A NEW LIFE FOR GAS

New global market
USING LNG IN TRUCKS AND SHIPS

Enabling the transition
STORING SOLAR AND WIND ENERGY AS GAS

Towards sustainability
50% GREEN GAS IN 2050

Gas as miracle oil for the energy system
THE VISION OF DICK BENSCHOP OF SHELL

Smart gas
IN BUILDINGS

Testing ground in Groningen
FOR DECENTRALISED GAS SOLUTIONS

Gas is one of the Netherlands' biggest success stories of the past fifty years. But we're now on the eve of a big Energy Transition. Will there still be a role for gas in this brave new energy world? And if so, what will it be?

A NEW LIFE FOR GAS
MORE EXCITING THAN THE OLD ONE?

To find out, we've sounded out dozens of energy experts, from the Netherlands and other countries around the world. The views that emerged are varied. On the one hand, the experts seem to agree that the next fifty years for gas will be totally different from the previous fifty: things will never be the same again. But at the same time, the experts believe that gas has every chance of becoming a Dutch success story once again. Why? Because it has everything a fuel needs to meet the future needs of society.

Until now, the part played by gas has been relatively simple. Gas was an ideal fuel for heating purposes and for generating electricity in power stations. On top of that, it was a commodity that produced a steady stream of income for the Netherlands, needing very little attention and more or less looking after itself.

But times have changed. Gas will increasingly be replaced by renewable energy sources as a fuel for generating electricity – not suprisingly, as the Energy Transition is all about replacing fossil fuels with renewables. Gas will also gradually play a smaller part in heating our homes, simply because newly built homes will become increasingly more energy-efficient and need less heating.

So does this mean the end of the gas era? Fortunately, for the Netherlands, the answer is no, not yet. In fact, gas may well come to take on an entirely new role in our energy provision. It could help to solve our energy needs in three ways.

First, for some uses, we can expect to see gas displacing its fossil competitors (coal and oil), mainly because gas is cleaner. Once countries have agreed on a fair price for CO_2 (which they're bound to do sooner or later), gas will be preferred to coal for generating electricity. And, for various reasons, gas is also well positioned to replace diesel and petrol in the transport sector – indeed, in some places, it is already doing so.

Second, gas and the gas grid are increasingly facilitating the further use of renewable energy in the sustainable economy of the future. Rather than being just a simple commodity and a network of pipelines, they're fast becoming a high-quality service provider, enabling the implementation of sustainable energy. In this way, gas can provide not only a flexible back-up for generating electricity when supplies of solar and wind power are insufficient, but also supplement energy from solar panels and solar boilers in buildings. In addition, the gas grid may well become the preferred way of storing and transporting electricity from sustainable sources – a fascinating prospect called 'power to gas', and a field in which Germany in particular has already made substantial advances.

Third, gas itself is set to undergo a metamorphosis, with more types of gas becoming available: natural gas, for instance, will be joined by biogas, green gas, hydrogen, synthetic gas and, yes, even wind gas. In other words, gas itself is becoming greener – which, of course, makes it ideal as a leading protagonist in the energy transition.

Viewed in this way, the new life that gas is moving towards may very well be much more exciting than the life it has enjoyed up till now!

But – and the experts agree on this, too – this sunny future cannot be taken for granted. Gas will have to earn its new role and work very hard at it. Industry and governments will need to do their utmost to ensure that gas can continue to make a valuable contribution to the sustainable economy, far into the future.

The Netherlands has a crucial role to play here. It has invested a great deal in acquiring knowledge, developing technologies and building infrastructures. In addition, the country has substantial gas reserves of its own. Economically speaking, it is therefore very important to the Netherlands that gas does not disappear from Europe.

In this publication, we present a vision of what this new life for gas might look like – the opportunities that may lie ahead for gas and the gas infrastructure, and what is needed to make the most of these opportunities. We hope that all those involved and interested in the energy sector in Europe may find some valuable insights here, and that this publication may provide a sound basis for discussions about the role gas can play in making our energy provision even more sustainable.

Rob Doets Secretary, KVGN
Geert Graaf Acting CEO, Gasunie
Gertjan Lankhorst CEO, GasTerra and Chairman, KVGN

plus...

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THE NEW ROLES OF GAS

Should the Netherlands go into rehab for its 'gas addiction'? No, say most experts. Gas can continue to play an important, positive role in our energy supply, providing it can adjust adjust to new circumstances. Let's take a closer look at the three new roles that gas may soon start to play.

Until recently, Dutch people didn't really talk about gas: it was just there. From time to time, the question of the income it generated for the country came up – and what it should be spent on. Every household received an annual gas bill in the letterbox. And that was about it.

This has definitely changed. Due to recent earth tremors in the Dutch gas fields and the shale gas hype, gas is back on the map. And how! In fact, many people are beginning to wonder whether it's such a good thing...

What's more, natural gas is a fossil fuel and therefore implicated in climate change. Weren't we supposed to be undergoing an energy transition so that we can do without fossil fuels? In addition, our own gas reserves are shrinking, leaving us at the mercy of countries like Russia, from whom we'll need to import gas. Not, in everyone's eyes, a particularly attractive prospect.

All in all, therefore, the question of whether we shouldn't at some point cure ourselves of our 'gas addiction' is a valid one.

THE GAS REVOLUTION

Sometimes, it's good to put things into historical perspective. This year, it's fifty years ago since the Netherlands put together an ingenious joint venture between public and private parties to ensure that the whole country would benefit from its unique gas reserves. One of the things they decided to do was to lay a gas network throughout the Netherlands. Almost all homes in the country were connected to gas – a revolutionary idea at the time. Inevitably, of course, we have now all become used to it. 'We've been spoiled,' says Hans Overdiep, Manager of Energy Transition at GasTerra. 'I once asked my children where they thought the heating in the house came from. They pointed to the thermostat button. They didn't have a clue!'

Overdiep grew up in Groningen, in the shadow of the factory where gas was produced through coal gasification. 'This coal gas, like coal itself, was delivered to the houses. So having a network for natural gas was a big advance at the time. But everyone's forgotten that now.'

The revolution didn't remain limited to the Netherlands. Today, 115 million households in Europe are connected to natural gas. This wasn't because they wanted to do the Netherlands any favours; it was because natural gas is such wonderful stuff. ***It doesn't smell, it doesn't produce smoke, it's incredibly efficient and it's incredibly cheap.***

Efficient and cheap? That's another thing only few people know, says Overdiep. 'You only begin to appreciate this when you start expressing natural gas in terms of kilowatt hours instead of cubic metres.' He does the math. One cubic metre of natural gas provides 10 kWh of energy for € 0.70, which means it costs € 0.07 per kWh. By contrast, electricity costs

€ 0.20 per kWh – almost three times as much. Then there's quantities used. Per year, an average household uses 3,500 kWh of electricity and 1,700 m^3 of natural gas, which amounts to 17,000 kWh. So most of the energy we use – by far – comes from natural gas, not electricity. 'That means, if you want to stop using gas, you'll have a very big energy gap to fill,' says

We shouldn't waste gas, but increase its value

Overdiep. 'For example, using solar panels to generate 3,500 kWh will cover less than 20% of your energy needs.'

