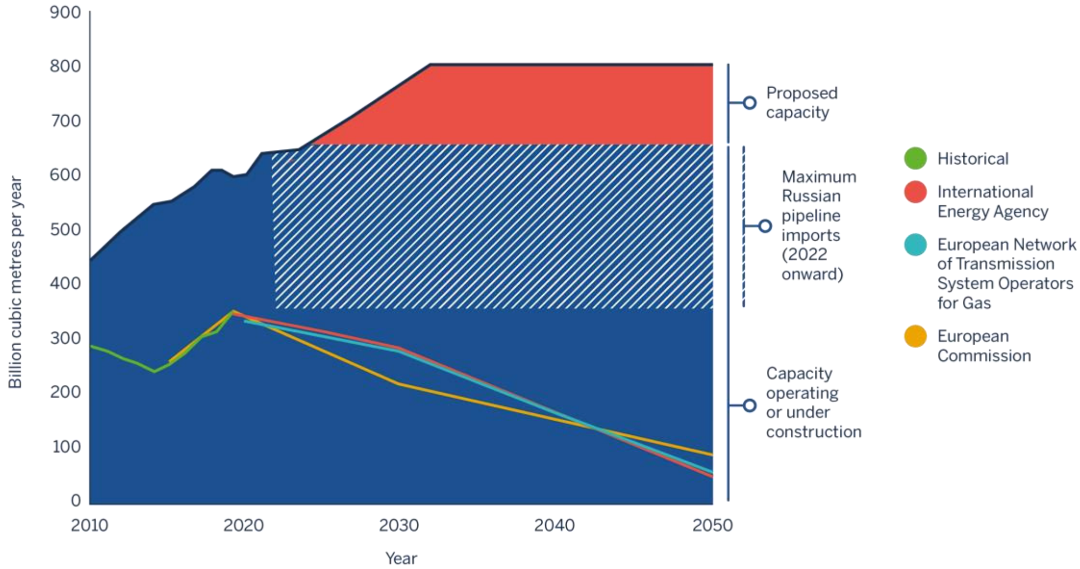
[26] Council of European Energy Regulators (CEER). (2018, 26 July). *CEER benchmarking report 6.1 on the continuity of electricity and gas supply (data update 2015/2016).* https://www.ceer.eu/documents/104400/-/-/963153e6-2f42-78eb-22a4-06f1552dd34c; see also European Network of Transmission System Operators for Gas (ENTSO-G). (2021). *The European Gas Network 2021* [map]. https://www.entsog.eu/sites/default/files/2021-11/ENTSOG_CAP_2021_A0_1189x841_FULL_066_FLAT.pdf

[27] See, for example Soraghan, M. (2021, 6 July). Natural gas surge may scuttle IEA net-zero plan. *EnergyWire.* https://subscriber.politicopro.com/article/eenews/1063736487; International Energy Agency (IEA). (2021). *Gas market report Q3-2021, including Gas 2021 – Analysis and forecast to 2024.* https://iea.blob.core.windows.net/assets/4fee1942-b380-43f8-bd86-671a742db18e/GasMarketReportQ32021_includingGas2021Analysisandforecastto2024.pdf

Figure 6 below).[28] A similar situation exists on the distribution side, where continued and planned investment into distribution pipelines does not match the anticipated needs of a decarbonised system.[29] As a consequence, further investment in infrastructure will result in stranded assets, the allocation of which will have to be addressed.

- Developing policies that redesign infrastructure and markets to meet end-use needs in a manner consistent with carbon targets.
- Addressing the ramifications of these changes, including future decommissioning of infrastructure that is no longer needed and changes to the business models of gas retailers and system operators.

Figure 6. EU-27 gas net imports and net import capacity



Source: Inman, M., Langenbrunner, B., & Zimmerman, S. (2022). *Europe gas tracker report 2022.*

Two broad objectives can guide action for decision-makers, as they address these challenges and determine how to meet consumer end uses in a decarbonising and decarbonised system most efficiently, effectively and equitably:

- Prioritise solutions that maximise emission reductions to accelerate progress towards climate targets.
- Aim for system decarbonisation, not gas decarbonisation.

[28] The EU has had substantial overcapacity for gas imports via pipelines and liquified natural gas terminals, and projects under construction and proposed would raise import capacity further. Even if pipeline import capacity from Russia (lined area) were not available, the bloc's net import capacity would remain in excess of demand under IEA, ENTSO-G and EU scenarios for net-zero emissions by 2050. Aitken et al., 2022, p. 4. For assumptions and sources, see Figure 3 on p. 8. Data and analysis for this figure are described further in online methodology.

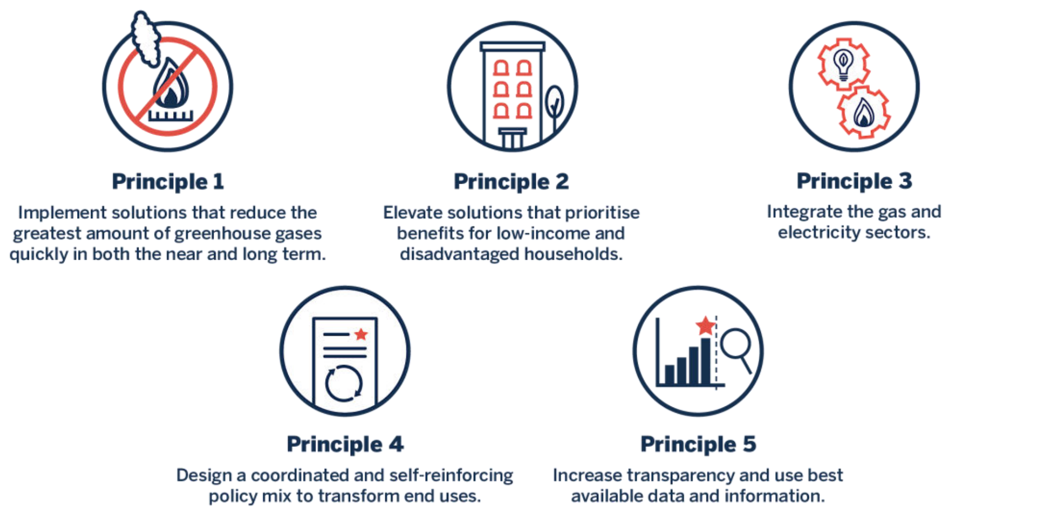
[29] Jahn, A., & Saerbeck, B. (2021). Worüber keiner reden will: Der bevorstehende Abschied vom Gasnetz [What no one wants to talk about: Saying goodbye to the gas network]. *Tagesspiegel Background*. https://background.tagesspiegel.de/energie-klima/worueber-keiner-reden-will-der-bevorstehende-abschied-vom-gasnetz; Anderson, M., Rosenow, J., Bürger, V., & Braungardt, S. (2022). *Fossil gas infrastructure first, energy efficiency never?* https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2022/3-policy-finance-and-governance; Artelys. (2022). *Does phasing-out Russian gas require new gas infrastructure?* https://www.artelys.com/wp-content/uploads/2022/05/Artelys-Russian-gas-phase-out-Briefing-note.pdf

Adherence to these broad objectives will ensure focus on the ultimate goals within the transition away from fossil gas. This report refines these broad objectives into principles decision-makers can use to implement next steps. We set out each of these principles, with examples of how the principle could guide improved policy in the Hydrogen and Decarbonised Gas Market package (the 'gas package'), and in EU and Member State Hydrogen Strategies ('hydrogen strategies').

Guiding principles for a transition away from fossil gas

The principles outlined below create a path to immediate and significant carbon reductions and craft a sustainable approach to developing least-risk, equitable and comprehensive solutions. These principles are interrelated and mutually reinforcing; as such, they will be most effective when implemented together. The first principle outlines the parallel needs to reduce GHG emissions by as much and as quickly as possible, and to build a system that can sustain and grow emission reductions in the long term. The second principle highlights the fact that low-income, energy-poor and vulnerable households need to come first in this energy transition. Solutions that prioritise these households and communities and ensure that they are not the last ones left dependent on an increasingly expensive gas system must be an integral part of any solution set to address a transition away from gas. The third principle discusses the need to integrate the gas and electricity sectors, not just in name but through concrete actions that facilitate access to solutions across sectors. The fourth principle recognises that not only is a mix of policies needed to achieve an efficient transition away from gas, but that mix needs to be coordinated and self-reinforcing to enable success. The fifth policy highlights the generally recognised but often overlooked need for transparency and the best available information to be built into the system to ensure well-informed decision-making. Together, these principles can guide decision-making to arrive at an efficient, equitable and decarbonised energy system.

Figure 1. Principles for a transition away from fossil gas



Principle 1: Implement solution sets that will reduce the greatest amount of greenhouse gases as quickly as possible in both the near and long term.

Keeping two goals in mind can help policymakers develop effective solutions for a gas transition. First, develop solution sets – that is to say a combination of integrated solutions across demand, supply and energy sectors – that will reduce GHGs as much as possible, at as rapid a rate as possible. Second, construct a sustainable system for further reductions, avoiding dead ends that may ultimately result in limited GHG reductions. Achieving GHG reductions within necessary timeframes requires adherence to both parts of this principle. Failure to take a hard look at overall reductions may result in solutions that reduce GHGs in one area but increase emissions in another. Similarly, jumping to solutions that give short-term GHG reductions, without considering how they may fare in the long term, risks not only inadequate GHG reductions, but also unnecessary costs for consumers in the form of stranded assets or unwise investment in technology not fit for purpose.

A focus on system decarbonisation will facilitate the development of solution sets that meet the twin goals of reducing GHGs swiftly while building a system for continuing reductions. Making decisions in one part of the system, without considering how that piece will fit within a larger strategy, may lead to the development of numerous small-scale solutions that do not ultimately work together. System decarbonisation is also needed to ensure that solutions are building a framework for sustained carbon reductions for the system as a whole. With limited resources and a short timeframe in which to achieve necessary GHG reductions, the opportunity cost of investment in a solution that results in carbon reductions for the next few years, but which does not lead to further reductions, is too high. Decision-makers will want the ability to quickly pivot when outcomes fail to deliver.

The five guiding principles create a path to immediate and significant carbon reductions and craft a sustainable approach to developing least-risk, equitable and comprehensive solutions.

At a high level, the European Commission has developed a solution set that provides a framework to meet these goals: first, develop a more circular energy system with energy efficiency at its core; second, electrify a greater share of end uses; and, finally, use renewable or low-carbon fuels for hard-to-electrify applications.[30] By prioritising energy efficiency, which can be implemented immediately and results in carbon savings in the short and long term, the strategy ensures that available, no-regrets, flexible solutions are implemented first. The emphasis on electrification next similarly recognises the potential for reducing consumption – one-third of primary energy consumption – derived from the inherent efficiency of electrical end-use technologies.[31] An increasingly decarbonised power sector compounds these carbon savings. Finally, the strategy allows for the use of renewable or low-carbon fuels where

[30] European Commission. (2020b). Communication From the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Powering a climate-neutral economy: An EU strategy for energy system integration. https://ec.europa.eu/energy/sites/ener/files/energy_system_integration_strategy_.pdf

[31] European Commission, 2020b.

other solutions are not yet feasible, thus providing an alternative pathway for GHG reductions. Overall, and importantly, the focus on energy system integration recognises the necessary shift from a supply-based approach to meeting energy needs to one that coordinates different opportunities to satisfy end uses in a flexible and responsive energy system.

Although the general framework is clear, incorporating Principle 1 into decision-making can raise thorny questions. Before they can implement the principle, decision-makers may realise that they lack adequate data and independent analysis about different options to achieve carbon reductions. They may also confront questions about whether advances in technology will offer new solutions, thus raising further questions of how to plan for those options. Later principles discussed in this report provide recommendations for how to address the situation of data access and increased planning and modelling requirements. The importance of this first principle lies in its focus on designing the best solutions possible, based on existing information, to build a system that can achieve swift, substantial and sustainable emissions reductions over time.

The Commission's recently released gas package and the Commission's and Member States' hydrogen strategies illustrate these challenges, along with opportunities to design solutions even during a time of uncertainty. The next section will use these examples to illustrate how adherence to this first principle can guide effective and sustainable system design.

Revise the gas package for a declining gas future and reduced greenhouse gas emissions

The Commission's gas package sets out an amended directive and regulation regarding the design and function of the internal gas market and access to gas transmission networks. The gas package is part of the EU's Fit for 55 package – the Commission's suite of legislation intended to put the EU on track to achieve its climate targets of a 55% reduction in GHG emissions by 2030, and net-zero emissions by 2050.

Inclusion of a gas package within the Fit for 55 legislation illustrates the inherent challenges in revising gas markets in line with decarbonisation goals. First, unabated fossil gas must be largely phased out of a decarbonised energy system, which raises the question of how rules aimed at perpetuating the current gas market can be reconciled with that goal. Second, the gaseous fuels that remain in the system will serve different end uses than those in the current system. The starkest example is the almost complete phaseout of gaseous fuels in the buildings sector. In short, in contrast to the gas package's characterisation of alternative fuels 'replacing'[32] fossil gas – the notion of merely decarbonising the gas that is running through the same pipes – the gas package could best foster the energy transition by confronting and addressing the changing role of gas overall.

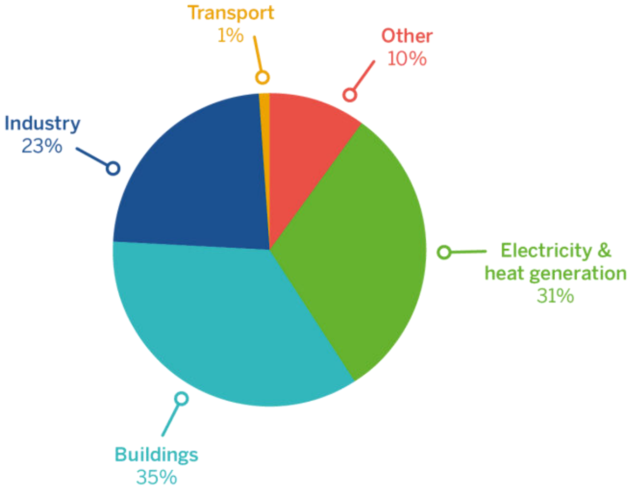
[32] European Commission, 2020a; European Commission, 2021c.

Adherence to Principle 1 requires a gas package design that enables equitable solutions that reduce carbon emissions as far and as quickly as possible, while also allowing for further sustained carbon reductions in future. For decision-makers to meet these goals, it is important that a significantly diminished future role for fossil gas is anticipated. As noted in the Energy System Integration Strategy, and the gas package itself, gas usage should be limited to “the use of renewable and low-carbon fuels, including hydrogen, for end-use applications where direct heating or electrification are not feasible, not efficient, or have higher costs.”[33] The strategy thus anticipates gas as a solution of last resort, coming in only where other solutions do not fit.

Modelling of solutions to meet carbon targets reveals that the use of fossil gas will need to decrease by at least two-thirds by 2050 from 2015 levels.[34] In certain sectors, the required decreases will be even greater: the buildings sector currently accounts for 36% of the EU’s fossil gas demand, but EU policy requires decarbonisation by 2050.[35] Additionally, energy efficiency and electrification will change how we meet many end uses merely because the economics and efficiency of those solutions will crowd out gaseous solutions.[36]

Alternative gases will play a role, but they will be used for very different end uses than those gas serves today. Figure 7[37] shows the breakdown of fossil gas demand in 2020, and Figure 8[38] the projected demand of hydrogen for those same end uses in 2050.

Figure 7. 2020 Gas consumption by sector



Source: Bellona Europa, Ember, Regulatory Assistance Project, E3G. (2022). *EU can stop Russian gas imports by 2025.*

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[33] European Commission, 2020b; European Commission, 2021a.

[34] See Figure 4 above. European Commission. (2020, 15 December). Questions and Answers: The revision of the TEN-E Regulation. https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_2393

[35] European Commission. (2021d). Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0802&qid=1641802763889; European Commission, 2021c, p. 18.

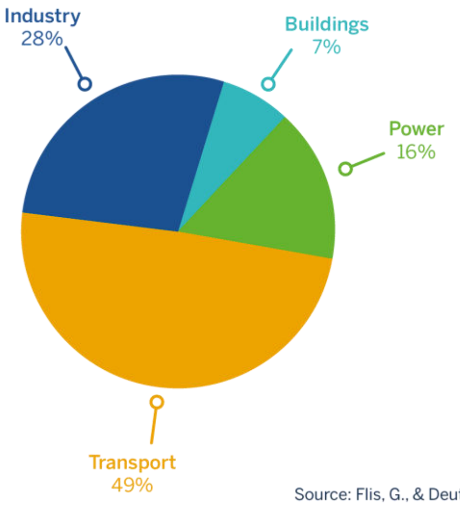
[36] European Commission, 2021a; European Commission, 2021b.

