Gas infrastructure can smooth Germany's energy transition

Harnessing Germany's vast gas infrastructure has the potential to play a critical role in helping to meet the country's greenhouse gas reduction goals. The network of storage tanks and pipelines could deliver all sorts of carbon-neutral green gases for use in heating, industry and transport. By obviating the need for extensive investments to expand its electricity network and for the installation of new electric end-user appliances (such as heat pumps), Germany could save as much as 12bn euros a year by using its gas infrastructure to transport energy. The savings would help underpin popular support for Germany's Energiewende, or energy transition.

Green gas as an alternative to electricity transport

Germany, like most other EU member states, has set itself ambitious targets to tackle global warming. By 2050, greenhouse gas emissions are to be reduced by 80-95% from 1990 levels. In practical terms, this means energy generation, transport and heating will have to be decarbonised almost completely while industry will have to reduce its emissions significantly.

People will need to consume energy more efficiently. But achieving the targets will principally entail sectors that currently rely on fossil fuels switching over to renewable energy. This includes heating, which today uses natural gas and heating oil, and transport, where the main fuel today is petroleum. Our previous article looked at some of the general options and challenges around heating in particular[1].

This switchover begs the question of how to transport renewable energy to millions of customers. To this end, Frontier Economics, supported by IAEW, 4Management and EMCEL, conducted a study of the German energy market on behalf of the Association of German Gas Transmission System Operators (FNB Gas). The association wanted to know what role the country's gas infrastructure could play. Our conclusion? A big role, befitting gas's importance in the economy.

Gas supplies about 24% of Germany's energy needs today – a figure that rises to 45% for heating. The transport, storage and distribution infrastructure is correspondingly extensive. There are 500,000km of pipelines, and in terms of transport capacity, gas beats electricity by more than a factor of four. Yet it is relatively unobtrusive: an important selling point given the public's aversion to eyesores. The gas network also has substantial storage capacity, as it has to cope with significant seasonality. Average gas consumption in February is more than three times greater than in August. To meet the spike in demand in winter, Germany has gas storage volume of around 260 TWh, enough to cover peak demand for more than two months without additional supply sources. By contrast, Germany can store just 0.04 TWh of electricity, which is not even sufficient to satisfy peak demand for an hour.

[1] https://www.frontier-economics.com/uk/en/news-and-articles/articles/article-i2193-green-heating/

It would seem to make sense to put this infrastructure to work in the future to transport "green gas", i.e. climate-neutral gas obtained from biogas or generated synthetically from renewable electricity in the form of hydrogen or methane. But given the conversion stages this would require, such as power-to-gas, and the impact on end-use applications (e.g. retaining gas boilers instead of completely switching to electricity-based heating systems), a further question arises: would this approach be cost-effective?

2050 energy systems with or without gas networks

To answer this question, we analysed three scenarios for 2050 encompassing every consumer sector, particularly heating and transport, as well as the largest sectors for final energy consumption:

- All-electric option – In this world, consumers would primarily use electrical applications such as heat pumps and electric cars. Gas infrastructure would no longer be used and would be decommissioned. Energy (as electricity) would be transported to the final customer entirely via power networks.
- Electricity with gas storage option – In this world, people would again mainly use electrical applications, but electricity could be stored temporarily in the form of gas and fed back into gas-fired power plants ("power-to-gas-to-power" or PtGtP). However, energy would still be transported to the final user exclusively via power networks (as electricity). Accordingly, gas transport and distribution networks would be decommissioned, but gas storage would still be used.
- Electricity and green gas – In this scenario, some functions would remain gas-based, but they would use green gas generated synthetically in German power-to-gas (PtG) plants based on renewably generated electricity. Consequently, in parallel to the power network, the existing gas infrastructure would continue to be used for energy transport and distribution.

To ensure a robust comparison of the scenarios, we built a series of assumptions into our models, including, importantly, identical end usage of energy – so, for example, the area heated or kilometres travelled are the same in each case.

Green gas for long-term energy storage will be essential

The most striking finding of our analysis is that an all-electric world is likely to be prohibitively expensive without the use of gas storage systems, at least for seasonal storage of renewable electricity.

The reason is quite simple. The extreme seasonality of electrified-heat demand coupled with the dependency of renewable power on the wind and the sun poses severe challenges, especially because of the shortcomings of electricity storage methods. What happens when there's a long spell of no wind in the dark days of winter? Pumped storage power plants or batteries can store energy for short periods and only in small quantities. As noted earlier, the current energy volume of all the electricity storage systems in Germany would meet the country's electricity load for less than an hour. Expanding this capacity would be extremely expensive - absent major technological breakthroughs.

Green gas significantly reduces system costs

Our comparison of the scenarios with and without gas transport networks also shows that using gas transport and distribution networks to supply end-customers with green gas could generate savings of around 268bn euros by 2050, or 12bn euros a year (in real terms, in 2015 prices). That's because there will be less of a need to invest in electricity networks or for final users to switch from gas boilers to more expensive electric heat pumps.

The prospect of making substantial savings should help soften public resistance to the Energiewende. Although Germans still take a fundamentally positive view of the expansion of renewable energy sources, they are a lot less keen when wind turbines or overhead power lines are built near their homes.

This "Not in My Backyard" attitude has already provoked stiff opposition to the expansion of electricity networks in Germany, causing severe delays. And this is even before the public has registered the need for a substantial extension of the country's electricity networks in the next few years in the course of "sector coupling", i.e. the decarbonising of sectors such as heat, transport and industry by using renewable electricity.

The use of the existing gas transport infrastructure represents an attractive alternative. Our models show that employing gas networks could reduce the need to expand Germany's electricity transmission network by around 40% and its distribution network by as much as 60%. Since gas networks already exist and have been built underground, they can contribute significantly to public acceptance of the Energiewende.

Furthermore, it is worth noting that Germany's gas infrastructure is an integral part of a pan-European network that allows energy to be transported over long distances. Germany can thus tap sources of green gas in other, less densely populated countries where it can be generated more cheaply. In order to ensure comparability with electricity-only solutions, our analysis has not even considered such cross-border green gas options. But in practice these could be of major significance for the Energiewende, both by strengthening Germany's security of supply and by reducing the need for it to generate its own renewable energy.

In a follow-up project for a group of European transmission system operators, we are now analysing whether existing gas infrastructure holds out potentially similar benefits for other countries and for Europe as a whole. Furthermore, in a project for the European Commission we are going to analyse existing regulatory barriers to the use of green gas, and potential political changes to overcome them.

Conclusion

Some will find it a counter-intuitive suggestion that gas, today a fossil fuel, can help tackle global warming. But our study of Germany's energy market shows that using the country's gas infrastructure to transport energy in the form of green gas can make a valuable contribution to decarbonisation in future. Indeed, our analysis finds that it may be unrealistic to imagine that Germany will be able to rely on intermittent supplies of solar and wind power without continuing to use the extensive storage capacity of its gas network. Using both gas storage and gas networks will be cheaper than the all-electricity alternative and is likely to find favour with a public still sceptical of the details of the Energiewende.

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