A similar story applies to the Netherlands as a whole. Pierre Bartholomeus, Global Director of Gas Consulting & Services of DNV Kema, points out that no less than 50% of our total energy use comes from gas. Industry and the market gardening sector, for instance, are heavily dependent on gas. And we haven't even mentioned the State, which depends on natural gas revenues for billions of euros in income each year.

THREE NEW LINES

In other words, you can't get rid of gas that easily. This doesn't mean, however, that we should leave everything as is. Indeed, it wouldn't even be possible. The sustainability train is thundering on. Solar and wind energy are developing well; while the energy-efficiency train is also puffing along nicely. We may even be moving towards energy-neutral buildings, which will invitably affect our use of gas.

What will the future of gas in sustainable energy provision look like?

Most people who are involved in energy matters (including many who don't work in the gas industry) believe that gas has a future. But this future will look different, because the way we organise our energy provision is changing. In this new set-up, gas will certainly have a role to play – providing it manages to adapt to the new circumstances. Indeed, some experts think that gas and the gas infrastructure may end up playing a very big role.

This new role for gas is a rather complex, threefold one. First, gas may function as a 'transitional fuel'. Second, it may be used permanently in combination with sustainable energy. And third, it may be made sustainable.

1 GAS AS A TRANSITIONAL FUEL

The first of these 'new' roles for gas is as a replacement of fossil fuels that are relatively more polluting than gas. In particular, this applies to fuels like coal in coal-fired power stations and diesel in heavy road transport. In this context, gas is often referred to as a 'transitional fuel' – a temporary bridge to 100% renewable energy provision.

This may seem a modest role, but it isn't. Almost all scientists agree that there is only one affordable way to reduce CO_2 emissions quickly and substantially; namely, by replacing coal-fired power stations by gas-fired power stations. In the United States, where this has already been done, CO_2 emissions have recently come down. By contrast, in Germany, where there are many solar panels and wind turbines but where coal-fired power stations are still very active, CO_2 emissions have even gone up.

Organisations like Greenpeace also underline the essential role gas should play in the Energy Transition. Ideally, Greenpeace would like to see fossil fuels phased out completely over the long term. But, says Greenpeace campaign leader, Hans Altevogt, 'You can't go from 10% to 100% renewables all in one go. It takes time. And we think that time can best be bridged using gas-powered energy.' This standpoint has even meant that Greenpeace and the gas industry have now become friends, he adds.

In the transport sector, gas is also a cleaner alternative than diesel and petrol. This is not only true in terms of climate change, but also in terms of air quality (no more emissions of atmospheric soot). Worldwide, energy companies are now particularly investing in using LNG (liquid natural gas) for shipping and road transport, a market that's expected to become very big. Gas may also acquire a large share of the market in fuel for private cars. *We will discuss this subject in more detail on p. 26.*

2 GAS AS A SERVICE PROVIDER OF SUSTAINABLE ENERGY

So although the role of transitional fuel should not be underestimated, it will only be temporary. This suggests that, within a couple of decades, the role of gas will be largely played out. But many energy experts – certainly those active in the gas sector – do not share this view. They certainly see a role for gas in the long term. They see gas as forming an ideal combination with sustainable energy. 'Even when the transition is over, we'll still have a great need for gas,' says Bartholomeus. 'Flexibility will still be required.' And gas infrastructure will play a crucial role in providing it.

This the second role that gas can play in the 'new gas' story. Solar and wind are known to fail sometimes, so a back-up will be needed – not only on the macro scale (for generating electricity), but also on the micro scale (for heating buildings).

How do you get hot water or heating in the winter, when the sun is not shining and there is no wind? You could solve this problem by storage, but the storage capacity of batteries is limited. Gas may offer a solution here. What Hans Overdiep sees as providing a particularly attractive solution here is the high-efficiency electricity-generating boiler, known as the HRe boiler. This is the successor of the condensed (or HR) boiler, orginally invented by Gasunie. The HRe is a gas-powered boiler that provides heat and also generates electricity. This makes it even more efficient than the HR boiler, which itself is already super-efficient. Did you know, for example, that the use of gas in Dutch households has been halved since the mid-1980s – mainly thanks to the HR boiler?

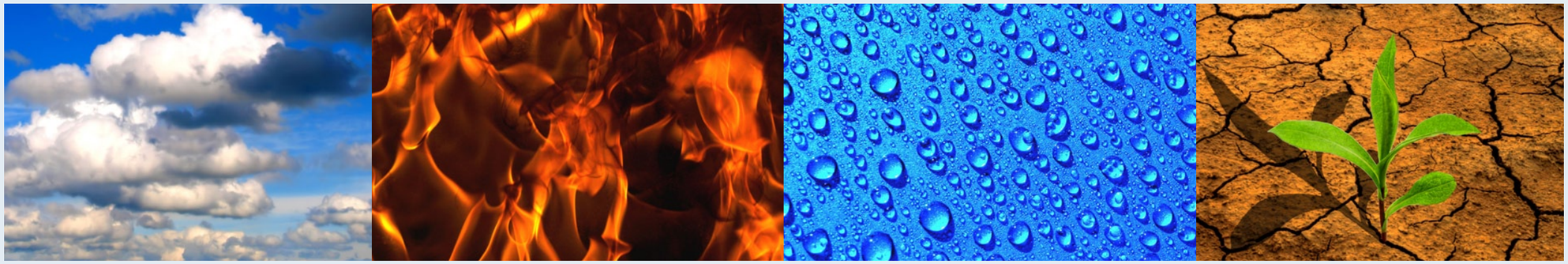
Of course, there are other options, such as storing heat and cold underground, which you can then bring to the surface using an electric heat pump. This would mean that gas would no longer need to be involved (although the pumps could also operate on gas). But the use of heat pumps would require a more substantial electricity network. We'll have to wait and see which energy mix will eventually turn out to be the most efficient and climate-friendly. Research on this matter is currently being carried out in Groningen, as part of the Entrance project, as well as in other places. *We will discuss the role of gas in houses and buildings in more detail on p. 22.*

At the macro level, the problem of the unreliability of solar and wind for the electricity network is much bigger. In Germany, this is a familiar phenomenon. At certain times, it results in a shortage of electricity; consequently, electricity has to be imported. At other times, there is a surplus of electricity (e.g., at night, with strong winds and at low-demand periods); when that happens, German electricity companies have to pay users to take the excess electricity off their hands.

Gas will need to get a lot more public backing

This mismatch between demand and supply (which is essentially what the problem boils down to) may be resolved by introducing all sorts of 'smart' systems in

the house (such as automatically switching machines on and off, depending on the supply of electricity). But this requires a huge investment in the infrastructure, as well as big changes in people's behaviour. Another solution may be to increase the capacity of the electricity networks and set up additional high-voltage cables to take power from places where wind



and solar energy is generated to places where it is most used (in Germany, this would be from the north to the south). But this is a drastic, expensive solution which everyone would rather avoid.