[37] Brown et al., 2022.

[38] Flis & Deutsch, 2021.

Whereas over a third of fossil gas consumption currently serves the buildings sector, hydrogen is expected to meet less than 7% of total buildings sector demand by 2050, with some models eschewing all use of hydrogen in buildings. By contrast, hydrogen is expected to play a major role in meeting transport needs – in particular for long-haul shipping and aviation – amounting to 50% of the demand expected for transport, compared to fossil gas' current role in meeting only 1%. Hydrogen will have a smaller role in the power and industrial sectors.

Figure 8. Hydrogen demand net-zero scenarios for 2050 (for EU27 + UK)



Source: Flis, G., & Deutsch, M. (2021). *12 insights on hydrogen*.

As these graphs demonstrate, the transition from fossil gas to alternative fuels such as hydrogen will not be a one-for-one switch. As a result, fuel sources, production, infrastructure and market structures will also need to change. The infrastructure needed to serve long-haul shipping and aviation with hydrogen, for example, will be very different to the pipelines that send fossil gas to meet residential heating needs today.

Developing policy that anticipates a declining gas system, particularly in certain sectors, is consistent with meeting EU carbon targets.[39] Other policies reflect the needed changes: the Energy Efficiency Directive anticipates a 60% reduction in carbon emissions from buildings by 2030; while the Energy Performance of Buildings Directive further requires that new buildings meet a zero-emissions standard by 2027 for public buildings, and by 2030 for all buildings. The existing building stock will be subject to minimum energy performance standards; the policies necessitate improvements that will reduce gas usage. These policy changes recognise the need for shifts in gas usage and will have direct impacts on the quality and location of gas demand. The new REPowerEU policy recommendations foresee reducing dependence on gas even more quickly.[40] Policymakers now face the challenge of designing a gas

[39] See, for example, International Energy Agency (IEA). (2022). *A 10-point plan to reduce the European Union's reliance on Russian natural gas, Fuel report.* https://www.iea.org/reports/a-10-point-plan-to-reduce-the-european-unions-reliance-on-russian-natural-gas

[40] European Commission. (2022c, 8 March). Communication from the Commission to the European Parliament, the European Council, The Council, The European Economic and Social Committee and the Committee of the Regions. REPowerEU: Joint European Action for more affordable, secure and sustainable energy. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A108%3AFIN

package that addresses these shifts, including integrating any remaining role for gas into a broader set of solutions to meet end uses.

Despite parallel policy requiring fundamental shifts in the way we meet end uses, the current gas package proposal silos the discussion of gas into one that largely addresses how current usage can be decarbonised. The package notes that projections anticipate total gas consumption will decrease only slightly, from 22% of total EU energy consumption to 20% in 2050, and then concludes that what is therefore required is "an ambitious transition of the gas sector towards low-carbon and renewable gases."[41] By framing the problem as one of gas decarbonisation, instead of system decarbonisation, the package fails to account for the fact that anticipated shifts in the end uses served, as illustrated above, will result in a very different landscape for gas policy. As a consequence, the proposed gas package sends convoluted signals rather than setting a clear direction on how to meet climate targets, with the resulting policy allowing for the perpetuation of a gas system that may not serve stated decarbonisation goals.

First, the gas package does not address head-on the changes needed to move away from our current usage of gas across numerous sectors and in dispersed end uses, to a system in which many end uses are electrified and alternative gases are used only as a solution for hard-to-electrify sectors. By focusing first on decarbonising gas to meet end uses, rather than considering what options exist for reducing carbon emissions from end uses more broadly, policymakers will miss opportunities to develop equitable solution sets that reduce carbon emissions sooner and more sustainably.

Energy efficiency and deep retrofits, for example, can reduce the amount of gas used in buildings as soon as those changes are made. These solutions benefit residents of those buildings immediately, and thus can be targeted at low-income, energy-poor and vulnerable households. Furthermore, the tools needed for those changes are presently available and, with proper policy direction, could be ramped up immediately to reduce a large portion of the EU's emissions. By contrast, decarbonised gases are not currently available to meet these end uses at scale, nor is it certain they will be within the timeframe needed, as is discussed in more detail below. To the extent they are available, the gas package itself, and the Commission's Energy System Integration Strategy, recognise that their highest use will be in hard-to-electrify sectors. In short, if the package were designed to reduce GHGs as much and as quickly as possible, it would consider the roadmap provided by the Energy System Integration Strategy, and prioritise rules that focus on facilitating gas delivery to those hard-to-electrify end uses. The gas package's emphasis on decarbonising gases, instead of decarbonising the system, thus fails to consider the urgency of carbon reductions, and does not look ahead to a system that can sustain future carbon reductions.

Developing policy that anticipates a declining gas system is consistent with meeting EU carbon targets.

The gas package's prioritisation of increasing competition between gas providers similarly sends confusing messages. On the one hand, with the Energy System Integration Strategy, the Energy Efficiency Directive, the Energy Performance of Buildings Directive, and even within problem area descriptions in the gas package

[41] European Commission, 2021a; European Commission, 2021b.

itself, the Commission sets out the need to electrify residential heating through the use of heat pumps or district heating. But despite that apparent consensus, the gas package includes several provisions aimed at increasing the share of alternative gases for residential end-use consumers.

The gas package includes, for example, provisions to increase competition and engagement for consumers in the alternative gas market, including prioritising the distribution of smart gas meters and promoting the idea of energy communities to facilitate the use of alternative gases in the current gas system.[42] The stated intent of these provisions is to increase competition for consumers, similar to the changes made to guarantee adequate retail competition on the power side. Mimicking the power sector in this regard, however, is not appropriate. To meet EU carbon targets and to comply with other EU policy as noted, consumers need to understand the economics of moving from, for example, a gas boiler to an electric heat pump. Requiring regulators to focus time and resources to ensure competition between gas suppliers sends the inaccurate message that consumers will continue to rely on gaseous fuels to meet end uses, a message which may lead consumers to improve or replace gas appliances, rather than switching to more efficient electric alternatives. These outcomes would be especially problematic for low-income, energy-poor and vulnerable customers who may themselves invest or be in a home where the landlord invests in new gas appliances, only to find gas prices increasing.

Including these goals in the package sends a signal that consumers will continue to rely on gaseous fuels, despite the Commission's own recognition that gas will not be used to meet end uses like residential heating. In doing so, the gas package shifts emphasis to solutions that may not reduce carbon emissions quickly, and directs investment towards options that are unlikely to be lasting solutions.

Taking into consideration our first principle – to consider how to reduce carbon emissions as much and as quickly as possible, and avoid dead-end paths that will result in only limited emissions reductions – the gas package could instead consider the role of gas within an integrated energy system. A gas package following such an approach would consider where gaseous fuels fit in a decarbonised system and facilitate their incorporation accordingly. At the same time, it would consider where gas is not expected to play a significant role and ensure that incentives for its usage in those areas were eliminated so that those carbon emissions could be reduced as quickly as possible. In this manner, the gas package could develop solutions to accelerate recognised areas for emissions reductions, and move the gas system towards one that could sustain emissions reductions with solutions that are certain to reduce carbon over a longer time frame. Ultimately, these issues indicate that a revised gas package may not be the best tool to address the challenges of building a decarbonised system, and that an energy system package would be a better fit.

Use hydrogen strategies to address the role of hydrogen, not as fossil gas replacement plans

The first principle of reducing GHG emissions as much and as quickly as possible can also guide EU and Member State hydrogen strategies. Hydrogen has received

[42] European Commission, 2021a; European Commission, 2021b.

significant attention as a possible low- or zero-carbon fuel[43] that can assist in decarbonising the energy system by serving hard-to-electrify end uses such as energy-intensive industry and certain heavy-duty transport sectors.[44] Ensuring that hydrogen strategies retain a focus on making hydrogen available to meet end uses that are more complicated or costly to electrify or abate is critical. By contrast, the development of strategies that expand the role of hydrogen to areas where other solutions could deliver more immediate and sustainable GHG reductions risks misplaced investment and consequent delays in emissions reductions.

Currently, hydrogen is produced worldwide almost entirely from unabated natural gas and coal, with carbon dioxide emissions from its production per year equalling the total amount of carbon dioxide produced annually by Indonesia and the United Kingdom combined.[45] Less than 0.1% of hydrogen is produced using water electrolysis, and less than 0.7% comes from renewable energy or from fossil fuel plants equipped with carbon capture and sequestration technology.[46] Furthermore, the facilities using fossil fuels and carbon capture are only able to address about 78.8% of hydrogen production emissions, with over 20% being released into the atmosphere.[47] These hydrogen production emissions are in addition to the significant emissions released during the production and transport of the fossil fuels to the production plants.[48] Recent studies demonstrate that producing hydrogen from fossil gas, even with carbon capture and sequestration, may not decrease GHG emissions overall.[49]

Because hydrogen is only an energy carrier, and not a primary source of energy itself, any strategy relying on hydrogen will first need to determine how it can be produced in a manner that results in an overall reduction of GHGs. As can be seen from Figure 9 below, different kinds of hydrogen are not yet widely available, with renewable hydrogen – hydrogen produced through water electrolysis using electricity from renewable energy sources – barely showing up at all.[50] Moreover, because almost all of

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[43] At a general level, green or renewable hydrogen is hydrogen produced through electrolysis of water molecules using clean energy sources. Blue hydrogen, sometimes referred to as low-carbon hydrogen, is hydrogen produced from fossil fuels using a thermal process such as steam methane reformation that has associated carbon capture facilities. Pink hydrogen is similarly produced using nuclear as the energy source. Grey hydrogen is produced from fossil fuels using a thermal process such as steam methane reformation without any carbon capture processes. Whether hydrogen can be called renewable or low-carbon requires further definition, however, as hydrogen produced through electrolysis, but with electricity from a grid which may not be entirely clean, may or may not qualify as renewable hydrogen depending on how this is defined. Similarly, it is unclear whether hydrogen produced with fossil fuels but with associated carbon capture facilities can qualify as low-carbon hydrogen if the carbon capture facilities are not in fact significantly reducing GHG emissions as compared to grey hydrogen, for example. These definitions are currently being addressed in EU policy files and are critical to ensuring that the solutions addressed are in fact achieving expected GHG reductions. For example, the EU hydrogen strategy defines low-carbon as "fossil-based hydrogen with carbon capture and electricity-based hydrogen, with significantly reduced full life-cycle greenhouse gas emissions compared to existing hydrogen production," but does not define "significantly reduced." European Commission. (2020c, 8 July). Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions. A hydrogen strategy for a climate-neutral Europe. https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf, p. 4. The gas package states that low-carbon hydrogen must have a GHG reduction threshold of 70%, but further detail remains to be determined in a delegated act. European Commission, 2021b, Directive, Article 1(10).

[44] European Commission, 2021a; European Commission, 2021b; European Commission, 2021c.

[45] International Energy Agency (IEA). (2019). *The future of hydrogen: Seizing today's opportunities*. https://www.iea.org/reports/the-future-of-hydrogen

[46] International Energy Agency (IEA). (2019).; *One Earth*, volume 4, Rosenow, J., & Lowes, R. Will blue hydrogen lock us into fossil fuels forever? pp. 1527-1529, copyright Elsevier. (2021). https://www.sciencedirect.com/science/article/abs/pii/S2590332221006047

[47] Rosenow & Lowes, 2021.

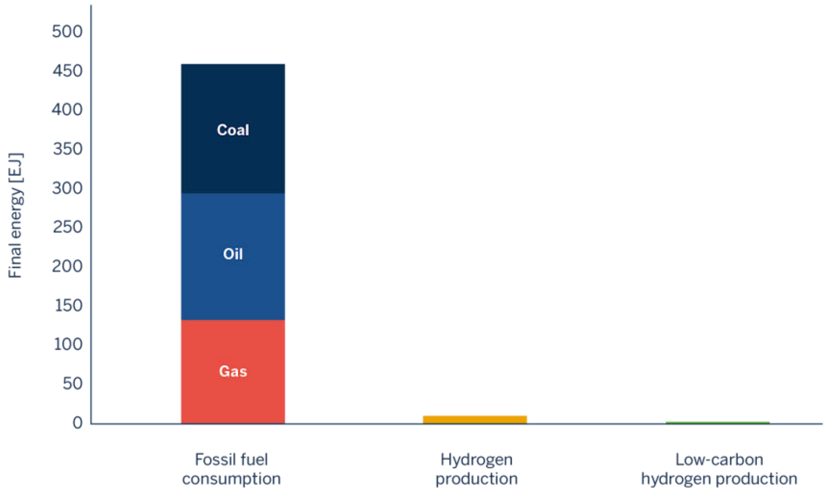
[48] The International Council on Clean Transportation (ICCT). (2021). *Life-cycle greenhouse gas emissions of biomethane and hydrogen pathways in the European Union*. https://theicct.org/publication/life-cycle-greenhouse-gas-emissions-of-biomethane-and-hydrogen-pathways-in-the-european-union; Howarth, R., & Jacobson, M. (2021). How green is blue hydrogen? *Energy Sci Eng. 2021; 00:1–12*. https://www.actu-environnement.com/media/pdf/news-38015-etude-energy-science-engineering-hydrogene-bleu.pdf

[49] The International Council on Clean Transportation (ICCT), 2021. Howarth & Jacobson, 2021.

[50] Rosenow & Lowes, 2021.

the hydrogen currently on the market is grey hydrogen, the production of which causes significant GHG emissions,[51] hydrogen is not an immediate solution.

Figure 9. Global fossil fuel consumption, hydrogen production and low-carbon hydrogen production



Source: Rosenow, J., & Lowes, R. (2021). Will blue hydrogen lock us into fossil fuels forever? *One Earth.*

Given the limited availability of hydrogen, and in particular green hydrogen, considering how to develop a hydrogen strategy that builds up hydrogen within the context in which it will be used can help decision-makers seeking to swiftly reduce GHG emissions. As discussed above, even when hydrogen is available in adequate supply, projections about how to decarbonise the energy system anticipate hydrogen and other alternative gases serving only hard-to-electrify sectors.[52] Keeping these end uses in mind is critical for planning hydrogen development, for example in decisions about where to develop electrolysers and how best to prioritise infrastructure. As renewable hydrogen needs to ramp up from essentially zero to meet numerous hard-to-electrify end uses, shifting focus away from those goals will only delay the decarbonisation of those sectors.

Conversely, diluting the focus of hydrogen to include other end uses risks crowding out other available solutions that can reduce GHG emissions pursuant to Principle 1. Building heat is an apt example: energy efficiency, district heating and electrification, in particular electric heat pumps, can meet building heating needs efficiently, effectively, and safely, while also reducing indoor air pollution.[53] If hydrogen is considered instead, it would likely delay the transition of heating equipment and in turn delay attendant emissions reductions. At the same time, the fossil gas infrastructure needed to serve those end uses would also be maintained and would likely continue to deliver fossil gas in the interim period until hydrogen becomes available, assuming sufficient supplies in the future.

Unlike the gas package, the EU and Member State hydrogen strategies largely maintain a focus on hard-to-electrify end uses. In the first phase, the EU Strategy anticipates

[51] Hydrogen Council. (2021). *Hydrogen decarbonization pathways: A life-cycle assessment.* https://hydrogencouncil.com/wp-content/uploads/2021/01/Hydrogen-Council-Report_Decarbonization-Pathways_Part-1-Lifecycle-Assessment.pdf; Howarth & Jacobson, 2021.

[52] European Commission, 2020b; European Commission, 2021a; European Commission, 2021b.