In such situations, gas may also offer a solution, because electricity can be stored and transported in gas form very efficiently. This power-to-gas approach is based in electrolysis: 'superfluous' wind or solar energy is used to separate water into hydrogen and oxygen. The resulting hydrogen can (within limits) be added to the gas network and transported through it. It is also possible to add in CO_2. This produces methane, which can be transported through the network in unlimited amounts.

If you want to stop using gas, you'll have a big energy gap to fill

Gas generated in this way is no longer a fossil fuel: it has become 'green gas'. This is also referred to as 'syn gas' (short for 'synthesis gas') or 'wind gas' or 'solar gas', depending on the source. The big advantage of this approach is that it makes it possible to store and transport green electricity extremely efficiently through the existing gas network. No new infrastructures are required. In addition, the availability of this option greatly improves the business case for wind farms and solar energy. Not surprisingly, then, many energy experts are very enthusiastic about the possibilities of the power-to-gas approach. *For more information about this, see p. 12.*

3 MAKING GAS SUSTAINABLE

The concepts of 'wind gas' and 'solar gas' bring us to the third role that gas can play in the future: gas can itself be 'greenified'. This explains why people like Hans Altevogt of Greenpeace prefer to speak of 'gas-fired fuels' rather than natural gas. These gaseous fuels include, of course, biogas and green gas (i.e., biogas added to the gas network).

In the Netherlands, agreements have been laid down in a Green Gas Innovation Contract to meet half of the country's demand for gas with green gas by 2050. This will not be an easy task. Gas (or 'green certicates') will definitely need to be imported from abroad, because the Netherlands does not itself have enough raw materials. *For more information about the possibilities and impossibilities of green gas, see p. 16.*

Nevertheless, the main point is clear: *natural* gas will get some company. The quantities of biogas, green gas, hydrogen and syn gas will increase. And – not unimportantly – there is no shortage of gas in the world anyway. Many people are still under the impression that we're running out of fossil fuels, but this certainly doesn't apply to gas – regardless of whether the shale gas revolution takes off in Europe or not.

It is not for nothing that a global company such as Shell has put a lot of money on gas. Already, half of the company's income derives from gas, and this will only increase in the future. That's why Dick Benschop, President Director of Shell Netherlands, certainly doesn't regard gas as a transitional fuel, but prefers to see it as a 'system fuel', by analogy with the idea of a 'system bank' – i.e., an indispensable element in the system. What's so unique about gas, he says, is that it can be applied at any level to make the sustainable energy system of the future run as efficiently as possible.
For the interview with Dick Benschop, see p. 10.

Jörg Gigler, independent energy consultant and Director of TKI Gas, a Knowledge and Innovation Consortium, says the same, though in slightly different words. 'The independent role that gas has played over the past fifty years is changing into an accommodating role,' he says. 'Gas will ensure flexibility and temporarily serve as a cleaner alternative. It will also become more sustainable itself.'

An interesting implication of this new role for gas is that, as Gigler points out, it will need to win a lot more public backing. People like Benschop also seem to be well aware of this: 'The more gas there is, the more people are talking about it.'

THE FUTURE OF GAS

Perhaps that will be the biggest change of all for gas in the coming years. Over the past fifty years, we've taken gas for granted. Now those days are gone.

Critical environmental consultant Jan Paul van Soest goes to the heart of the problem: 'The earth tremors in Groningen and the discussion about shale gas have dented the positive image of gas,' he says. 'Outsiders no longer have a clear picture of the future. People have lost confidence in gas. To win it back, the gas industry needs to provide them with a clear vision of the future, and to make it very concrete.'

For a natural-gas nation like the Netherlands, with its extensive gas infrastructure and leading global gas knowledge institutes, a lot is at stake. The choices that need to be made now will determine the future of gas. The Dutch authorities and industry can adopt a policy that focuses on the long-term future of gas: for instance, by investing in start-ups, in research and development, and in infrastructure, or by trying to get Europe to raise the price of CO_2. Alternatively, the Netherlands can choose to leave the gas path, and set off along a radically different road.

Of course, investing in the future of gas doesn't mean pushing the use of gas uncritically. All energy experts agree on what should be the highest priority with regard to energy policy: conservation, conservation and still more conservation. Independent energy consultant Teus van Eck puts it bluntly: 'There's no way the amount of energy we're now using can be made sustainable.'

In this context, Hans Altevogt of Greenpeace points out that huge quantities of gas are still being wasted, because, for instance, co-generation is not being supported. 'Gas is a valuable commodity,' he says. 'We should use it as long as we can. We should get all the value we can out of it. We shouldn't waste gas, but increase its value.' ●

The more gas there is, the more people are talking about it

GAS AS A SYSTEM FUEL

THE VISION OF SHELL AS GAS COMPANY

Interview with Dick Benschop, President Director Shell Netherlands

Shell – the largest company in the Netherlands – is highly committed to gas for its future. Although it started off as an oil company, it has now become almost fifty percent a gas company. And this development is continuing.

As a company that's used to thinking very far ahead, Shell believes that gas has clearly a long future ahead of it, says Dick Benschop, the passionate President Director of Shell Netherlands. 'I'd rather not talk of gas as a transitional fuel. This term implies that gas reserves will run out in the foreseeable future. I regard gas as a system fuel, a fuel that is crucial to the energy system, in the way that system banks are crucial to the financial systems.'

The special thing about gas, says Benschop, is that it can be deployed at any level within the energy system. 'Gas can be used more efficiently than any other fuel, at any level and on any scale – from large gas-fired power stations to condensed boilers and fuel cells, as well as anything in between.' In addition, he says, gas forms an ideal combination with solar and wind energy. 'Renewables need back-up when there is not enough sun or wind, and storage when there's too much of it. Gas is able to perform both these functions.'

Hybrid power stations

For instance, electricity may be stored by converting electricity generated by wind or sunlight into hydrogen or (with the aid of CO_2) into methane, and then feeding this into the gas grid ('power-to-gas'). This produces green gas, which can be stored and transported via the existing gas infrastructure. This saves billions of euros that would otherwise need to be invested in electricity networks. 'In this respect, gas is also very efficient,' says Benschop. 'Ten times more energy can be transported through the gas network than through the electricity network.'

It is common knowledge that gas-fired power stations provide a good back-up for occasions when electricity from solar or wind power fails. An interesting, new development in this regard, says Benschop, is that companies like Siemens and General Electric are developing hybrid power stations, combining gas turbines with solar collectors or wind turbines.

But developments in the gas industry certainly don't stop here. Shell, for instance, is a global leader in LNG (liquid natural gas). The company is the first in the world to start building a floating LNG factory. The new GATE Terminal in Rotterdam already gives the Netherlands the capacity to import LNG, and from now on, this terminal can be used to transport gas to the Netherlands from all over the world, without the need for pipelines.

Very vulnerable

LNG that is transported to the Netherlands is not only converted into regular natural gas, but will also increasingly be used to fuel shipping and heavy goods vehicles, replacing diesel. This will greatly reduce the emission of pollutants.

'LNG will become a very huge market in heavy road transport worldwide,' says Benschop. 'Rotterdam is in discussions about this with other major ports around the world, such as Singapore, Shanghai and Los Angeles. The Netherlands can take the lead here. We're past the experimental phase: the whole chain is working together on this. Shell has already started using an inland vessel that is 100% powered by LNG, and a second will follow shortly. There will also be filling stations for ships and trucks. Incidentally, the ships themselves will also incorporate a whole range of innovations.'

GAS CAN BE USED MORE EFFICIENTLY THAN ANY OTHER FUEL, AT ANY LEVEL AND ON ANY SCALE

In passenger transport, Shell expects to see a whole 'mozaic' of developments, with new opportunities for various kinds of fuel: petrol, diesel, electricity, hybrid and hydrogen, as well as natural gas. 'We don't expect any one form of fuel to win. Consumers and authorities will make different choices.'

The same goes for buildings, where many combinations for energy supply are possible: solar panels, solar boilers, heat pumps, mini CHP (combined heat and power) devices and fuel cells. Research has shown that condensed boilers are just as efficient as electric heat pumps, says Benschop. 'These pumps may provide free heat from the ground, but they require a lot of electricity.' He also points out that a double infrastructure of gas and electricity is the safer option. 'If you base your entire energy supply on electricity alone, you make yourself very vulnerable.'

And we haven't even discussed shale gas yet – another development that is taking place all over the world and is having a big impact on the energy system. 'The production of unconventional gas results in a much, much bigger supply of gas – which is positive.' But more gas also means that there will be more discussion about gas, says Benschop. He believes Dutch industry would be well-advised not to allow the controversy about shale gas in the Netherlands to discredit the position of gas in the country. 'We need opportunities for an open debate and for careful investigation into what exactly lies beneath the surface of the Netherlands.'

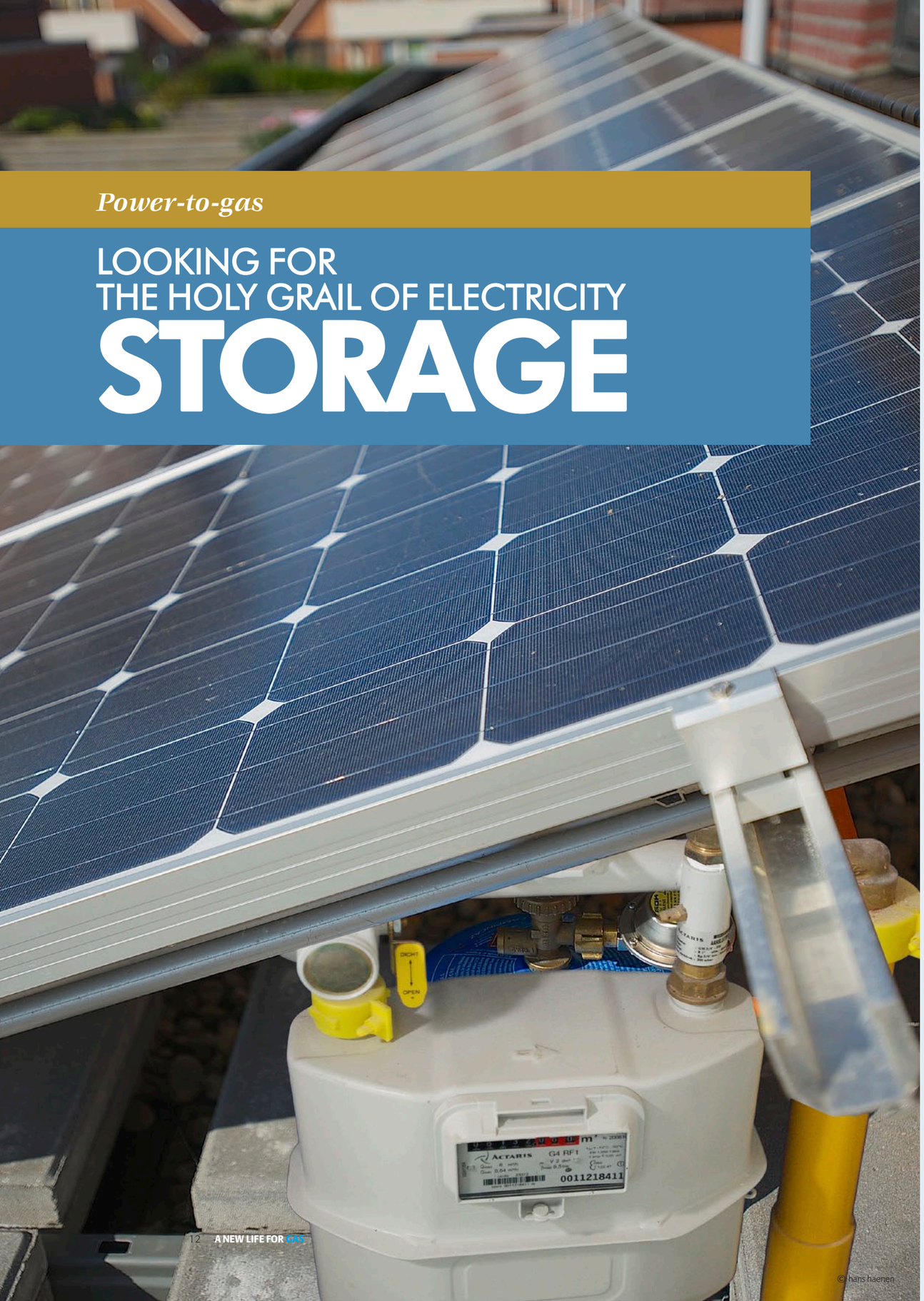
Despite all these highly promising developments within the gas sector, gas is still a fossil fuel and as such will contribute to global warming. What does Benschop think he can do to solve this problem? 'During this phase of the transition, we need to reduce our CO_2 emissions as cost-effectively as possible, and this can be achieved by replacing coal by gas. This is already happening in the United States, where emission levels are dropping as a result. In Europe, on the other hand, we're being rather negligent, which has led to emissions in Germany – a renewable energy country par excellence – rising. That is painful. We need to agree on a good price for CO_2, so that gas will become an attractive alternative to coal, and our highly efficient co-generation (CHP) power plants will become profitable again. At the same time, we need to invest in renewables in order to reduce costs.'

EVERYWHERE, YOU CAN SEE SYSTEM DEVELOPMENTS THAT ARE POSITIVE FOR GAS

Roundabout

This phase will last roughly until 2030. From 2030 onwards, the share of various forms of green gas will grow rapidly, thinks Benschop, while CO_2 capture and storage will become increasingly widespread.

The President Director of Shell Netherlands is clearly convinced that the era of gas won't be coming to an end for quite some time. On the contrary: gas's new life has only just begun. 'Everywhere, you can see system developments that are positive for gas. And for the Netherlands, as a 'gas roundabout', the opportunities for growth and innovation are especially promising.' ●



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Power-to-gas

LOOKING FOR THE HOLY GRAIL OF ELECTRICITY STORAGE

The biggest problem of solar and wind energy is their variability and unpredictability. Sustainable energy isn't always available when it's needed. If you can accommodate this in a positive way, you hold the key to energy transition. Could gas create this breakthrough?