[53] International Energy Agency (IEA), 2022.

building up the needed components to integrate hydrogen, including plans to increase development of electrolysers and install at least 6 GW of renewable hydrogen electrolysers by 2024 to decarbonise existing hydrogen production. This strategy is meant to facilitate the use of hydrogen for new end uses such as industrial processes or possibly heavy-duty transport, and to lay the regulatory foundations for a hydrogen market.[54] In the second phase, from 2025-2030, the EU Strategy foresees making hydrogen "an intrinsic part of an integrated energy system." In this phase, the strategy plans for the installation of at least 40 GW of renewable hydrogen electrolysers and sees hydrogen becoming cost-competitive. The REPowerEU proposals call for an acceleration of hydrogen development, with targets of 10 million tonnes of domestic hydrogen production and up to 10 million tonnes of imported hydrogen and ammonia.[55] The EU hydrogen strategy anticipates that additional policies will be used to increase hydrogen use in new end-use applications, such as steel-making, trucks, rail and some maritime transport. It may also be used as a tool to balance a renewables-based electricity system.[56] In a third phase, from 2030 onwards to 2050, the EU strategy predicts that renewable hydrogen technologies will be deployed at a large scale, reaching all hard-to-decarbonise sectors.[57] In short, throughout its phased approach, the hydrogen strategy anticipates hydrogen as a fuel for hard-to-electrify end uses, and not as a replacement for gas where other solutions are more readily available.

Developing strategies that foresee hydrogen in areas where other solutions offer more immediate and sustainable greenhouse gas reductions clearly risks misplaced investment and delays in lowering emissions.

A risk in the hydrogen strategies is acquiescence to the use of blue hydrogen as an interim measure to build up the hydrogen market. As noted above, the use of blue hydrogen may not reduce GHG emissions[58] – and, with increases in gas prices, it may not even be a less expensive option.[59] Its use does, however, perpetuate dependence on fossil gas and the infrastructure needed to deliver that gas to hydrogen production facilities.[60] The allowance for 'low-carbon' or blue hydrogen and blending of hydrogen and fossil gas in the hydrogen strategies[61] supports investment in blue hydrogen, at the

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54 European Commission, 2020c, p. 5.

55 European Commission. (2022d, 18 May). Commission staff working document: Implementing the REPowerEU action plan: Investment needs, hydrogen accelerator and achieving the bio-methane targets. Accompanying the document Communication from the Commission to the European Parliament, the European Council, The Council, the European Economic and Social Committee and the Committee of the Regions, REPowerEU Plan. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD%3A2022%3A230%3AFIN&qid=1653033922121

56 European Commission, 2020c, p. 6.

57 European Commission, 2020c, p. 7.

58 Whether blue hydrogen can ever really be low-carbon remains a question given that present-day carbon capture and storage technology and upstream methane leakage offer only modest GHG reductions compared to fossil gas. Only in a best case, with stringent regulation around carbon-capture-and-storage capture rates and methane leakage mitigation can one achieve a low-carbon form of hydrogen. The International Council on Clean Transportation (ICCT), 2021.

59 Increases in gas prices have erased the cost advantage of blue hydrogen. Even if gas prices fall again, the price volatility of gas will continue to make blue hydrogen a risky investment. See Buck, M., Dusolt, A., Hein, F., Redl, C., Graf, A., Holl, M., Sartor, O., & Baccianti, C. (2022). *Regaining Europe's Energy Sovereignty: 15 Priority Actions for REPowerEU*. Agora Energiewende. https://www.agora-energiewende.de/en/publications/regaining-europes-energy-sovereignty/

60 Rosenow & Lowes, 2021.

61 European Commission, 2020c.

expense of using that investment elsewhere. Furthermore, the fossil fuel industry has used the opportunity of blue hydrogen discussions to assert that blue hydrogen could be used to meet end uses more broadly, including in buildings and other *easy-to-electrify* sectors. By creating an opportunity for blue hydrogen, the hydrogen strategies send an inappropriate signal that this resource has a place in a decarbonised energy system.

In sum, the hydrogen strategies start from an assumption that hydrogen is needed in a decarbonised energy system. They then consider the existing situation, in which blue and green hydrogen are largely unavailable or cost-prohibitive, and determine that significant investment is needed to develop a hydrogen market to ensure an increase in the demand and supply of hydrogen. The invasion of Ukraine, which has led to both scarcity and increases in the price of fossil gas, has refocused the discussion to the development of green hydrogen, both within the EU and through imports.[62] Taken together, the EU actions emphasise massive investment of both time and resources in the development of hydrogen, but they do so outside of considerations of how this hydrogen will fit within an integrated system. The ramp-up of hydrogen is therefore separated from discussions concerning the development of renewable energy needed to create this hydrogen, and for what and where this hydrogen is needed. This enthusiastic emphasis on hydrogen development, without consideration of need, therefore risks creating sub-optimal outcomes both in terms of cost and carbon emissions.

Principle 2: Elevate solutions that prioritise benefits for low-income and disadvantaged households.

Climate goals must be addressed in tandem with solutions to overcome the structural inequities that result in disadvantages for low-income, energy-poor and vulnerable households.[63] Past energy choices have led to, and exacerbated, unequal treatment of the people and communities least able to impact those decisions.[64] By design or negligence, energy decisions have created disparities in access to energy resources and to a healthy environment and clean energy options.

The extraction and combustion of fossil fuels often occurs in low-income and vulnerable communities, thus subjecting those areas to disproportionate pollution impacts.[65] Other policies have unduly added to the energy burden – meaning the percentage of household income spent on energy costs – for energy-poor and low-income energy users. For example, levies to promote renewable electricity have been added to electricity bills for all households, both for those who are easily able to pay and those who face high energy burdens.[66] Carbon pricing can similarly impose

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[62] See, for example, European Commission, 2022c.

[63] The Intergovernmental Panel on Climate Change's latest report highlights this need. Intergovernmental Panel on Climate Change (IPCC). (n.d.). *Climate Change 2022: Mitigation of Climate Change* [Summary for policymakers]. https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf

[64] See, for example, European Commission, 2022c.

[65] See, for example, Bankwatch Network. (2020). *Alarming levels of air pollution in settlements in coal regions are choking Central and Eastern Europe*. https://bankwatch.org/wp-content/uploads/2020/03/Air-pollution-briefing-Bankwatch-Feb2020-final.pdf?fbclid=IwAR0XXClKsnQzREV2hZQXAuM0w34CVAPH4CW4ioHBLVxSvx-QPMTD6pY1-lg; Zachová, A. (2021, 22 February). Czech coal mining regions confronted with 'hidden' energy poverty. *Euractiv*. https://www.euractiv.com/section/energy-environment/news/czech-coal-mining-regions-confronted-with-hidden-energy-poverty

[66] Rosenow, 2021; Sunderland, L., Jahn, A., Hogan, M., Rosenow, J., & Cowart, R. (2020). *Equity in the energy transition: Who pays*

disproportionate impacts on vulnerable households, especially when they are not given sufficient information or opportunities to adapt before being subjected to increased prices.[67] At the same time, renovation and clean heating incentive programmes have tended to be biased towards households who can contribute to the upfront costs, often leaving low-income households without access to support. With a better understanding of the causes and circumstances that led to this situation, decision-makers can start to identify how to address past inequities and how to avoid future harm in the transition away from fossil gas.

Gas, primarily fossil gas, currently accounts for 32% of final energy consumption in EU households, with 64% of that used for home heating.[68] Disadvantaged energy users face a disproportionately high energy burden due to low incomes, inefficient housing and, in some cases, reliance on high-cost fuels. Across the EU, between 50-125 million people experience energy poverty, or the inability to access or afford sufficient energy services to meet their needs.[69] Given the recent gas price spikes, in particular since the invasion of Ukraine, these numbers are likely an underestimation.

In addition to the impact of stress on those struggling to pay the bills to meet these basic needs, living in cold and inefficient homes has direct health impacts. Living in cold homes increases the rate of disease, especially circulatory diseases, respiratory problems and mental ill-health. Homes that are hard to keep warm or cool can lead to higher mortality rates, particularly for elderly residents more vulnerable to negative impacts.[70] At the same time, fuels used for heating and cooking, including fossil gas, coal and oil, can cause indoor air pollution that is exacerbated in poorly built and insufficiently ventilated homes.[71] The percentage of households subject to these unhealthy conditions is strongly correlated with lower incomes (see Figure 10).[72]

and who benefits? Regulatory Assistance Project. https://www.raponline.org/knowledge-center/equity-in-energy-transition-who-pays-who-benefits

67 Thomas, S., Sunderland, L., & Santini, M. (2021). *Pricing is just the icing: The role of carbon pricing in a comprehensive policy framework to decarbonise the EU buildings sector*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/pricing-just-icing-role-carbon-pricing-comprehensive-policy-framework-decarbonise-eu-buildings-sector

68 European Commission, 2021c, p. 28; See also European Commission. (2022 June). *Eurostat statistics explained: Energy consumption in households*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households

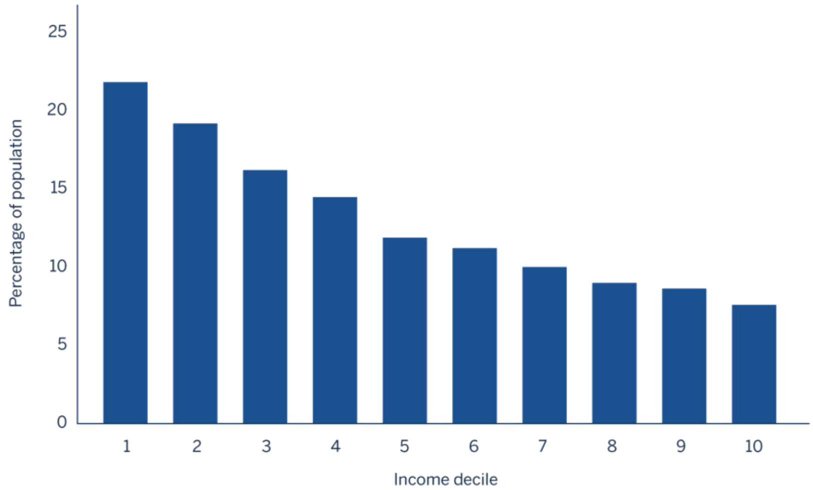
69 European Commission. (n.d.). EU buildings factsheets topics tree: energy poverty. https://ec.europa.eu/energy/eu-buildings-factsheets-topics-tree/energy-poverty_en; The actual number of those currently in energy poverty is unclear given the coronavirus pandemic and overlapping price crisis. In July 2021, the Commission proposed the first EU-wide definition of Energy Poverty in the Energy Efficiency Directive (currently still under negotiation) as "a household's lack of access to essential energy services that underpin a decent standard of living and health, including adequate warmth, cooling, lighting, and energy to power appliances, in the relevant national context, existing social policy and other relevant policies." European Commission. (2021). Proposal for a Directive of the European Parliament and of the Council on energy efficiency (recast), art. 2(48). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELLAR%3A951949c6-5389-11ec-91ac-01aa75ed71a1

70 Geddes, I., Bloomer, E., Allen, J., & Goldblatt, P. at Department of Epidemiology and Public Health, UCL. (2011). *Health impacts of cold homes and fuel poverty*. Marmot Review Team. https://www.instituteofhealthequity.org/resources-reports/the-health-impacts-of-cold-homes-and-fuel-poverty/the-health-impacts-of-cold-homes-and-fuel-poverty.pdf

71 Zhu, Y., Lin, Y., Mathews, T., & Wang, Z. (2020). *Effects of residential gas appliances on indoor and outdoor air quality and public health in California*. UCLA Fielding School of Public Health Department of Environmental Health Sciences. https://coeh.ph.ucla.edu/effects-of-residential-gas-appliances-on-indoor-and-outdoor-air-quality-and-public-health-in-california; Seals, B., & Krasner, A. (2020). Gas stoves: Health and air quality impacts and solutions. Rocky Mountain Institute. https://rmi.org/insight/gas-stoves-pollution-health

72 Sunderland et al., 2020.

Figure 10. Presence of leak, damp or rot in EU dwellings, by income decile, 2017



Source: European Commission, Directorate General for Energy and EU Energy Poverty Observatory. (2017).
Total population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor.

Fossil-fuelled appliances cause additional health impacts. Homes without fuel-combustion appliances have about half the level of nitrogen dioxides compared to outdoor levels, whereas homes with combustion appliances often exceed outdoor levels.[73] Nitrogen dioxide is an irritant for the eyes, nose, throat and respiratory tract and can cause bronchial and lung issues, including increased risk of respiratory infections, especially in young children.[74] In addition to indoor air pollution, these same households may experience disproportionate health impacts in their communities from fossil fuel production or combustion. Pollution from coal mines, oil and gas production, and fossil fuel plants, often situated in or near lower-income areas, can degrade air and water quality.[75]

In sum, as the price of fossil gas increases, with alternative gases similarly unavailable at low cost, and as the per-customer system costs rise due to infrastructure upgrades with fewer consumers on the system to pay for those costs, customers remaining on the gas system will face higher prices to meet heating, cooking and other needs. Without intervention, disadvantaged energy users, who cannot move away from the gas system as quickly as others, are at higher risk of being stuck with the costs of an increasingly expensive and unhealthy system.[76]

It is from this starting point that decision-makers must design solutions that enable an equitable transition away from fossil gas. Building equitable solutions means prioritising policies that address the roots of the challenges faced by disadvantaged energy users: marginalisation into areas without affordable and efficient housing

[73] European Climate Foundation. (2022). *Building Europe's net-zero future: Why the transition to energy efficient and electrified buildings strengthens Europe's economy*. https://europeanclimate.org/resources/renovating-and-and-electrifying-buildings-strengthens-europes-economy-and-energy-security; United States Environmental Protection Agency. (n.d.). *Nitrogen dioxide's impact on indoor air quality*. https://www.epa.gov/indoor-air-quality-iaq/nitrogen-dioxides-impact-indoor-air-quality#Health_Effects

[74] United States Environmental Protection Agency, n.d.

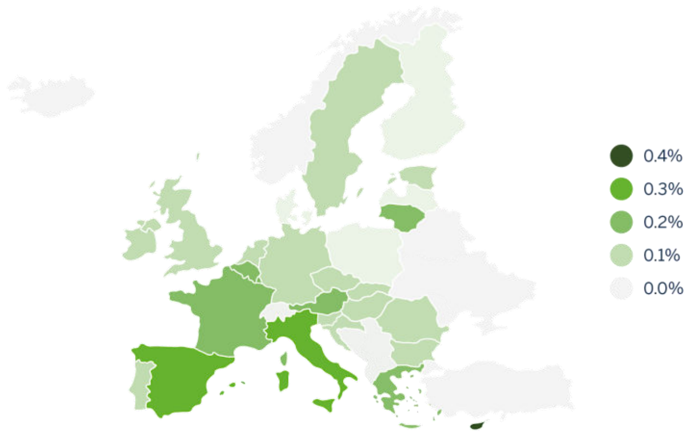
[75] See, for example, Bankwatch Network, 2020; Zachová, 2021.

[76] European Commission, 2021c, p. 28.

options; lack of access to opportunities to reduce the household energy burden, such as energy-efficiency tools or zero-emissions heating options; inequitable allocation of the taxes, levies and network costs reflected in energy bills; a constrained ability to consider energy choices due to misleading signals around energy options;[77] and limited resources to investigate options.[78]

Measures that decrease the dependence of struggling households on any energy source are a first and immediate action. Deep retrofits and energy-efficiency measures serve to reduce overall energy needs and improve indoor living environments and therefore health outcomes. With decreased energy demand, a wider range of solutions then become available to transition households away from price-volatile and polluting fossil fuels. As analyses[79] demonstrate that heating must increasingly be electrified, it makes sense to start the process by prioritising the transition for households with lower incomes and higher energy burdens. As shown in Figure 11 below,[80] programmes to deliver deep building renovations are so far delivering only a small fraction of the renovation rate needed to meet climate and equity targets.

Figure 11. Deep energy renovation in residential buildings, average, 2012–2016



Source: Rochet, A. (2021, 30 November). Build back better: Renovating buildings for renewed climate ambition. *Energy Monitor.*
Note: Deep renovations are those that result in energy savings of at least 60%.

Programmes can focus early action on such households either by replacing gas appliances and heating with electric alternatives, in particular electric heat pumps, on a unit-by-unit basis, or in a neighbourhood approach that prioritises clean district

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[77] Retail messaging that asserts heating will be transitioned from fossil gas to hydrogen boilers can lead energy users to the conclusion that investment in a 'hydrogen-ready' boiler is an easy transition, instead of considering electric alternatives that are more efficient and will not leave the consumer subject to volatile and increasing fuel prices. See, for example, British Gas. (2022, 21 January). *Hydrogen boilers: everything you need to know.* https://www.britishgas.co.uk/the-source/greener-living/hydrogen-boilers.html

[78] See Sunderland et al., 2020.