How can you store electricity in an efficient and affordable way? That is widely seen as the biggest challenge in energy research at the moment. All over the world, researchers are working on this. Solar and wind power can generate huge amounts of electricity, but not always when it's needed.

'It's becoming increasingly clear that renewable energy sources, such as wind and solar, won't conform to human rhythms,' says Catrinus Jepma, Professor of Energy and Sustainability at Groningen University and scientific director of the Energy Delta Institute (EDI) in Groningen. 'The Energy Transition will only succeed if we come up with a smart way of storing sustainable energy.'

In Germany, one of the leading countries in the Energy Transition, the problem of electricity storage has turned into a national issue on television and in the press. Jepma predicts that this will also happen in the Netherlands, once the share of sustainable energy starts to grow as planned.

WALKING A TIGHTROPE

The problem of storing electricity has reared its head before in the electricity sector. The electricity network should always be in balance: the same amount of electricity should be put into the network as is removed from it. This requires a constant balancing of demand and supply – particularly supply, because consumer demand dictates what is required. The electricity sector makes a distinction between base capacity and peak capacity, the latter being used to compensate for peaks in demand. Gas-fired power stations are particularly suitable for peak capacity, because their power output can be regulated easily and quickly, whereas coal-fired and nuclear power stations are mainly used to provide base capacity.

Until recently, balancing demand and supply – which is essential for the supply of electricity – did not give rise to any problems. Over the past few years, however, this relatively stable picture has been rudely disrupted by the increase in wind and solar energy, which is much more difficult to regulate. Moreover, energy from these sources has priority on the grid, which means that it cannot be shut out by the system operator. This has made balancing the grid a complicated matter, and sometimes it's almost like walking a tightrope. To be able to inject more sustainable energy into the system, new solutions are urgently required.

The problem with electricity is that it is difficult to store. Traditionally, hydroelectric power served as a buffer, but this potential is already almost being used to the full. Batteries have limited storage capacity, are expensive and not always environmentally friendly.

The business case for wind energy suddenly improves a great deal thanks to power-to-gas

One solution would be to expand and connect the electricity networks and high-voltage cables, but this is also an expensive option, and one that often meets public resistance.

Another solution would be to start regulating demand much more on the basis of supply, instead of the other way around. However, this would necessitate a considerable change in the way households and businesses manage their energy usage. Stimulated by fluctuating prices, and with the aid of all sorts of

'smart' technologies, they will need to adjust their usage to the fluctuating supply of electricity. No-one knows how long this development will take and how successful it will be. Some have suggested making large-scale use of electric car batteries in this process, by charging them en masse during a period when there is a surplus of electricity. However, this, too, is obviously still, at best, something for the future.

BIG LEAP FORWARD

And then there is another – surprising – solution, which has recently come to the fore more clearly, and that is gas. Or rather: power-to-gas – because you can convert electricity ('power') into gas as well. This is done by using electricity to separate water into hydrogen and oxygen (by the process of electrolysis). This hydrogen can then (within limits) be injected into the gas network. It is also possible to add CO_2, which will produce methane. This is actually the same as natural gas, and can be injected into the network in unlimited quantities.

The Energy Transition will only succeed if we come up with a smart way of storing sustainable energy

Could power-to-gas be the Holy Grail of electricity storage, enabling the Energy Transition to take an enormously Big Leap Forward?

Most technical people you talk to about power-to-gas are reasonably optimistic about this idea, and on paper it certainly all looks very convincing. 'Besides hydroelectric power,' says Jepma, 'power-to-gas is the only practical, large-scale solution to today's storage problem.' And there are many others who share this view.

One of the special properties of gas is that you can store huge amounts of energy in it, at low cost. And the big advantage of power-to-gas is that this wonderful storage and transport system already exists, ready for use, in the form of the gas pipelines. There's no need to build a new infrastructure. For example, Germany has 500,000 km of gas pipelines transporting 1,000 billion kWh each year – twice as much as passes through the electricity network. In addition, another 200 billion kWh of gas can be stored underground in Germany. Of course, the Netherlands also has an excellent gas infrastructure, which is highly suitable for electricity storage.

As mentioned earlier, Germany is the global leader in research into power-to-gas. This is not surprising, given the enormous increase in wind and solar energy in that country and the determination of the Germans to make a success of the Energy Transition. At the moment, there are some twenty large-scale research and demonstration projects relating to power-to-gas in Germany, involving all the big German energy companies. Incidentally, one of the big instigators was Greenpeace Energy, which has been offering wind gas to consumers for quite some time.

The fact that Audi makes good use of power-to-gas in their advertisements shows just how 'sexy' the subject has become in Germany. Earlier this year, in Werlte, the carmaker opened the first industrial-scale power-to-gas factory in the world. The electricity for this 6 MW production facility (which can be scaled up to 20 MW) is generated by four off-shore wind turbines in the North Sea. The wind gas that is produced in this way (called 'e-gas' by Audi) can, of course, be used by every car that runs on natural gas, but, in addition, Audi has launched a special, trendy car-on-gas: the A3 Sportback g-tron. At the opening of the factory, an Audi spokesman declared proudly that this might well become the 'flagship of the Energy Transition'.

Meanwhile, the results of the German research are encouraging. Earlier this year, ZSW (a Stuttgart-based centre for solar energy and hydrogen research), where leading scientist Michael Specht works, announced that they had succeeded in producing gas of 'Russian quality'. According to ZSW, the availability of CO_2

Just turn the renewables into gas and we'll take care of the rest!

(which is required for converting hydrogen into methane) is not a problem. In Germany alone, 6,000 biogas installations are in use, producing enough CO_2 for 25 Terrawatt hours of gas, which means that seven million households can be supplied with electricity.

BUSINESS CASE

Compared to all this German activity, the Netherlands is lagging quite a long way behind. At the moment, the Netherlands only has one demonstration project in operation, run by Stedin and DNV Kema in Rozenburg; and this is still in its initial phase. However, Stedin and GasTerra have already carried out an important four-year practical test on the off-shore island of Ameland, in which they tested the ability of pipelines and equipment to cope with hydrogen. The result was highly promising: increasing the proportion of hydrogen in the gas network to 20% appeared to have no negative effect whatsoever.

So, technically speaking, there seem to be but few obstacles to power-to-gas. The question now is whether the concept can be rolled out in an economically responsible way. According to Jepma, one of the difficulties here is that the advantages of power-to-gas will benefit various parties, all of whom have to be involved (such as windfarm operators, network operators, and possibly also chemical companies). 'The business case for wind energy suddenly improves a great deal thanks to power-to-gas,' says Jepma. 'At the moment, the energy output of windfarms is low. But once you can store the energy, this will improve a lot. And network operators will no longer need to make the huge investments currently needed to transport wind energy and guarantee the network's stability.'

The fact that Audi makes good use of power-to-gas in their advertisements shows just how 'sexy' the subject has become in Germany

Both wind energy and network management are largely financed with public money, so there is also a role for policymakers here, says Jepma. 'My research group is currently carrying out a social cost/benefit analysis. We hope to be able to demonstrate that there is a business case for power-to-gas, but this can only be done by involving the externalities. You can't have wind gas compete with natural gas just like that – electrolysis is too expensive for that, and natural gas too cheap.'

Jepma has yet another idea: he is arguing for the conversion of drilling platforms in the North Sea into electrolysis factories. 'Many of these platforms are due to be demolished, because gas production from small fields is in decline. Oil companies have already reserved billions of euros to finance this demolition. They can save their money, and this which will help to compensate them for the dwindling production of small fields. Moreover, public resistance will be minimal, because production will be happening far away, out at sea.'

As a leading gas nation which partly depends on gas for its income, the Netherlands clearly needs to link up quickly with the German activities in the field of power-to-gas, says Jepma. 'Gas is vulnerable, as we've recently witnessed. There's no more growth in the household market. And coal has become a fearsome competitor in the electricity market. That's why gas has to take the initiative. Back-up is one thing, but storage and transport are something totally different. There is only one really promising storage method, and that is power-to-gas.

The gas industry should rise up and tell the policymakers: Just turn the renewables into gas and we'll take care of the rest! ●

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Green gas

IT'S NOT EASY BEING GREEN BUT IT'S WHAT WE WANT TO BE

Green gas should soon be as common as green electricity. But this will require a huge shift, not only on the part of the gas industry, but also of the Netherlands as a whole. Some people are already arguing for a 'green fields policy', following the example of the successful 'small fields policy'. We line up the opportunities and challenges of the Green Gas Revolution.

Kermit the Frog hit the nail on the head in the famous Muppet song from 1970: 'It's not easy being green…' For the time being, this is also true for green gas in the Netherlands. So far, green gas represents just a small percentage of national gas consumption in the Netherlands: clearly, the greenification of Dutch gas supply still has a long way to go.

However, the Dutch gas sector, together with the politicians, has had the courage to map out an ambitious growth path for the future. This has been laid down in the Green Gas Innovation Contract (2012). It defines a three-step approach: small-scale biogas production based on fermentation (until 2015); fermentation in addition to large-scale biomass gasification (until 2030); and, finally, scaling up of gasification and incorporation of foreign green gas (until 2050).

For this approach to be successful, between now and 2030 no less than one hundred times as much gas would need to be produced: from the more than 30 million m^3 per year today to 300 million m^3 in 2014, and at least 3 billion m^3 in 2030. Incidentally, this is still barely 10% of the current annual gas consumption in the Netherlands. By 2050, the share of green gas should have grown further to half the total gas consumption (currently roughly 40 billion m^3). All in all, this is a tremendous shift, especially when you realise that today, only half of the basic Dutch energy consumption is based on natural gas.

According to today's experts, this is a very ambitious scenario, but not impossible. Catrinus Jepma, Professor of Energy and Sustainability at Groningen University, is a 'system thinker'. In his opinion, the hundredfold increase for green gas will only be attainable if, in the coming decades, there is a total commitment to fermentation and gasification gas, not just from the Netherlands, but also from other countries. The latter would be achieved through trade certificates, so that the green origin of the gas is guaranteed.

THE PLAYING FIELD

The best way to put the Dutch situation and ambitions into perspective is to compare them with neighbouring Germany, says Gerard van Pijkeren, Director of Vertogas, a subsidiary of Gasunie that is responsible for issuing green gas certificates. These certificates guarantee the origin of the green gas and assure buyers, who are trading on a virtual market, that the purchased gas is genuinely green and of the same quality as natural gas.

'At the moment,' says Van Pijkeren, 'Germany is clearly moving faster.' There are three factors that give the Germans an advantage. First, Germany is an energy-importing country, so for them producing green gas is a direct way of becoming less dependent on foreign suppliers. This is different for the Netherlands, because we're a producing country. Secondly, Germany has a much greater quantity of biomass at its disposal, whereas the Netherlands doesn't have enough biomass at hand to produce green gas on a large scale due to its small land area and its dense population. Thirdly, Germany has organised responsibility for feeding into the gas network differently.

The network operators are responsible for this, and not, as in the Netherlands, the biogas producers. This significantly simplifies the projects for producers.

There isn't a single scenario in which the Netherlands can evade the import of green gas

According to Van Pijkeren, there are several reasons why so few projects have been launched recently. Firstly, there is a shortage of biomass (leading to high prices); secondly, it is difficult to finance projects; and finally, there is a cost threshold for feeding into the gas network. At the moment, Dutch producers of green gas are responsible for their connection to the gas network, which, from a technical point of view, is a complex and expensive matter (because of the high quality requirements). 'The consequence of all of this is that at the moment almost all the remaining projects are run by parties who have their own waste streams (such as waste processors), the required technological capacities, and sufficient capital to finance the project out of their own pocket.'

BIOMASS FERMENTATION - A LIMITED RANGE

Bram van der Drift, Manager of Syngas and Gasification at Energieonderzoek Centrum Nederland (ECN) agrees that the economics of green gas are currently incompatible with its objectives. 'Take biomass fermentation, for instance. This process is actually only interesting if it's subsidised, and if there are consumers of both heat and electricity close at hand, or if the gas can be used to replace diesel or petrol.' It's not profitable for individual owners of biogas to refine this biogas ('gas cleaning') into green gas (i.e., gas that can be injected into the natural gas network), as the connections to the gas network are too expensive. They're trying to solve this by means of green gas hubs, whereby the biogas of several producers is collected via a shared pipeline and refined in a single central installation. Various such initiatives have now been set up.

Van der Drift explains that, for the time being, all green gas in the Netherlands derived from fermentation (with the sole exception of household waste processor Rova/HVC in Zwolle) is fed into the low-pressure network of the regional network operators. The medium-pressure RTL gas network operated by GTS can also accommodate green gas, but feeding it into the high-pressure HTL network of GTS is more difficult, because of the strict requirements that apply to gas, particularly if it is to be exported. The possibilities here will need to be investigated on a case-by-case basis. But it is precisely the national network that, unlike the regional networks, offers a large buffer capacity. In the regional networks, the green gas sector is quickly confronted with what is called the 'hot summer nights phenomenon', when the available capacity is often too low. That is why Gasunie and the regional network operators are currently studying the possibilities for installing an overflow facility – from the networks of the regional network operators to the medium-pressure gas network of GTS. A pilot project may be set up to gain experience.

Another reason why the range of fermentation in the Netherlands is limited (and will probably remain so) is the scarcity of suitable biomass. 'Suppose we were successful in converting all the biogas from fermentation into green gas and injecting it into the natural gas network. Even then, it would only contribute a tiny bit to achieving our objectives,' says Van der Drift. Stepping up production by importing biomass from abroad is not an option. As it happens, the basic raw material for fermentation mainly consists of wet material, which is extremely difficult to ship.

BIOMASS GASIFICATION - AN EMBRYONIC TECHNOLOGY

But there is also good news. As mentioned in the Innovation Contract, in the medium and long term, an important role will be played by biomass gasification. In this process, mainly dry and fibre-like material is heated to a high temperature, when it is converted into what is called synthetic natural gas (SNG), or 'syn gas'.