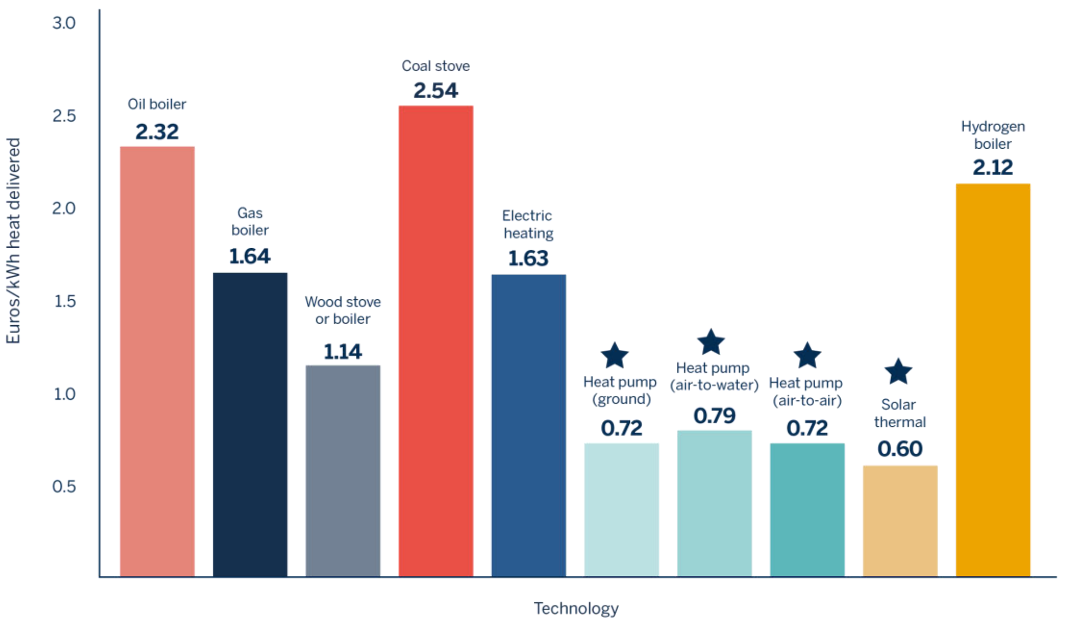
[79] Rosenow, J., & Lowes, R. (2020). *Heating without the hot air: Principles for smart heat electrification*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/heating-without-hot-air-principles-smart-heat-electrification; International Energy Agency (IEA), 2021; Intergovernmental Panel on Climate Change, 2021; Krishnan, M., Samandari, H., Woetzel, J., Smit, S., Pathod, D., Pinner, D., Nauclér, T., Tai, H., Farr, A., Wu, W., & Imperato, D. (2022). *The net-zero transition: What it would cost, what it could bring.* McKinsey & Company. https://www.mckinsey.com/business-functions/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring

[80] Note: Most recent data available is for 2012-2016. Rochet, A. (2021, 30 November). Build back better: Renovating buildings for renewed EU climate ambition. *Energy Monitor.* https://www.energymonitor.ai/tech/built-environment/build-back-better-renovating-buildings-for-renewed-eu-climate-ambition

heating for low-income areas. Aside from the early benefits delivered to these households, such programmes would also help to ensure that disadvantaged households are not left on the gas system as gas prices increase. By contrast, solutions that do not address the root of the focus on short-term savings, such as assistance for households to replace gas heating with more efficient gas heaters, only perpetuate disadvantaged households' exposure to rising gas prices.[81]

This point is illustrated in Figure 12 by analysis of the heating costs of moving energy users from conventional boilers to either electric heat pumps or hydrogen boilers.[82] As can be seen from the example below, and similar to the analyses in other Member States, heating with an electric heat pump is expected to be much less expensive for households than using a hydrogen boiler.[83]

Figure 12. Heat pumps and solar thermal projected to be cheapest technologies for households in next decade



Source: European Climate Foundation and the European Alliance to Save Energy. (2022). *Building Europe's net-zero future: Why the transition to energy efficient and electrified buildings strengthens Europe's economy.*

By contrast, heating bills can be cut in half with electrification and energy efficiency, as illustrated in Figure 13 below.[84]

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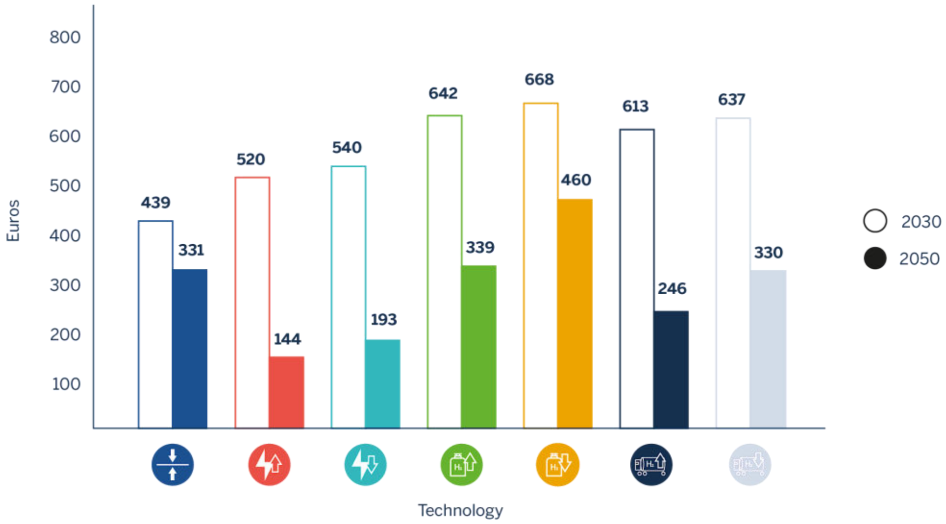
[81] Sunderland, L. (2020). *Getting off gas: Future risks for energy poor households.* Regulatory Assistance Project https://www.raponline.org/blog/getting-off-gas-future-risks-for-energy-poor-households; The Warmer Homes Scotland programme, for example, provided assistance to households to replace old fossil gas boilers with more efficient gas boilers. Home Energy Scotland. (n.d.). *Warmer Homes Scotland: in detail.* https://www.homeenergyscotland.org/find-funding-grants-and-loans/warmer-homes-scotland; With its new heating plan, Scotland is changing its tack with a goal of decarbonising all buildings by 2045, which means replacing the heating systems of nearly 90% of Scotland's 2.5 million homes that are currently heated with fossil fuels. Maby, C., & Sunderland, L. (2022). *Owning the future: A framework of regulations for decarbonising owner-occupied homes in Scotland.* https://www.raponline.org/knowledge-center/owning-future-framework-regulations-decarbonising-owner-occupied-homes-scotland

[82] European Climate Foundation, 2022.

[83] BEUC The European Consumer Organisation. (2021). *Goodbye gas: Why your next boiler should be a heat pump.* https://www.beuc.eu/publications/beuc-x-2021-112_goodbye_gas_why_your_next_boiler_should_be_a_heat_pump.pdf

[84] Scenarios read from left to right: baseline (medium blue); electrification with high renovation rate (red); electrification with low renovation rate (turquoise blue); domestic green hydrogen with high renovation rate (green); domestic green hydrogen with low renovation rate (yellow); imported green hydrogen with high renovation rate (navy blue); and imported green hydrogen with low renovation rate (silver). European Climate Foundation, 2022.

Figure 13. Average annual heating bills in Europe, six decarbonisation scenarios



Source: European Climate Foundation and the European Alliance to Save Energy. (2022). *Building Europe's net-zero future: Why the transition to energy efficient and electrified buildings strengthens Europe's economy.*

Policies that build on options that are immediately available and offer efficient, safe and cost-effective solutions, including energy efficiency and heat pumps, will ameliorate the energy burden of disadvantaged energy users. Promises of options that may offer solutions down the road do nothing to address current energy poverty, and risk leaving vulnerable energy users in an even worse position.[85]

European Union and Member State policies usually state the idea behind Principle 2 as an overarching goal or tenet.[86] Policies to meet this goal, however, are often misdirected at short-term savings and do not place the policies within the context of wider efforts. These mistakes are evident in the gas package and in hydrogen strategies that offer hydrogen as a means to address energy poverty.

Eliminate gas package elements that perpetuate gas for residential end users

The gas package presents an opportunity to address the situation that low-income, energy-poor and vulnerable households are facing as they consider spikes in energy costs and increased uncertainty about whether those costs are an aberration or the start of a sustained trend.[87] The gas package's approach, however, violates Principle 2's direction to prioritise benefits for disadvantaged energy users because it focuses on solutions that only perpetuate dependence on gas.

The package's narrow focus on gas decarbonisation, as opposed to system decarbonisation, bleeds into its treatment of disadvantaged customers. Where the gas package could consider ways to facilitate the transition of household end uses away from gas, it instead emphasises measures that would incentivise households to remain

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[85] Rosenow, J., & Sunderland, L. (2021). Pipe dream: alleviating energy poverty with hydrogen. *Euractiv*. https://www.euractiv.com/section/energy/opinion/pipe-dream-alleviating-energy-poverty-with-hydrogen

[86] "Member States should take the necessary measures to protect vulnerable and energy poor customers. The decarbonised gas market should not be developed without them being able to fully benefit from it." European Commission, 2021b, p. 2.

[87] See, for example, Rystad Energy. (2022). *Rystad Energy impact report: Russia's invasion of Ukraine*. https://pages.rystadenergy.com/Rystad-Energy-Russia-Invasion-Ukraine-Report-March-2022

on gas. For example, by identifying customer engagement in the gas market, and barriers to increased competition in the 'green gas' market as problem areas to be addressed, the package diverts attention to whether customers have sufficient information to switch *gas* providers.[88] This misplaced focus translates into provisions in the Directive and Regulation centred around increasing an energy user's ability to switch providers, such as requirements for installation of smart meters, shorter switching times and easier entry into the market for new providers.[89] The inclusion of citizen energy communities, which are taken from the electricity market design, further distracts from the recognised need to transition households away from dependence on gaseous solutions – even lower-carbon gaseous solutions – because they do not usually represent as efficient an option to decarbonise residential end uses.[90] All of these elements that focus on staying on gas pose a greater risk to low-income households. The high and volatile future energy costs associated with being locked into fossil gas or hydrogen use are less easy to bear for these households, and alternatives are often inaccessible.

By including measures that require consumer investment in perpetuating gas usage, even in areas where that usage is expected to decrease dramatically (namely residential heating and cooking), the gas package fails to provide the resources that consumers need to consider more beneficial switching to electrical end uses. Increasing competition within the gas market itself thus fails to recognise the more pressing need to transition residential consumers, and in particular energy-poor and vulnerable energy users, to more sustainable end uses, including through district heating and electrification. Provisions in the package that allow for gas users to cross-subsidise the development of hydrogen networks could further increase costs.[91]

The gas package could instead address what is required to enable energy users to consider solutions to meet their needs across both the power and gas sectors. The priority is to meet the needs of low-income and vulnerable households with the most cost-effective and sustainable solutions, not merely the most competitive solution within the gas market. Furthermore, the gas package could elevate those tools for disadvantaged energy users to ensure that they are able not only to choose across competitors in the gas market, but across sectors.

To enable this result, the gas package could facilitate better planning across sectors at the Member State and local level,[92] as discussed below in Principle 3. Member State targets to transition energy users away from gas can then also be considered and integrated into expected market development. For example, the Scottish government has committed to targets to phase out installation of new or replacement fossil fuel boilers and is shifting incentives away from support for gas boilers to zero-emission

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[88] European Commission, 2021c, pp. 23-24.

[89] European Commission, 2021b, p. 60, p. 74 (Art. 15), p. 76 (Art. 18).

[90] European Commission, 2021c, p. 1; European Commission, 2020b, p. 8.

[91] European Commission, 2021a, Art. 4.

[92] Agora Energiewende. (n.d.). *Decarbonising heat in buildings, success story Norway*. https://www.agora-energiewende.de/en/success-stories/decarbonising-heating-in-buildings; Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg [Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg]. (2021); *Kommunale Wärmeplanung [Municipal heat plan]*. https://um.baden-wuerttemberg.de/de/energie/energieeffizienz/in-kommunen/kommunale-waermeplanung/#:~:text=Mit%20der%20Novelle%20des%20Klimaschutzgesetzes,Dezember%202023%20einen%20W%C3%A4rmeplan%20vorlegen; Rijksdient voor Ondernemend Nederland [State Service for Enterprises, Netherlands]. (2022*). Transitievisie Warmte en Wijkuitvoeringsplan* [Transition vision: Heat and district implementation plan]. https://www.rvo.nl/onderwerpen/aardgasvrij/transitievisie-warmte-en-wijkuitvoeringsplan

options before the phaseout begins.[93] Norway has also imposed gradual targets to phase out fossil boilers while incentivising heat pumps. Together with increased taxes for fossil fuels and development of district heating, these policies have provided both policy and economic direction for the residential sector as a whole.[94] Such policies can prioritise incentives given to energy-poor and vulnerable customers to signal a needed shift, not just in the residential sector overall, but for energy users who would benefit most. Incorporating these goals into more integrated planning would mean the gas market could be managed in a more informed way.

By contrast, provisions in the gas package that signal maintenance of the gas system, even in residential areas where it largely will not be needed, will lead to further investment into the gas network itself. These investments would be problematic by themselves, but their impact will be compounded if the costs for additional investments fall on the shoulders of energy-poor and vulnerable households already struggling to pay for their energy needs. Because dependence on the gas network for residential users is expected to shrink dramatically,[95] future investments in the network will be covered by fewer energy users. Whereas investments in the gas grid were once seen as a means to ameliorate high energy prices for low-income households, given the contraction of the gas market, such investments today will serve only to expand likely stranded costs for those least able to avoid them.

Design hydrogen strategies to focus hydrogen development on hard-to-electrify end uses

Hydrogen strategies present another opportunity to assist disadvantaged energy users, by ensuring that hydrogen development is directed away from them. As a limited fuel that has high value in decarbonising sectors that are hard to electrify, hydrogen is unlikely to become a common fuel to meet residential end uses.[96] Not only is its supply limited, but infrastructure to carry hydrogen to end uses is also limited and thus significant investment would be required either to upgrade existing pipelines or to create new infrastructure to safely transport hydrogen. Given these considerations, investing in infrastructure to meet least-regrets, hard-to-electrify end uses is a more secure approach.

Despite seeming consensus on the priority uses for hydrogen, as exemplified in Figure 14 below,[97] many strategies still provide some allowance for hydrogen as a fuel for building heat.[98] Such an approach is problematic for low-income, energy-poor and vulnerable households because it risks subjecting them to two unhelpful outcomes.

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[93] Energy saving trust. (2021, 2 November). *An introduction to Scotland's Heat in Buildings Strategy*. https://energysavingtrust.org.uk/an-introduction-to-scotlands-heat-in-buildings-strategy; Scottish Government. (2021, 7 October). *Heat in Buildings Strategy – achieving net zero emissions in Scotland's buildings.* https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings/documents; Maby & Sunderland, 2022.

[94] Agora Energiewende, n.d.

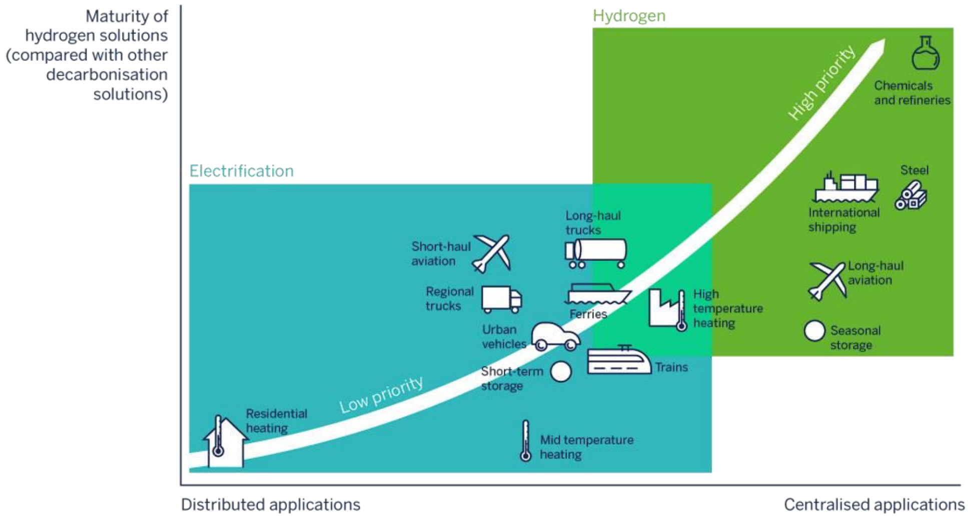
[95] European Commission, 2021c, p. 8; European Commission, 2020b.