ECN, based in Petten in the Netherlands, focuses on developing this technology further. Technically speaking, gasification is not new or complicated (think of coal gasification), but the refinement steps are far from easy or fully developed. 'Fifteen years ago,' says Van der Drift, 'we started to develop a method for making gas from biomass gasificators suitable for injecting into the Dutch natural gas network. Each refinement step took a couple of years.' Meanwhile, ECN has become part of a consortium (with, amongst others, Gasunie and Taqa) that is working on developing a Green Gas Demo and Expertise Centre in Alkmaar (The Netherlands).

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The consortium is now waiting to undergo evaluation in Brussels to secure public funding for the project. Van der Drift emphasises the need for faster decision-making. 'If the objectives are considered to be important, and people realise that theory and practice should be brought together, demo gasification projects will really need to start right now. It takes decades to subsequently scale up such projects – a next step that is specifically described in the Innovation Contract.'

Another advantage of biomass gasification is that its basic raw material (unlike that for fermentation gas) can easily be shipped. As Van der Drift observes, this development fits in seamlessly with the ambitions of the Port of Rotterdam, which has plans to develop into an important biomass port in North-West Europe in the coming years. If that works out, the bio-based economy will really begin to take off.' Professor Jepma agrees that the gasification technology, providing it's developed further, may lead to a huge upscaling. Because SNG can be fed into the high-pressure network, the Dutch chemical industry –20% of whose basic raw material currently consists of natural gas – can also immediately start to develop as a 'co-greenifier'.

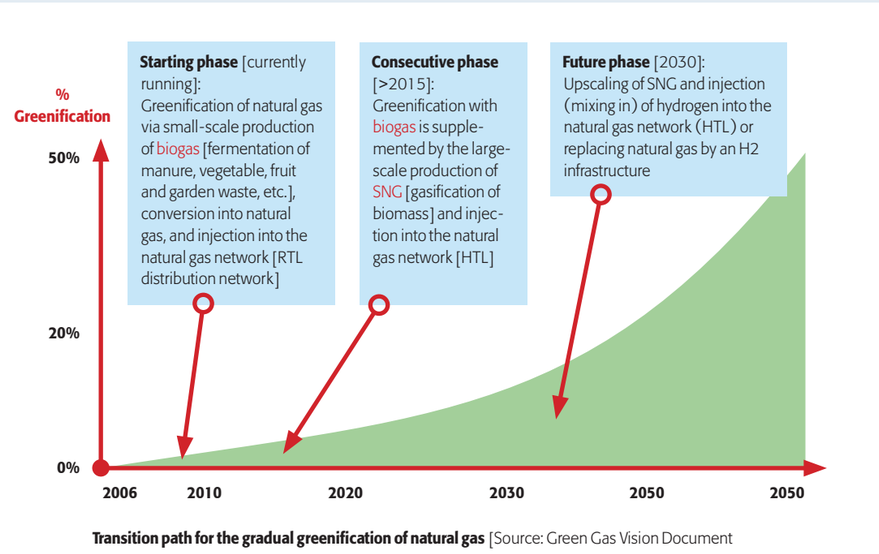
FOREIGN GREEN GAS

For Gerard van Pijkeren, scaling up means, in particular, enabling cross-border trade in green gas. 'There isn't a single scenario in which the Netherlands can evade the import of green gas.' As Director of Vertogas, he therefore puts a lot of effort into also having his green certificates acknowledged across the border. 'This is already working fine for electricity and liquid biofuels, but for green gas there is no uniformity as yet. At present, the Dutch government doesn't allow green gas produced in Germany onto the transport market, and no uniformity has been reached at European level either. So if a German green gas producer exports its gas, it will lose its subsidy in its own country and won't be eligible for a subsidy in the importing country. This clearly has to change.'

Besides the efforts being put into creating a European market, other options are also being studied. Together with Gazprom, Gasunie has initiated studies into the potential of green gas for this exporting giant. This turns out to be huge: 50-100 billion m^3 per year, more than enough to cover the entire gas consumption of the Netherlands. Van Pijkeren: 'We're currently looking into building a pilot plant in the form of a fermentator and a refinery. The refinery and certification knowledge involved comes mainly from the Netherlands and Germany.'

Green gas offers a way of making our energy provision sustainable

Catrinus Jepma also sees how the greenification of the Dutch gas system could involve a signficant role for cross-border trade. 'The volumes of green gas could increase considerably once foreign green gas is also fed into the system.' The professor believes that,



Transition path for the gradual greenification of natural gas [Source: Green Gas Vision Document

Biogas:
Produced by the fermentation of biomass (e.g., crop residues, liquid waste streams and maize, often in combination with animal manure)

SNG, (synthetic natural gas):
Produced by the gasification of woody biomass or coal
Green gas: Collective term for refined biogas, SNG and landfill gas (from landfills), which is a suitable replacement for natural gas.

for both fermentation and gasification, it would be better to have the conversion take place locally, and then import the green gas via an international trading system.

This development fits in seamlessly with the ambitions of the Port of Rotterdam, which has plans to develop into an important biomass port

GREEN FIELDS POLICY

To give the development of green gas a little support, more and more people within the gas sector are in favour of a 'green fields policy', by analogy with the existing 'small fields policy' (whereby small gas fields are exploited, in order to slow depletion of the main field). Gas traders would then be obliged to buy the relatively expensive green gas – on reasonable terms and at a competitive price. This would, for the time being, help to make sure the main field of Slochteren is not exhausted too quickly and would give green gas a good boost.

'When green is all there is to be, it could make you wonder why, but why wonder, why wonder. I am green and it'll do fine. It's beautiful and it's what I want to be,' as Kermit the Frog sings at the end of his song. As the role of traditional gas diminishes, the Dutch gas sector and the Dutch government will need to prepare themselves for a green gas future. No matter how high the obstacles may seem, green gas offers a way of making our energy provision sustainable. ●

BRUSSELS: GAS IS GOOD

AS LONG AS IT HELPS US MEET OUR CLIMATE GOALS

What is the EU's position on gas? The European Commissioner for Energy, Günther Oettinger, makes it crystal clear. 'The natural gas industry has the sympathy of EU policymakers,' he says, 'as long as it helps us meet our energy and climate goals and contributes to our competitiveness.'

The EU has set itself the target of reducing greenhouse gas emissions by 80–95% by the year 2050, and it has drawn up a 'roadmap' for achieving this goal. This roadmap calls for the widespread adoption of renewable energy sources. 'However, gas will continue to play a crucial role in the transformation of the energy system,' says Oettinger. 'The flexibility of gas and the low levels of capital investment that it requires will make it highly complementary to the growing share of sustainable energy.'

Oettinger adds that replacing coal and oil with gas can also help to reduce CO_2 emissions – at least until 2030 or 2035. And after that? 'In the longer term,' says the Commissioner, 'gas-fired power stations will need to be combined with technology for the capture and storage of CO_2.' Over the past few years, the EU has tried to get a series of such Carbon Capture and Storage (CCS) projects off the ground – but these efforts have so far failed miserably, due to a lack of political support from the member states and resistance from the general public.