[96] European Commission, 2020b; Rosenow & Lowes, 2020; Flis & Deutsch, 2021.

[97] IRENA International Renewable Energy Agency. (2022). *Geopolitics of the Energy Transformation: the Hydrogen Factor*. https://www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-Transformation-Hydrogen

[98] European Commission, 2020c, p. 6; Bundesministerium für Wirtschaft und Klimaschutz [German Federal Ministry for Economic Affairs and Climate Action]. (2020). *The national hydrogen strategy*. https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.html; United Kingdom Department for Business, Energy & Industrial Strategy. (2021). *UK hydrogen strategy*. https://www.gov.uk/government/publications/uk-hydrogen-strategy

Figure 14. Clean hydrogen policy priorities



Source: IRENA International Renewable Energy Agency. (2022). *Geopolitics of the energy transformation: the hydrogen factor.*

In one result, disadvantaged energy users could be left on the gas system, with the promise that hydrogen is coming and will affordably and efficiently meet their needs. In this situation, households will not only be dependent on an increasingly expensive gas system, but they will also have to bear the costs of transitioning to a hydrogen system, including for changing out appliances or prematurely being sold 'hydrogen-ready' appliances, along with infrastructure upgrades. Adding to the risks are the questions around using hydrogen inside homes, including questions of indoor air quality impact and the safety of hydrogen.[99]

In a second outcome, instead of prioritising energy-efficiency measures and deep retrofits that could have immediate benefits for disadvantaged energy users, investments could be diverted to developing a hydrogen grid and transitioning these households to hydrogen. In this situation, energy users would lose out on the compounding benefits of energy efficiency and home retrofits, and at the same time may be left with poorly insulated homes that require significant amounts of energy to heat, whether from increasingly expensive fossil gas or from limited and costly hydrogen.

In either case, avoiding the root of the issues leading to energy insecurity, and instead focusing time, resources and attention on a purportedly easy alternative to gas, will leave energy users worse off.

Principle 3: Integrate the gas and electricity sectors.

The third principle recognises that, to develop an energy system that can meet GHG reduction targets, it is essential to integrate the gas and electricity sectors in both planning and operation.[100] As we transition from meeting end uses with fossil gas to

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[99] See, for example, European Commission, 2020c; Bundesministerium für Wirtschaft und Klimaschutz [German Federal Ministry for Economic Affairs and Climate Action], 2020; United Kingdom Department for Business, Energy & Industrial Strategy, 2021; Saadat, S., & Gersen, S. (2021). *Reclaiming Hydrogen for a Renewable Future: Distinguishing oil & gas industry spin from zero-emission solution.* Earthjustice. https://earthjustice.org/sites/default/files/files/hydrogen_earthjustice_2021.pdf

[100] European Commission, 2020b; European Commission, 2021c.

utilising energy-efficiency measures, demand-side management, electrification and zero-carbon gaseous fuels in hard-to-electrify sectors, we must now plan, build and operate systems in a manner that allows us to identify and utilise the most effective, efficient and equitable solutions. Integrating these sectors requires changes in governance structures, planning requirements and markets to find and implement those pathways.

Decision-makers can enable and facilitate the shifts needed for these changes to happen. Although developing a decarbonised energy system is technologically and economically possible, it will not happen unless decision-makers put the pieces in place to enable a transition towards new resources. As noted in Principle 1, time is of the essence. The longer Europe waits to make the changes needed to decarbonise, the greater the costs will be. As the European Commission states, the "short-term regulatory costs entailed ... must be assessed against the costs and efforts that a late integration and decarbonisation of the energy system would require in the long term."[101]

Within this principle, we outline two areas where decision-makers can prioritise integration to ensure that the system is building towards the framework outlined in the Energy System Integration Strategy. First, it is important to require integrated system planning to maintain a focus on overall system decarbonisation, rather than potentially incongruous sector-by-sector decarbonisation. A second key factor is developing market rules that will enable competition between solutions across sectors.

Governance and integrated energy system planning

A first step towards integrating the gas and electricity sectors will be to create a system in which solutions to meet end uses can be considered across sectors. As the European Commission has noted: "coordinated planning and operation of the entire EU energy system, across multiple energy carriers, infrastructures, and consumption sectors is a prerequisite to achieve the 2050 climate objectives."[102] Whereas planning traditionally addressed how to meet end-use demand with supply, and assessed the infrastructure required to meet those needs, planning is now needed to determine *how* to meet the end use most efficiently, given carbon targets and technology advances that now make electrification a better option to meet many end uses. In short, by setting out limitations and timelines that cannot be met with continued or even greater reliance on fossil fuels, carbon targets turn previous planning assumptions of continued growth and infrastructure development on their head.[103] Mandating a requirement to analyse the impacts of not taking action – or utilising a non-pipe alternative that does not rely on additional infrastructure but meets end uses through energy efficiency, demand-side measures or switching to electrification – can lead to further insights and solutions. The process can also address the lifecycle emissions of alternatives to inform analysis of future pathways.

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[101] European Commission, 2021b, p. 12.

[102] European Commission, 2021b, p. 3, 11, 41; European Commission, 2020b, p. 17.

[103] Already with the Fit for 55 targets, the Commission noted that "EU carbon targets require that the amount of fossil gas is reduced by up to 80 percent by 2050 to meet carbon targets." European Commission, 2020a, p. 54, footnote 123.

The disconnected nature of current planning processes does not facilitate development of an integrated system.[104] Gas transmission planning happens within the European Network of Transmission System Operators for Gas (ENTSO-G), electric transmission planning within the European Network of System Operators for Electricity (ENTSO-E), and distribution planning by the distribution system operators (DSOs). Although ENTSO-G and ENTSO-E have begun to develop integrated planning,[105] these efforts alone are not fit for purpose. First, the ENTSOs are not in a position to consider an overall vision for Member States' energy systems, and thus cannot provide the guidance that regulators and other decision-makers need to inform energy-system decision-making. Second, the ENTSOs are still directed to focus scenarios on future infrastructure needs. With this focus, and because the system operators are leading the scenario development, the scenarios may maintain a bias towards infrastructure solutions. Third, they do not include distribution system planning, which is critical to ensure that demand is driving supply and not the other way around.

As the European Commission has noted: "coordinated planning and operation of the entire EU energy system, across multiple energy carriers, infrastructures, and consumption sectors is a prerequisite to achieve the 2050 climate objectives."

Because options to meet end uses are generally developed within the confines of one sector or another, solutions are consequently similarly limited. If, for example, there is insufficient gas supply to meet end-use needs, the question that currently follows is how to increase gas supply, not whether electrification of end uses could decrease the demand for gas, or perhaps even eliminate it entirely. If solutions are considered sector by sector, opportunities to achieve the highest carbon reductions will be missed. Non-integrated planning leads to an inherent bias to plan for the sector in question, thus overlooking solutions in other sectors such as electrification, or combinations of resources such as pairing supply-side solutions with energy efficiency and demand-side flexibility.

Similarly, development of the supply and infrastructure needed to meet end uses stems from current or expected demand forecasts that are usually created by the network operator itself.[106] Putting control of planning into the hands of the entity invested in its own operations can result in a fundamental bias towards a perpetuation of the current system or even continued projections of growth. These projections then become a self-fulfilling prophecy as additional infrastructure is built to meet purported needs.[107]

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[104] European Commission, 2021b, p. 3: "Current network planning schemes and practices are deficient as there are discrepancies between the EU TYNDP [Ten-year network development plan] and national network development plans – a better linkage between TYNDP and NDP would allow transnational exchange of information on transmission systems usage."; European Commission, 2021c: "[C]onsideration of energy system integration in current network planning schemes and practices is deficient."; Agency for the Cooperation of Energy Regulators (ACER). (2021, 4 May). *ACER finds serious shortcomings in ENTSOG's gas network plans – underlining the need for current TEN-E reforms to strengthen independent project assessments.* https://documents.acer.europa.eu/Media/News/Pages/ACER-finds-serious-shortcomings-in-ENTSOs%E2%80%99-energy-network-plans.aspx

[105] European Network of Transmission System Operators for Gas (ENTSO-G) and European Network of Transmission System Operators for Electricity (ENTSO-E). (2022, April). *TYNDP 2022 Scenario Report – Version April 2022.* https://2022.entsos-tyndp-scenarios.eu

[106] European Commission, 2021b, p. 3, 11, 41; European Commission, 2021c, p. 17.

[107] See, for example, Agency for the Cooperation of Energy Regulators (ACER) and Council of European Energy Regulators (CEER).

Policymakers and regulators can develop new governance structures to achieve integrated planning of this nature.

Moving forward, integrated planning needs to look not only at requirements for meeting supply and demand in the near term based on the current situation, but also at what will be needed as demand changes. Structural efficiency measures and advances in the efficiency of various technologies will likely decrease overall energy demand. Furthermore, energy demand will shift as many end uses are electrified and whole end-use sectors, for example residential consumers, may no longer need gas infrastructure. It is vital to immediately incorporate these changes into planning to avoid overbuilding what are likely to become unneeded gas networks, and potentially underbuilding electric transmission and supply.[108] In short, policymakers and regulators have the ability to design and require planning processes that have linkages across the gas and electricity sectors and across transmission and distribution network planning, to allow first for an integrated view of potential solutions, and then for infrastructure planning to develop those solutions.

A directive requiring an integrated energy plan (IEP) as part of Member States' National Energy and Climate Plans (NECP), with coordination across Member States, would facilitate high-level analysis. Member States could then choose the most effective, efficient and equitable scenarios to meet end-use needs, in line with carbon targets, so that all resource options and the necessary infrastructure between Member States can be considered. The ENTSO planning process could be informed by and fed back into NECP planning. Decision-makers, including the Agency for the Cooperation of Energy Regulators and national regulatory authorities, could develop review mechanisms for the specific plans to ensure that the scenarios comply with Member State and EU carbon goals, and that the anticipated infrastructure serves the plan's goals. The integrated plans would inform planning and decisions about operations and infrastructure development to meet an integrated and climate-aligned scenario, rather than planning occurring within silos disconnected from broader decarbonisation efforts.

Once Member States have analysed integrated and climate-aligned scenarios and developed a national IEP, specific planning processes would then provide the detail regarding development or decommissioning infrastructure to meet the goals of the IEP. Thus, instead of network planning effectively determining supply choices to meet end uses, network planning would be governed by Member State NECPs.

Numerous planning processes will still be needed, including planning for energy efficiency and demand-side management, power and gas, but they can be integrated to avoid redundancies in serving end uses and to identify and capture efficiencies that might be missed in less granular scenario planning. Critical to all processes will be to make certain that decision-makers have sufficient choices and information to make

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(2019). *The bridge beyond 2025 conclusions paper*. https://acer.europa.eu/Official_documents/Acts_of_the_Agency/SD_The%20Bridge%20beyond%202025/The%20Bridge%20Beyond%202025_Conclusion%20Paper.pdf: "It may be inappropriate for the TSOs, as owners/operators of one of the competing options for providing energy system management, to have a monopoly over the identification of system needs."; European Commission, 2021c, p. 21.

[108] European Commission, 2021c, p. 21: "Additionally, there are discrepancies between the EU-wide ten-year network development plan (TYNDP) and national network development plans (ETS NDP) in relation to the requirement of e.g. joint scenario building between electricity and gas infrastructures, which is all not required for NDPs. As a consequence, this may result in overestimating infrastructure needs in national plans, but also in the TYNDP as the TYNDP is based upon NDPs, and may hence negatively affect more efficient and coordinated infrastructure investments enabling a faster and better transition."

decisions that ensure they can meet needs within the necessary constraints (as discussed below in Principle 5).

Integrating markets for competition across sectors

In addition to integrating planning, it may be necessary to redesign energy markets so that they are serving climate goals and the plans to meet those goals. The current gas market rules sought to develop an internal market for natural gas "to achieve efficiency gains, competitive prices, and higher standards of service, and to contribute to security of supply and sustainability."[109] In an integrated and decarbonising system, these goals are evolving. The market now needed is one that ensures decarbonisation goals can be met by enabling access to the most efficient means to meet end uses, including competitive choice across demand- and supply-side options, high standards of service that provide up-to-date and transparent information about options to meet consumer needs, and security of supply across sectors. In short, market rules should encourage competition across sectors, rather than creating a market structure that may provide incentives for continued or further use of gas to meet end uses, buoyed by the inertia of the status quo.

Policymakers have the opportunity to redesign the market to ensure competition to meet these new needs. A threshold consideration must be whether any advantages garnered from market design are warranted and compatible with climate targets. Failure to guarantee that market design is consistent with a decarbonised system will risk providing advantage to, and incentivising investment in, solutions that are ultimately at cross-purposes with decarbonisation.

Amend the gas package to anticipate integrated planning and markets

Although the third principle's goal of system integration is straightforward, achieving it requires fundamental changes to the status quo that may be uncomfortable. Creating an integrated system will challenge decision-makers to chart pathways that weave this goal into decision-making in practice at all levels. In short, by designing for system integration, decision-makers open doors to solutions across the sectors. As soon as walls are erected around one sector or another, however, the range of opportunities to meet end uses efficiently immediately shrinks.

The gas package proposal illustrates this situation. The current proposal recognises the need for system integration, and more integrated planning.[110] The problem areas that the gas package proposal sets out to tackle, however, do not address integrating the gas market into a comprehensive energy system. Instead, they frame the problem as one of gas decarbonisation: three of the four problem areas are aimed at creating a market for alternative gases, without boundaries as to where those gases will likely be needed or

[109] European Commission. (2009). Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0073

[110] European Commission, 2021b, pp. 12, 18.

whether the creation of a greater decarbonised gas market will favour gaseous fuels.[111] Although the gas package is necessarily focused on gas, failing to consider how to integrate it into a more cohesive system sends decision-makers in the wrong direction in two ways. First, looking at the problem as one of gas decarbonisation sets up a larger challenge than may be necessary. As noted above, decarbonised gas will be needed for hard-to-electrify end uses, but it will not need to reach every home and business. Second, this narrow focus immediately limits opportunities to think about solutions outside of the gas sector. If the goal is gas decarbonisation, it sends the signal to decarbonise gas and fails to flag the fact that there may be other ways to meet end-use needs.

By focusing on system decarbonisation, rather than gas decarbonisation, decision-makers could create a gas package that supports energy system integration. Doing so, however, would involve several changes in approach to the package.

First, the gas package could improve planning processes to integrate sectors from the start. Although the gas package recognises that current network planning is deficient,[112] and includes it as a problem area that needs to be addressed, it does not go far enough in setting out options that will thoroughly integrate energy planning across sectors, as outlined above.

The current proposal adopts a 'National Planning based on European Scenarios' option. This option continues to put the transmission system operator (TSO) in a central position, by requiring the national planning to be based on scenarios that the TSO develops in its 10-year network development plan (TYNDP).[113] Although the proposal requires "infrastructure operators, including LNG [liquified natural gas] terminal operators, storage operators, distribution system operators as well as hydrogen, district heating infrastructure and electricity operators" to provide and submit information to the TSO to develop the plan, the proposal does not specify who will determine what information is needed, how that will inform the plan, and how regulators will ensure that the plan appropriately uses that information to consider options to meet end uses most effectively and efficiently.[114] In short, the proposal does not address the inherent bias towards gas of having the TSO develop the plan, or the consequent bias towards system expansion. Although the proposal requires consideration of alternatives to system expansion, including demand response and energy efficiency,[115] and that the TSO include information about areas that can be

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[111] The gas package sets out four problem areas: I. Hydrogen infrastructure and hydrogen markets; II. Renewable and low-carbon gases in the existing gas infrastructure and markets, and energy security; III. Network planning; and IV. Low-level customer engagement and protection in the green gas retail market. With the exception of network planning, discussed further below, the focus of the problem areas is on creating a decarbonised gas market, not in looking at the most efficient ways to meet end-use needs and then determining what is required to develop those solutions. European Commission, 2021b, pp. 10-12.

[112] European Commission, 2021b, p. 3: "Current network planning schemes and practices are deficient as there are discrepancies between the EU TYNDP [Ten-year network development plan] and national network development plans – a better linkage between TYNDP and NDP would allow transnational exchange of information on transmission systems usage."; European Commission, 2021c: "[C]onsideration of energy system integration in current network planning schemes and practices is deficient."

[113] Agency for the Cooperation of Energy Regulators (ACER) and Council of European Energy Regulators (CEER), 2019: "It may be inappropriate for the TSOs, as owners/operators of one of the competing options for providing energy system management, to have a monopoly over the identification of system needs."

[114] European Commission, 2021b, Art. 51 (1), p.100.

[115] European Commission, 2021b, Art. 51 (3), p. 101.

decommissioned,[116] these provisions do not force a hard look at such alternatives.[117] Rather, with the TSO at the helm, those pieces can be relegated to pro forma requirements that do not receive the attention needed for a properly integrated system. Requirements that the TYNDPs are in line with NECPs and support EU climate goals are similar nods in the right direction, but they do not provide enough specificity to address the fact that, in practice, those goals will likely mean significant changes to the gas system, in line with the Energy System Integration Strategy.[118]

Instead of a TSO-centred approach, the gas package could require that gas planning stem from the Member State IEPs as outlined above. In short, rather than leaving the pen solely in the hands of the TSOs, Member-State-led IEPs could impose constraints within which TSOs and DSOs would be required to operate. To guarantee that the system operators remain within that space, the gas proposal could impose additional requirements and compliance metrics on the TYNDPs and distribution network plans that monitor whether they are meeting the goals of the IEPs. One approach would be to require an independent body of technical experts to confirm that the proposed plan provides an efficient and cost-effective path to meet needs, in compliance with Member State IEPs.[119] An important part of those plans will be a greater emphasis on requiring TSOs and DSOs to consider where gas networks can be decommissioned or repurposed to ensure that customers are not paying for maintenance of pipelines that are no longer needed to meet end uses.[120]

By focusing on power system decarbonisation, rather than gas decarbonisation, decision-makers could create a gas package that supports energy system integration.

In addition to more integrated planning processes, the gas package could further sector integration through a structural recognition of the Energy System Integration Strategy's conclusion that gaseous fuels will be needed only "for end-use applications where direct heating or electrification are not feasible."[121] As noted above, a fundamental flaw in the gas package proposal is its prioritisation of the creation of a market for alternative gases, instead of an energy market that enables competition across sectors. By setting out problem areas that focus almost entirely on the creation

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[116] European Commission, 2021b, Art. 51 (2)(c-d), p. 100.

[117] This bias towards development can be seen in the existing system, which operators continue to expand unnecessarily. See, for example, Artelys FRANCE. (2020). *An updated analysis on gas supply security in the EU energy transition*. https://www.artelys.com/wp-content/uploads/2020/01/Artelys-GasSecurityOfSupply-UpdatedAnalysis.pdf; Institute for Energy Economics and Financial Analysis (IEEFA). (2021, 16 March). *IEEFA Europe: Snam woos investors with net-zero claims, while growing its spending on fossil gas infrastructure.* https://ieefa.org/ieefa-europe-snam-woos-investors-with-net-zero-claims-while-growing-its-spending-on-fossil-gas-infrastructure/?utm_source=rss&utm_medium=rss&utm_campaign=ieefa-europe-snam-woos-investors-with-net-zero-claims-while-growing-its-spending-on-fossil-gas-infrastructure; Agency for the Cooperation of Energy Regulators (ACER). (2021, 5 November). *ACER finds markets not willing to commit to gas network expansion*. https://www.acer.europa.eu/events-and-engagement/news/acer-finds-markets-not-willing-commit-gas-network-expansion

[118] European Commission, 2021b, Art. 51 (2)(g), p. 101; European Commission, 2021c.

[119] Giannelli, E., & Fischer, L. (2020, 31 March). Benchmarks for the new Trans-European Networks for Energy Regulation (TEN-E). E3G. https://www.e3g.org/publications/benchmarks-for-the-new-trans-european-networks-for-energy-regulation-ten-e

[120] Agency for the Cooperation of Energy Regulators. (2021, 16 July). *Transporting pure hydrogen by repurposing existing gas infrastructure: Overview of existing studies and reflections on the conditions for repurposing [Review].* https://www.acer.europa.eu/events-and-engagement/news/repurposing-existing-gas-infrastructure-pure-hydrogen-acer-finds; Flis & Deutsch, 2021; Flora, A., & Wynn, G. (2020). *Hiding in plain sight — European gas pipeline companies' greenhouse gas emission*. Institute for Energy Economics and Financial Analysis (IEEFA). http://ieefa.org/wp-content/uploads/2020/12/European-Gas-Pipeline-Companies-Emissions-Hiding-in-Plain-Sight_December-2020.pdf

[121] European Commission, 2021c; European Commission, 2021a; European Commission, 2021b.

of a place for alternative gases, when in fact such a place may not be needed to achieve carbon goals, the gas package puts a finger on the scale in favour of those solutions. This situation is most starkly illustrated by the gas package's insistence that greater competition among gases is needed in the retail sector – end uses which are squarely excluded from any anticipated gas needs.[122]

Instead, the gas package could adopt the Energy System Integration Strategy's "three complementary and mutually reinforcing concepts" of system integration – a more circular economy with energy efficiency at its core, greater direct electrification of end uses and the use of alternative gases where direct heating or electrification is not feasible. By taking this framework as a starting point, and anticipating further refinements to be added by Member State NECPs, the gas package could focus the gas market to serve those hard-to-electrify sectors, while prioritising means to reduce gas usage in end uses for which it is not expected to be needed. Instead of requiring investment into smart meters or additional information for customers about gas providers, for example, the gas package could require DSOs to create system maps that anticipate areas where gas usage will decrease, and develop plans for system transition in those areas. Instead of considering whether blended fuels are needed to jumpstart a hydrogen market, the gas package could incentivise bringing alternative gases to hard-to-electrify sectors where it is clear they will be needed.[123]

In sum, the gas package proposal does not support a transition to a more integrated energy system. As the Energy System Integration Strategy and the gas package itself recognise, however, an integrated system is essential for achieving climate goals. Keeping the principle of integration front of mind will help decision-makers design a proposal that situates gas markets within a broader plan for system decarbonisation.

Do not allow hydrogen strategies to crowd out other solutions

Similar to the gas market's prioritisation of gas decarbonisation over other solutions, EU and Member State hydrogen strategies also distract from other available, effective solutions. The EU Hydrogen Strategy outlines the importance of hydrogen within an integrated system, noting that, while renewable energy is expected to decarbonise much of Europe's energy consumption, hydrogen has the potential to fill some of the gaps that renewable energy cannot. Thus, the strategy notes the need to prioritise the development of hydrogen to meet those specific needs and to replace fossil fuels in sectors such as industrial processes and hard-to-abate sections of the transport system.

The EU Hydrogen Strategy anticipates the use of green hydrogen first to decarbonise applications that currently use grey hydrogen, and then to decarbonise hard-to-electrify sectors. This focus is in line with the Energy System Integration Strategy and other analyses that envision a role for hydrogen to enable decarbonisation of the energy system as a whole.[124] As these strategies have been developed and rolled out,

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[122] European Commission, 2021a; European Commission, 2021b (problem area IV); European Commission, 2020b; Flis & Deutsch, 2021.

[123] Just replacing grey hydrogen with green hydrogen could utilise available hydrogen resources efficiently with marked GHG reductions. See, for example, European Commission, 2022b; European Commission, 2022d.

[124] Rosenow & Lowes, 2020; Phillips, J., & Fischer, L. (2021). *Between hope and hype: a hydrogen vision for the UK*. E3G. https://9tj4025ol53byww26jdkao0x-wpengine.netdna-ssl.com/wp-content/uploads/Between-Hope-And-Hype-A-Hydrogen-Vision-For-The-UK.pdf; Lovisolo, M.. (2021). *Is hydrogen in home heating hot air?* Bellona Europa. https://network.bellona.org/content/uploads/sites/3/2021/04/Bellona-Report_-Is-Hydrogen-in-home-heating-hot-air_.pdf; Twinn, C. (n.d.). *Hydrogen: A decarbonisation route for heat in buildings?* London Energy Transformation Initiative (LETI). https://www.leti.london/hydrogen

and other EU Member States draft their own hydrogen strategies, the discussion around hydrogen has expanded. Some are now calling for maintaining gas networks for hydrogen delivery and for using hydrogen to fuel end uses across the spectrum, including even easy-to-electrify end uses such as residential heating.[125] The term 'hydrogen-ready' has been co-opted to mean not only something that may be fuelled by or may carry hydrogen, but also to cover all manner of methods for perpetuating gas networks. A more appropriate approach is to prioritise hydrogen usage in areas that can be readily decarbonised using hydrogen, rather than seeking to expand its usage to areas where it is not needed.

As the EU and Member States further develop and implement their hydrogen strategies, it will be all the more important to keep the principle of sector integration in mind. Hydrogen will be a solution for some end uses, but there are many other solutions that can deliver GHG reductions more efficiently, effectively and quickly, in addition to promoting a more resilient and flexible energy system. Moreover, because it will take the next couple of decades to ramp up hydrogen production to meet anticipated needs,[126] it is important to ensure that the hydrogen hype does not drown out the solutions for decarbonising immediately. This point is even more important given that production of green hydrogen depends on a dramatic increase in renewable energy to produce it. To meet the Commission's REPowerEU target of 10 million tonnes of domestic hydrogen production, an additional 550 TWh of renewable electricity would be needed.[127] In short, hydrogen is not an overnight or independent solution – its efficacy will be augmented when considered as part of a solution within an integrated system.

Principle 4: Design a coordinated and self-reinforcing policy mix to transform end uses.

Simply put, to transition away from fossil gas in line with EU climate targets, end-use needs must be met with clean resources. To enable that result, a mix of policies needs to operate in concert to facilitate a rapid and significant transition from the current situation, wherein the EU consumes around 400 billion cubic metres of fossil gas per year, to one where the use of fossil gas is declining at a rate of over 4%, or more than 16 billion cubic metres per year.[128] Moreover, the recent invasion of Ukraine makes an even faster decline necessary, as discussed above. Reducing fossil gas consumption at this scale requires policy measures to decarbonise end-use needs and complementary policies to transition the energy system to one that supports the changed end-use demands.

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125 See, for example, Bothe, D., & Janssen, M. (2021). *The role of hydrogen in heating buildings [Executive summary of a study for Viessmann Climate Solutions (translation of German original)]*. Frontier Economics. https://www.frontier-economics.com/media/4592/hydrogen-in-the-heat-sector.pdf

126 European Commission, 2020c, pp. 6-7; Agora, Flis & Deutsch, 2021.

127 Recently released drafts of delegated acts define what would qualify as green hydrogen. European Commission. (2022, 23 May). *Commission launches consultations on the regulatory framework for renewable hydrogen*. https://ec.europa.eu/info/news/commission-launches-consultation-regulatory-framework-renewable-hydrogen-2022-may-20_en. The figure of 550 TWh noted here is the amount of renewable energy that would be needed to develop the hydrogen anticipated by the REPowerEU plan in keeping with that definition. Claeys, B., Rosenow, J., & Anderson, A. (2022, 27 June). Is REPowerEU the right energy policy recipe to move away from Russian gas? *Euractiv*. https://www.euractiv.com/section/energy/opinion/is-repowereu-the-right-energy-policy-recipe-to-move-away-from-russian-gas

128 Inman, M., Aitken, G., & Zimmerman. (2021). *Europe Gas Tracker Report 2021*, p. 8. Global Energy Monitor. https://globalenergymonitor.org/report/europe-gas-tracker-report-2021

No single policy instrument or regulation can drive this process on its own. With its suite of policies encompassed by the Fit for 55 package to meet the goals of the European Green New Deal, the EU recognises this fact. The Energy Efficiency Directive and the Energy Performance of Buildings Directive include measures to transition end uses so that they can be met with low-carbon solutions. And policies such as the Renewable Energy Directive and the gas package address the necessary changes to the energy system to ensure that new end-use needs can be met. Importantly, these policies need to be designed so that they reinforce one another and provide consistent incentives across legislation.[129] Conflicting messages about goals or paths to meet those goals can cause inefficiencies and delay at a time when the achievement of climate targets is paramount.

At a high level, the policy mix needed to transform end uses, shown in Figure 15, includes:

- carbon pricing,
- regulation requiring decarbonisation of end uses,
- incentives to enable and accelerate achievement of decarbonisation objectives, and
- rebalancing structural components that currently favour gaseous solutions.

Figure 15. Design of a policy mix to decarbonise gas end uses

To support and facilitate meeting climate targets, decision-makers can modify existing policies to align them with decarbonisation goals and develop new policies. Critical to both tasks is an understanding of how the individual pieces are supporting the end goal, rather than considering the success of the policy mechanism in its own right.

129 Rogge, K.S., Kern, F. & Howlett, M. (2017). Conceptual and empirical advances in analysing policy mixes for energy transitions. *Energy Research & Social Science*, *33*. pp. 1-10 https://www.sciencedirect.com/science/article/pii/S2214629617303092

Below we explore this principle by considering the policies needed to decarbonise heating. We then address whether the gas package and hydrogen strategies would succeed in supporting such a transition.

The role of carbon pricing

The EU Emissions Trading System (EU ETS) is a cap-and-trade system with a progressively smaller cap for carbon emissions within certain sectors in Europe, including power generation, industry and intra-European aviation.[130] Through the EU ETS, unabated fossil gas will be phased out over time in those sectors, resulting in an overall reduction of gas use.

The Fit for 55 package includes an extension of the ETS, and a new parallel ETS for the buildings and transport sectors. The creation of an ETS for the buildings sector would bring the important tool of carbon pricing to efforts to transition away from the use of fossil gas in that sector — currently the most significant fossil gas end-use sector in many European countries.[131] Given that the status quo retail cost of fossil gas is often lower than low-carbon alternatives for heating buildings in Europe, putting a price on carbon can improve the case for clean heating technologies. Incorporating carbon externalities through a carbon price can thus facilitate the accelerated deployment of energy efficiency and electrification.

Importantly, as discussed above in Principle 2, further measures are needed to ensure that energy efficiency and electrification reach low-income households first so that they can mitigate the adverse impacts of higher fuel costs. A gradual and measured introduction of a carbon price will allow further opportunities to protect low-income households from possible impacts on their disposable income, to avoid forcing them to underheat their homes even more than they already do.[132] Furthermore, the revenues from the EU ETS can, and should, be used to finance energy-efficiency improvements in homes. Carbon revenue recycling is already well established in some EU Member States such as the Czech Republic and Germany.[133] With a potential expansion of the EU ETS to the buildings sector, the amount of revenues will increase, offering more opportunities for using those revenues for building energy-efficiency improvements.

Relying solely on an ETS to meet the climate goals, however, would carry risks that might financially strain consumers and ultimately slow decarbonisation efforts. Only a comprehensive and ambitious buildings policy framework will deliver on Europe's climate and energy goals.[134] Without regulatory and supporting policy measures, the responsiveness of building owners to energy price signals is notoriously small. The sector is beset by market failures and barriers that have stopped the weighted average building renovation rate from rising above 1% per year. Addressing these issues

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130 Thomas et al., 2021.

131 Lowes, R., Rosenow, J., Scott, D., Sunderland, L., Thomas, S., Graf, A., Baton, M., Pantano, S., & Graham, P. (2022). *The perfect fit: Shaping the Fit for 55 package to drive a climate-compatible heat pump market, p. 12, 18.* Regulatory Assistance Project, Agora Energiewende, CLASP and Global Buildings Performance Network. https://www.raponline.org/knowledge-center/the-perfect-fit-shaping-the-fit-for-55-package-to-drive-a-climate-compatible-heat-pump-market

132 Thomson, H., & Bouzarovski, S. (2018). *Addressing energy poverty in the European Union: State of play and action*. EU Energy Poverty Observatory. https://www.precarite-energie.org/IMG/pdf/paneureport2018_final_v3.pdf

133 Wiese, C., Cowart, R., & Rosenow, J. (2020). The strategic use of auctioning revenues to foster energy efficiency: status quo and potential within the European Union Emissions Trading System. *Energy Efficiency*. Issue 8/2020, pp. 1677–1688. https://www.springerprofessional.de/en/the-strategic-use-of-auctioning-revenues-to-foster-energy-effici/18374330

134 Thomas et al., 2021.

requires the adoption of regulatory and supporting policy measures – like funding, finance and practical support – alongside carbon pricing.

Regulation to decarbonise end uses

As explained above, carbon pricing alone will not be able to deliver end-use decarbonisation fast enough. Regulation has been successfully applied to achieve market transformation towards cleaner and more efficient technologies.

There are many options for using regulation to trigger a shift from fossil gas to clean end uses:

- Minimum energy performance standards for buildings and appliances can be designed to require that fossil gas end uses are gradually converted by phasing out the sale, installation or use of fossil-fuel-combusting appliances.
- A clean heat standard can be implemented that requires heat or heating fuel suppliers to achieve targets for reducing emissions.[135]
- Manufacturers of fossil gas heating systems can be obliged to sell a rising share of clean heating systems.[136]
- Industry can be required to electrify processes up to certain temperatures.

Incentives to overcome upfront barriers

In acknowledgment that clean heating technologies are often associated with higher upfront costs, governments in several countries have offered financial incentives to end users to encourage them to switch away from fossil fuels. These incentives need to be refocused and expanded. For example, in the past, financial incentives for energy efficiency supported the switch from a gas-burning appliance to a more efficient gas-burning appliance. This support delivered substantial energy savings as inefficient appliances were phased out, but perpetuating gas dependence is no longer a viable option in the context of full decarbonisation. In some countries, policymakers have discontinued support of incentive programmes for technologies that use fossil gas. Policymakers wanting to accelerate the phaseout of fossil fuels can evaluate existing funding programmes and redirect support away from those incentivising gas-burning appliances and towards clean heating technologies.

Removing structural barriers by reforming energy taxes and levies

Most, if not all, independent analyses of pathways to net-zero emissions demonstrate that electrification plays a critical role in moving away from fossil gas. The current price ratio of electricity to fossil gas irrationally favours gas in many European countries. Part of the reason for electricity being on average 3.3 times more expensive than fossil gas[137] is that more taxes and levies are added to electricity than to gas bills.

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[135] Cowart, R., Seidman, N., & LeBel, M. (2022). *A Clean Heat Standard for Massachusetts.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/clean-heat-standard-massachusetts

[136] This policy has been proposed by the UK government and is currently under consultation. UK Department for Business, Energy & Industrial Strategy. (2021, 19 October). *Consultation outcome: Market-based mechanism for low carbon heat.* https://www.gov.uk/government/consultations/market-based-mechanism-for-low-carbon-heat

[137] Rosenow, 2021.

Much of this imbalance is a result of policy and regulatory choices and can be resolved through reform. The European Court of Auditors has called for these changes.[138]

In many countries, the costs of renewable energy deployment and integration have been added to electricity bills. One of the most prominent examples of this is Germany, where the costs of feed-in tariffs were added to electricity over the years and eventually made up about 20% of the average electricity price. In addition, the industrial sector is sometimes exempt from the energy taxes and levies that residential consumers pay. This situation shifts an increased burden to other consumers and thereby further increases the ratio between electricity and gas prices for households. Germany decided to reduce those levies related to renewable energy by 43%, and the incoming government has agreed to shift electricity levies from consumers' bills to general taxation.[139]

A mix of policies needs to operate in concert to facilitate a rapid and significant transition from the current situation, wherein the EU consumes around 400 billion cubic metres of fossil gas per year.

In sum, a combination of policies is needed to achieve the rapid decarbonisation of end uses needed to meet climate targets. Norway, which is close to completely decarbonising heating in the buildings sector, provides a striking example of this point. Norway implemented a combination of policies to achieve its goal, including regulation that set gradual bans on fossil fuel boilers and also developed district heating, incentives in the form of subsidies for residential heat pumps, and taxes on fossil fuels used for heating.[140] Norway's emissions from household heating in 2020 were 2% of total national emissions, whereas the EU average is 36%.[141] The Netherlands represents another example where multiple policies are designed to enable a gas phaseout.[142]

Ensure that the gas package supports a strategic policy mix

Given the need for a combination of policies that support one another to achieve climate targets, decision-makers are in a position to ensure that these policies operate in concert with one another to decarbonise end uses. In designing a climate-aligned gas package, it is vital that all market rules support the combination of policies already in place or in development to meet climate goals. At the very least, the rules should not stand at odds with policies to meet those targets.

The gas package proposal does not fit within the decarbonisation puzzle because it sends messages inconsistent with EU climate targets, efficiency first and system integration. The Commission has outlined a clear plan for what is needed for overall system decarbonisation: a more circular energy economy with energy efficiency at its

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[138] Simon, F. (2022, 31 January). EU's energy taxation policy contradicts climate goals, auditors say. *Euractiv*. https://www.euractiv.com/section/energy/news/eus-energy-taxation-policy-contradicts-climate-goals-auditors-say

[139] The German Federal Government. (2022, 27 April). *Renewables levy abolished: Relief for electricity consumers*. https://www.bundesregierung.de/breg-en/news/renewable-energy-sources-act-levy-abolished-2011854

[140] Agora Energiewende, n.d.

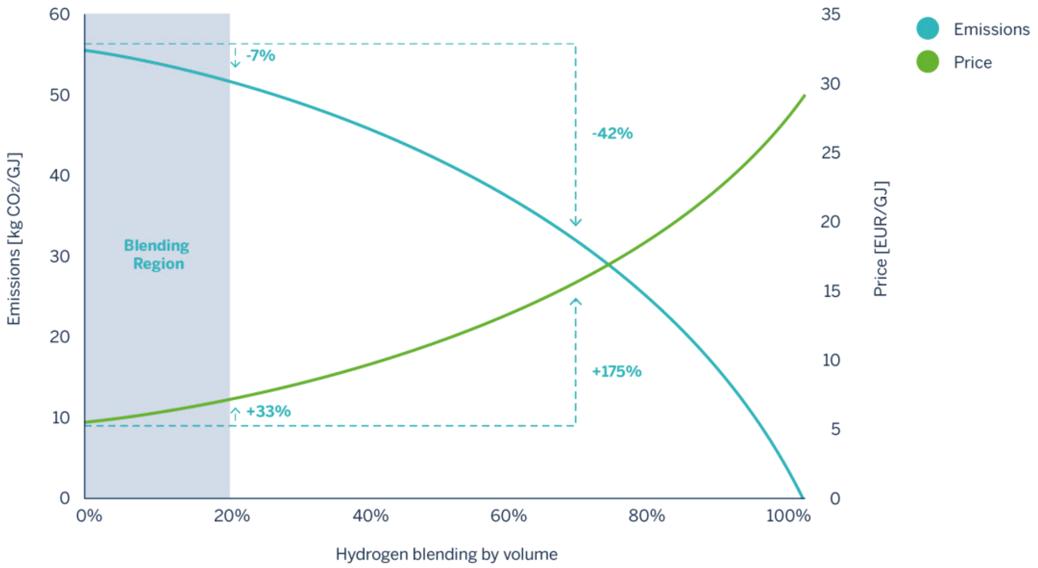
[141] Agora Energiewende, n.d.

[142] Koster, E., Kruit, K., Teng, M., & Hesselink, F. (2022). *The natural gas phase-out in the Netherlands*. CE Delft https://cedelft.eu/publications/the-natural-gas-phase-out-in-the-netherlands

core, increased electrification and the use of alternative gases to meet hard-to-electrify sectors. As noted above, other elements of EU policy support these goals: the Energy Efficiency Directive, which sets targets for energy savings; the Energy Performance of Buildings Directive, which requires new and existing buildings to meet minimum energy performance standards; and the Renewable Energy Directive, which sets targets for renewable heating and cooling. The gas package needs to work in concert with these policies to facilitate the decarbonisation of end uses to first reduce the total amount of gases needed to support the system, and to reserve the limited supply of alternative gases for end uses that would otherwise struggle to decarbonise.

The gas package notes these goals, but does not embrace them. Instead of considering how the gas market could be situated within a combination of decarbonisation policies, it is framed around building a market for alternative gases without considering the context of need for that market. On the residential side, for example, provisions requiring investment of resources into continuing gas service, such as smart meters and facilitation of gas provider switching, will result in residential consumers being left on a less effective and less efficient system in meeting their needs than investment in energy efficiency and electrification.[143] The package's inclusion of rules that support low-carbon hydrogen, which may not even reduce overall GHG emissions[144] and is now less cost-effective than renewable hydrogen,[145] further muddies the role of gas in a decarbonised system. Finally, allowing for blending hydrogen into the gas supply sends the message that the gas system should be perpetuated. Blending 20% hydrogen into the grid would reduce GHGs by only 7% and increase costs by 33%, as shown in Figure 16 below.[146] Blending would thus use up hydrogen, which is more valuable in hard-to-abate sectors, for limited GHG reductions and increased costs.

Figure 16. Hydrogen blending abatement costs, 2030



Source: Flis, G., & Deutsch, M. (2021). *12 insights on hydrogen.*

[143] European Commission, 2021b.

[144] The International Council on Clean Transportation (ICCT), 2021; Howarth & Jacobson, 2021.

[145] Buck et al., 2022.

[146] This analysis assumes a fossil gas price of 20 EUR/MWh (=5.6 EUR/GJ) and a hydrogen price of 3.7 EUR/kg. Flis & Deutsch, 2021.

Decision-makers could instead design the gas package to align with the combination of policies to meet carbon reductions. The package's explanation sets the proposal within this context; decision-makers can help ensure that the specific provisions support these policies. For example, the proposal already notes that hydrogen is expected to be used "mainly in the areas where electrification is not an option."[147] As a result, the package notes, dedicated hydrogen infrastructure is needed to support the use of hydrogen to decarbonise specific end-use applications. To facilitate meeting this goal, the package could provide rules that enable development of a market targeted at hard-to-electrify sectors. For example, the package could include requirements that infrastructure planning prioritise least-regret hydrogen infrastructure development (as outlined in the graphic on page 31), or could provide incentives for the replacement of grey hydrogen with green hydrogen, an immediate and relatively simple path to achieving carbon reductions.[148] To enable electrification in cases where it is a more cost-effective and efficient option, the package could include provisions to make certain that consumers have relevant information about the costs and GHG emissions associated with gas or electricity services, not merely about switching between gas providers. Prohibiting switching charges or termination fees could further ensure that consumers were able to consider their options across energy systems.

In short, instead of creating rules that ensure a market design that fits a decarbonising system – namely one with almost no fossil gas, with alternative gases serving hard-to-electrify end uses – the proposed gas package widens the pathway for gases, including hydrogen. This approach diverts resources and attention away from solutions that could immediately and sustainably reduce carbon emissions. By situating the gas package within the broader suite of decarbonisation policies, decision-makers can resolve these inconsistent signals.

Focus hydrogen strategies to meet end uses that need hydrogen

Hydrogen strategies also need to be aligned with overall decarbonisation objectives. Common to all scenarios for system decarbonisation is a recognition of the limited availability of renewable hydrogen and hydrogen infrastructure. As a result, the strategies rightly focus on the role for hydrogen as one of meeting hard-to-decarbonise end uses. This focus makes sense even if hydrogen becomes less expensive because electrification can still meet end uses more efficiently and effectively than hydrogen solutions – and, importantly, can do so immediately, in line with Principle 1. Least-regrets hydrogen strategies that do not tip the scales in favour of hydrogen in unneeded sectors are important for several reasons: 1) to ensure hydrogen is available where it *is* needed; 2) to incentivise infrastructure development to serve those end uses; 3) to disincentivise hydrogen infrastructure development when it is unneeded, so as to avoid stranded assets or perpetuation of existing gas pipelines based on promised hydrogen development; and 4) to avoid allowing hydrogen to distract from solutions that can decarbonise end uses more effectively, efficiently and quickly.

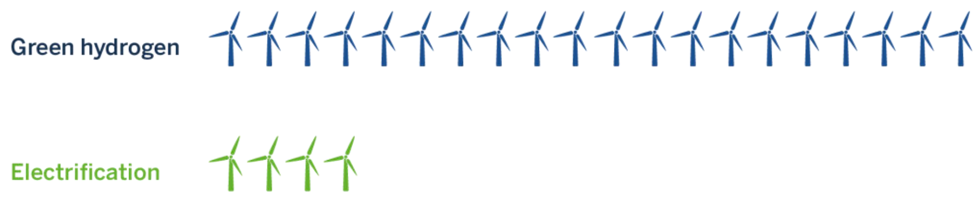
[147] European Commission, 2021b, p. 1.

[148] Flis & Deutsch, 2021.

Hydrogen development and infrastructure is needed to secure sufficient quantity and delivery capacity to use hydrogen to serve hard-to-electrify end uses, but it does not need to do more than that. Anchoring development around industrial clusters that will need hydrogen to decarbonise, such as the chemical or steel industry, ensures that investment goes to developing no-regrets hydrogen corridors that allow efficient use of hydrogen for decarbonisation.[149] Ultimately, there may be a larger hydrogen grid serving additional end uses, but an initial focus on no-regrets corridors will provide a path for efficient decarbonisation by aligning available hydrogen with GHG-intensive demand.

This approach will also ensure that where end uses can more efficiently be met through electrification, hydrogen strategies will not distract from those solutions. Delivering hydrogen for building heat, for example, would almost certainly be an investment that would not only divert a needed resource to easily decarbonised end uses, but it would also result in an inefficient allocation of resources. Figure 17 below illustrates the disparity in primary energy needed to heat buildings directly with renewable energy versus the inefficiency of converting renewable energy into hydrogen to serve the same end use.[150]

Figure 17. Amount of renewable energy needed to heat buildings with hydrogen and direct electrification in the UK



Source: *Energy Monitor* analysis of figures from UK Committee on Climate Change. (2018). *Hydrogen in a low-carbon economy.*
Note: 1 symbol = 1,500 turbines.

As Member States further develop their hydrogen strategies, it is critical that they focus on identifying the best uses of hydrogen, sources of supply and the infrastructure needed to bring supply to the specified end uses. Allowing an outsized discussion around hydrogen risks the creation of inflated hydrogen strategies, which risks both diverting hydrogen away from end uses where it is needed and attention away from solutions such as energy efficiency and electrification that can immediately reduce GHG emissions. Focused hydrogen strategies will allow hydrogen to play its critical role in decarbonisation as quickly as possible, in line with the full suite of policies needed to achieve system decarbonisation.

149 Flis & Deutsch, 2021.

150 Rosenow, J. (2021). Heating with hydrogen: Are we being sold a pup? *Energy Monitor.* https://www.energymonitor.ai/sectors/heating-cooling/heating-homes-with-hydrogen-are-we-being-sold-a-pup

Principle 5: Increase transparency and use best available data and information.

Integral to any robust decision-making process is the ability of those considering various options, including regulators, system operators, and policymakers, to rely on the best available data and information. This need is amplified during a time of transition, when considering and comparing new paths forward. Decision-makers need unbiased information to inform thinking about a transition away from dependence on fossil gas, including data about the existing gas system, what needs to be done to retire or transition existing infrastructure, where opportunities exist to avoid further investments in unneeded infrastructure, potential options to meet end uses and how those will contribute to a decarbonised system. To make certain that the information before them is sufficient, decision-makers can subject the data to scrutiny by making it publicly available and creating processes for gathering additional information. In doing so, they gain access to a range of perspectives and analysis that can inform, challenge and ultimately strengthen decisions. Adherence to this principle thus reduces the risk of making decisions that waste time and resources – a situation that the climate can no longer afford.

Implementation of this principle is closely tied with the planning requirements outlined above. In those processes, regulators can assess whether system operators are considering the information needed to evaluate an array of solutions. Policymakers can ensure provisions are in place to require that data be shared with regulators and be made publicly accessible to stakeholders so that they can also provide input and analysis on the data being used. To ensure that regulators and system operators are considering stakeholder input, policymakers can require public processes that guarantee opportunities for additional information and critical analysis to be added to the procedures.

Decision-makers and stakeholders can then analyse the data and information available to verify that it is supporting solution sets to meet end uses in line with carbon targets. One approach is to use available data to create a system map with overlapping layers of information, including the information noted in the text box below. These layers could include an underlying map of existing infrastructure, end users served by that infrastructure, current and projected demand and supply, and the assumptions upon which that data is based. Information regarding the infrastructure in the ground could be included on the map itself, with more dynamic information explained in supplementary and supporting materials.

This information can then inform the development of solution sets to meet current and projected demand and analysis of these scenarios to test them against considerations of cost, risk, equity and alignment with climate targets. Gas suppliers[151] and system operators[152] generally have this information, but it is not always shared in a manner that allows decision-makers or stakeholders an opportunity to analyse how this data informs solutions. Having baseline information from which regulators, system operators and stakeholders can discuss scenarios to meet end uses will allow richer discussions and solutions among and within these groups.

[151] See example of data on physical flows for Ireland: Gas Networks Ireland. Dashboard reporting: Physical flows. https://www.gasnetworks.ie/corporate/gas-regulation/transparency-and-publicat/dashboard-reporting/entry-flows/physical-flows

[152] ENTSO-G, Transparency Platform, https://transparency.entsog.eu/#/map

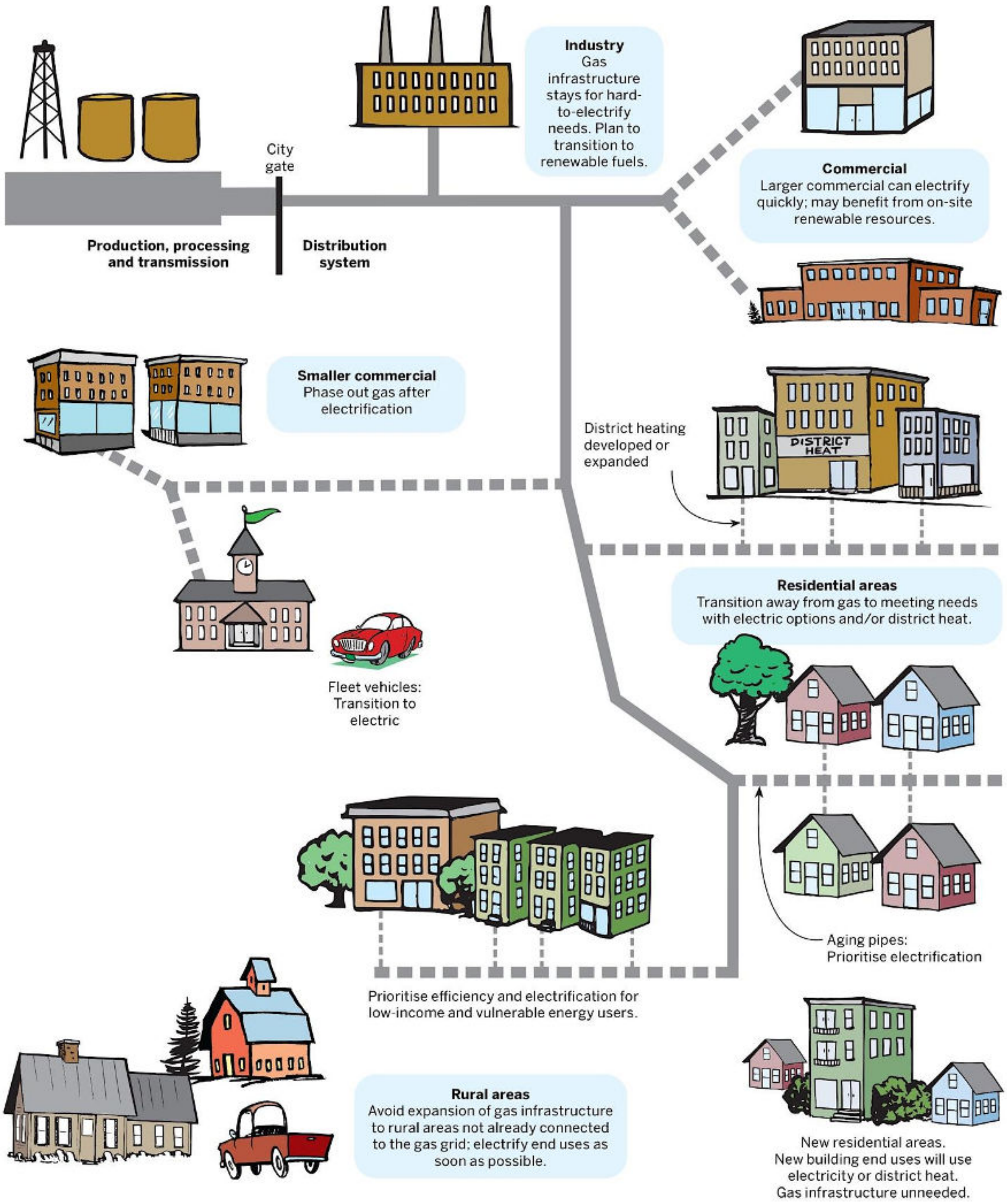
Baseline information for effective decision-making

Regulators and other decision-makers considering potential infrastructure requests can facilitate good decision-making by ensuring that they have the information needed to take a view of the system as a whole. The list below includes information that will allow regulators to consider the existing system, where the system might be headed and different pathways to move between the two.

- Transmission, distribution and gas service infrastructure, including the length and diameter of pipelines, pipeline material and pipeline pressure. This description should include the condition of existing pipelines, including the age and condition of the pipes, leakage rates (number of leaks per kilometre) and depreciation status.
- Interconnects, gate stations, compressor stations and any storage facilities.
- Areas of constraint or congestion in the system.
- Areas where maintenance or replacement of existing infrastructure may be needed and an explanation for why these areas need attention, such as safety considerations or aging or damaged pipes.
- The size of all consumer classes, including residential, commercial, industrial and transportation consumers.
- Requirements for delivery, including firm contracts, or contracts for which supply cannot be disturbed, and interruptible contracts, or contracts that allow for interruption of delivery under certain circumstances.
- Density of service areas, such as number of consumers and demand.
- Areas that the utility has considered for system expansion or contraction.
- Areas that the utility has identified as difficult to serve.
- Any additional detail about its consumer base that might affect planning.
- Assessment of the utility's current and anticipated demand and its assumptions to reach those projections, broken down by consumer class, by season and by volumetric and peak requirements, based on current and historical delivery.
- Assumptions the DSO uses when assessing demand, including weather forecasting assumptions, current efficiency or demand-side management requirements or programmes, and an analysis of the potential for electrification of gas end uses that may occur naturally, either because of cost-effectiveness over the planning horizon or with the assistance of programmes that address inherent market barriers.
- Factors that the DSO uses to forecast changes to demand, including considerations of any areas where the utility is seeing changes in gas usage due to electrification, potential programmes that might incentivise electrification or remove market barriers, or areas of increased gas usage.
- Sources of supply, supply contracts including contracted quantities and duration of contracts, and any storage or contingency supply resources.
- Any known or anticipated concerns about current sources of supply, such as anticipated price increases, previous delivery problems including any constraints due to weather or transmission limitations, potential changes in sources of supply, and attendant considerations about possible needs for gas connection moratoria.

The simplified map[153] in Figure 18 illustrates how looking at information about the system in layers can highlight opportunities for system changes that align with GHG reduction goals, prioritisation of low-income, energy-poor and vulnerable customers in a transition, and focused development of alternative fuel infrastructure.[154] Creating such a map gives decision-makers a visualisation of where the system might be headed, which can lead to the development of solution sets that might not otherwise be identified.

Figure 18. Illustrative system map scenario



[153] Final illustration by Tim Newcomb. (2021). Newcomb Studios.

[154] Another visualisation forms part of a report on the transition in the Netherlands, see Koster et al., 2022, p. 7.

Although system operators are beginning to share this data on public platforms,[155] policymakers could require the further development of an EU-wide platform where information must be recorded and made available to the public in a format that is accessible and usable, and in a manner that allows for timely input into planning processes. To avoid claims of confidentiality outweighing a more general rule of transparency, decision-makers can establish a system in which they can determine whether a request for confidentiality is legitimate. This process can be governed by rules that establish clear metrics for confidentiality requests and the rationale for decisions on confidentiality requests.

Policymakers can also create open and transparent processes that allow stakeholders to add to and challenge assumptions being made by decision-makers or system operators. By creating stakeholder processes wherein relevant parties have access to data, can submit additional data and have insight into system operators' decision-making, policymakers and regulators can enable testing and review of data from various perspectives. For such a process to be effective, detailed data must be shared, including inputs and assumptions, outputs of analysis and explanations of any models used, and those models should be made available.

Transparent, open processes are a hallmark of robust decision-making, but are often skimmed over, or given only pro forma attention. Using the best available data and creating a transparent system to share and test that data can improve decision-making and communication with interested parties, facilitating achievement of the first four principles in this report.

Expand transparency and public participation requirements in the gas package

The gas package presents an opportunity to introduce increased transparency into the gas sector to ensure that, during a period of rapid and increasingly chaotic change, decision-makers have access to information to inform their analysis. An initial step, which would inform both the gas market proposal and ongoing work on gas issues, would be an analysis and outline of the current requirements for system operators, suppliers and other related entities to share, including:

- Current information requirements.
  - Identification of the regulatory authority for current requirements.
  - With whom this information must be shared.
  - Where this information is available.
- What requirements are in place to consider confidential information.[156]
  - Processes for non-public review of claims of confidentiality to separate confidential pieces from remaining information.
  - Transparent metrics for making decisions about confidentiality.
  - Methods to release non-confidential information.
  - Opportunities to review claims of confidentiality.

With this initial outline of information requirements, decision-makers can then determine where there are gaps in oversight and transparency in the system and what

[155] ENTSO-G. (n.d.), *Transparency platform*, https://transparency.entsog.eu/#/map; European Network of Transmission System Operators for Gas (ENTSO-G). *Ten year network development plan*. https://www.entsog.eu/tyndp

[156] European Commission, 2021a, pp. 25-26.

additional data is needed to inform future decisions as old paradigms shift. Decision-makers can then consider whether there is sufficient regulatory authority to expand current data-sharing requirements, and how to improve systems to increase transparency.

The current gas market rules do not provide a consolidated list of data requirements, and the gas package proposal does little to improve on current rules.[157] Information requirements are scattered throughout the package, but it does not provide a clear picture of overall data requirements or how that data might be accessed. In general, data requirements carry over from existing rules and are thus largely limited to a traditional approach of market operation and infrastructure additions that were within the purview of system operators, users and investors. Furthermore, they are based on assumptions of a gas market operating in isolation and a system expanding to support increased gas usage. Thus, the requirements are targeted to make certain that those players have sufficient information to operate and develop new assets in the system and are consequently limited to sharing information within those groups. For example, current provisions require that system operators share information only with specific entities, such as system users, to ensure they have "efficient access to the infrastructure."[158]

As the system evolves, however, decision-makers and stakeholders need additional information about the system to consider steps to limit any growth of the system to the selected end uses for which gaseous fuels will be used, to limit infrastructure upgrades, and to consider next steps to decommission unneeded infrastructure.[159] The gas package proposal does not expand information requirements in a way that provides policymakers and regulators access to the data needed to consider the system from this new and evolving vantage point. Requirements that ENTSO-G increase transparency do not fulfil this need.[160] As noted above in regard to planning, leaving this important function in the hands of system operators will not resolve transparency issues unless additional data-sharing provisions, which require access to raw data and the ability to conduct independent analyses of that data, are included within the package. Furthermore, shifting the responsibility for transparency to ENTSO-G means that DSOs, which must increasingly be integrated into the system, may not have sufficient information.[161]

Moreover, by not including additional data and information requirements, the gas package sends a signal of business as usual – a message that would stand in stark contradiction to EU climate targets and the even more recent targets included in the REPowerEU communication. This lack of perspective, fuelled by a lack of information,

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[157] European Commission, 2009; European Commission, 2021a; European Commission 2021b.

[158] European Commission, 2021a; European Commission 2021b.

[159] European Commission, 2021c, p. 22: "Current development plans focus on the identification of additional investments, while neglecting information on which infrastructure may not be required anymore in the future. There is hence a need to adapt the network planning to not only focus on new investments, but to provide information on infrastructure parts that could be decommissioned or repurposed." Agency for the Cooperation of Energy Regulators (ACER) & Council of European Energy Regulators (CEER), 2019: "New investment in natural gas assets should be checked to ensure consistency with decarbonisation targets."

[160] European Commission, 2021a, p. 23.

[161] Agency for the Cooperation of Energy Regulators (ACER) & Council of European Energy Regulators (CEER). (2021). *Position paper on the key regulatory requirements to achieve gas decarbonisation*. https://acer.europa.eu/Official_documents/Position_Papers/Position%20papers/ACER-CEER%20Position%20paper%20on%20gas%20decarbonisation_final.pdf: "With respect to the Hydrogen and Decarbonised Gas Market Package, regulators advocate including in the TSO NDPs the information from the distribution level which potentially affects planning at transmission level."

stands in the way of decision-making that is aligned with climate targets and other EU policy. Without adequate information requirements, decision-makers may not recognise that the decisions system operators and suppliers are making are in fact leading to greater investments in a system that cannot support decarbonisation targets. For example, system operators continue to invest significant resources into fossil gas pipeline infrastructure, at a time when decommissioning should be the headline.[162] These investments not only divert attention away from needed action, such as transitioning end uses and system decommissioning, but they also shift resources to infrastructure that will likely become stranded, and increase costs for consumers, including vulnerable energy users who may struggle to leave the gas system.

By contrast, recognition of a greater need for transparency and information sharing, and provisions making that need a priority, would send the message that the gas system must become more open to allow for integration into a broader energy system that can meet decarbonisation goals.

Require that best available data and projections inform hydrogen strategy timelines and projections

As discussed above, the limited availability of clean hydrogen and the investment that would be necessary to deliver hydrogen to distributed end uses limit its role in a decarbonised system to serving hard-to-decarbonise end uses. This analysis is based on current data about the infrastructure needed to further develop renewable resources to power electrolysers to produce green hydrogen, the investment required for those electrolysers, development of infrastructure to deliver that hydrogen to end users, and the resulting costs and consequent increase in consumer prices to do so. Despite those limitations, discussions and projections about hydrogen's availability vary widely. Estimates depend on the optimism of the speaker about the speed at which the costs of hydrogen will fall, and how quickly markets can be developed – and hydrogen subsidies implemented – to enable hydrogen to become more cost-competitive. Projections are thus made that hydrogen will serve end uses ranging from fairly-universally-agreed-upon hard-to-electrify end uses to residential heating and cooking.

As decision-makers confront these varying scenarios, it is critical that they have adequate information to test claims and determine where best to utilise scarce resources to reduce GHG emissions with the urgency required.[163] They need information not just about where alternative gases will be developed, but also information about greenhouse emissions from any feedstocks (in the case of blue hydrogen, for example), about the infrastructure needed to deliver hydrogen to end uses, about whether there is sufficient hydrogen supply to meet the needs projected by project proponents, and about the safety of meeting varying end uses with hydrogen.

This information must also be updated regularly based on changing circumstances. Already, the price of blue hydrogen, once considered a bridge to development of hydrogen markets that could support green hydrogen, has increased dramatically in response to the spike in fossil gas prices. Recent analysis reveals that the relative GHG reductions of blue hydrogen may also be minimal, if there are any at all. Finally, and as discussed above, additional information about the safety and pollution caused by

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[162] Anderson et al., 2022. Aitken et al., 2022.

[163] Agency for the Cooperation of Energy Regulators (ACER) & Council of European Energy Regulators (CEER), 2021: "An integrated system perspective is needed to find the optimal design for support schemes, while not producing unintended consequences or perverse incentives; e.g. the promotion of green hydrogen should not jeopardise the direct use of renewable energy in the electricity sector."

hydrogen combustion calls into question its suitability for certain end uses. In sum, requirements for updated and critically examined information are increasingly important as decision-makers consider the significant commitments – and high opportunity costs – required to invest in hydrogen solutions.

Conclusion

The gas sector is in the midst of a profound change, which is necessary to meet climate targets. Also important, however, is how that transition proceeds. Decision-makers can focus efforts on system decarbonisation to meet end uses efficiently, with the least carbon impact, and in a manner that protects disadvantaged consumers. They can identify where certain energy sources would best meet different needs, thus ensuring that energy sources, infrastructure and end-use equipment are developed in line with sound planning and are available to efficiently meet end uses.

A constrained focus on decarbonisation of the gas system, by contrast, will lead to solutions that merely perpetuate a system that needs to evolve. Although gaseous fuels will continue to be needed in a decarbonised system, their role will be fundamentally different in the future. Rather than needing a gas network that serves individual consumers, hydrogen and zero-carbon fuels will be needed only for hard-to-electrify sectors such as aviation and heavy industry. Failing to recognise this fundamental shift will only delay this essential transition. Just as a focus on a 'clean coal' future wasted time and resources without success, a focus on 'greening' gas supplies is similarly misplaced.

Instead, by addressing the decarbonisation of the energy system as a whole, policymakers, regulators and stakeholders can identify the most effective paths to achieving carbon reductions quickly, equitably and efficiently. They can do so by first determining the most efficient way to meet end uses and then considering the infrastructure and supply required. This integrated approach will create the pathways to a decarbonised system at least cost to consumers and the climate.

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