With regard to the security of supply of gas, Oettinger says the EU is striving to ensure that the means at its disposal will be available in all member states. Over the past few years, much has already been invested in the European gas distribution network with the aim of better integrating Eastern European countries with the rest of the EU. The EU is also striving for further diversification of the offering, says Oettinger.

Oettinger feels that shale gas should be a part of the European gas offering. The European Commission is of the opinion that exploratory drilling will in any case need to be carried out to find out how much shale gas there is. 'After that,' says Oettinger, 'member states will need to assess for themselves the potential for environmental damage and determine whether the risks are acceptable.' ●

Gas in buildings

SMART ENERGY FOR THE HOME OF THE FUTURE

In the future, homes and buildings of all kinds will require less and less energy while making ever more use of 'decentralised' energy sources, such as solar panels. Will gas still have a role to play in that scenario? The answer is, in all probability, yes. Its contribution will certainly shrink somewhat in volume, but at the same time it will become more targeted and refined. The energy provided will be smarter.

Sometimes, it's a good idea to have an outsider take a look at your situation. It can help clarify things and produce excellent results. Simon Blakey, an internationally renowned British energy consultant, has made an in-depth study of the Dutch gas market – and he's impressed by what he has found. 'Did you know that gas use in Dutch households has dropped by 50% in the last 25 years? Unbelievable. It's fallen from 3,150 m^3 in the mid-1980s to 1,630 m^3 last year. And that's not only thanks to better insulation, but above all thanks to the spread of the condensed boiler.'

Blakey found that the condensed boiler is much more common in the Netherlands than in surrounding countries. 'In the Netherlands, 90% of households have a condensed boiler. In countries such as Italy, Germany and England, that figure is only 15 to 25%.' In other words, there are enormous opportunities in the rest of Europe for households to save on their gas

THE 'SOLAR PANELS OF WINTER'

While the Dutch condensed boiler (HR boiler) is still setting the global standard in energy efficiency, its successor is already stepping into the starting blocks: the HRe boiler. The 'e' stands for electricity, because this boiler delivers both heat and power (with the help of a Stirling engine). That's why it's also called a micro combined heat and power (CHP) device. Hans Overdiep of GasTerra is now one of the foremost advocates of the HRe boiler. He explains why: 'The way we produce energy now is actually a bit odd. We generate electricity in big power stations. We put fuels in, and half of the energy is lost as heat in the cooling water – unless, of course, you're using a CHP device. It makes much more sense to generate the electricity in your own home and use the heat generated to warm the building. That's one important improvement we can make with the HRe boiler.'

The HRe boiler is twice as efficient as a modern electric power station, says Overdiep. It emits half as much CO_2 per kWh as a gas-fired power station and just a quarter of the CO_2 emitted by a coal-fired power station. It uses slightly more gas than the condensed boiler (180 m^3 or roughly 10% more), but yields 1,650 kWh of power – almost half of what an average household uses.

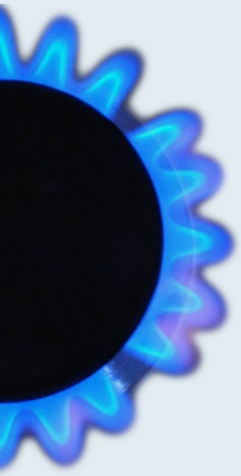
In the Dutch province of Gelderland, people are so enthusiastic about the potential of the HRe boiler that the local government has decided to subsidise 10,000 of them. The project is being led by Alexander de Roo, chairman of the Dutch Wadden Sea Association and a former Member of the European Parliament for the Dutch environmentalist party GroenLinks, who is serving as an advisor to the province. What's remarkable about this project is that GasTerra has agreed to deliver green gas to these boilers – at no extra charge. De Roo calls the HRe boilers 'the solar panels of winter', because winter is the time they work hardest and produce the most power.

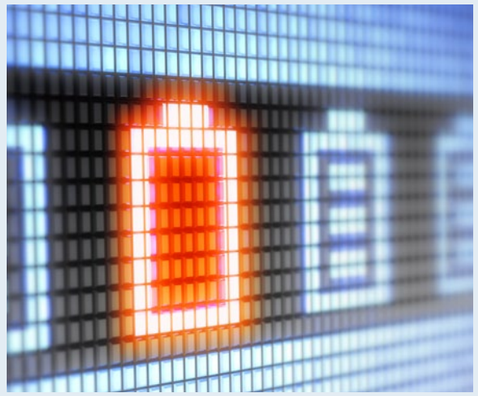
De Roo acknowledges that the price of the HRe boiler (which is made by Remeha in the Netherlands and assembled in London with Stirling engines from China) needs to come down. 'To make that happen, we need to start producing the boilers in much larger quantities. And we want to provide an impetus for that.' An HRe boiler currently costs € 8,500 before tax, and is 20–25% more energy efficient than a condensed boiler. This means that it will take someone who already has a condensed boiler a long time to recoup the cost of a new HRe boiler. That's why we're looking for new opportunities outside of the Netherlands, where the penetration of condensed boilers is much lower.

Not everyone believes in the future of the HRe boiler. Energy advisor Teus van Eck feels that the boiler's electrical yield, roughly 20%, is too low. He sees more potential in BlueGen – a micro CHP device that has a fuel cell rather than a Stirling engine.

usage – a significant finding in the light of the challenges of the ongoing Energy Transition.

Thanks to the condensed boiler, invented by Gasunie, the Netherlands has for decades been a world leader in the efficient use of gas, says Hans Overdiep, Manager Energy Transition at GasTerra. 'It's an example of a smart Dutch innovation that most Dutch people aren't aware of,' says Hans. 'We recently had a visit from a team from Japan, and they were very impressed. However, in countries like Germany, we're still having a hard time getting people to use these boilers. This is because they're worried about condensation – but we've known for years that their fears are ungrounded.'





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The condensed boiler (which has already been succeeded by the combined heat and power boiler (HRe): see box on p. 23), shows just how efficiently and flexibly gas can work in buildings. It also demonstrates how unobtrusive gas can be. As Overdiep points out, discussions about energy conservation tend to focus almost entirely on electricity, although in fact more than 80% of the energy used by a typical household comes from gas! 'Yes, you can achieve a lot with solar panels, and technologies like thermal energy storage,' says Overdiep, 'but there are limits. A solar water heater is great – but what if the sun's not shining? Luckily, I still have a small, efficient combi-boiler that will cut in when the water's not getting hot enough.'

HEAVY CABLES

Of course, there are other options. For example, electricity can be stored in batteries. But, at least in their present form, these are expensive, bulky, and limited in capacity. 'I have a lithium-ion battery pack in my electric car,' says Overdiep. 'It weighs 200 kg, and can store 10 kWh of electricity – equivalent to one cubic metre of natural gas, which weighs 0.8 kg. Viewed like that, the battery stores almost nothing. And you won't be able to fit a battery pack like that in your meter cupboard.'

Thermal energy storage is also a possibility, says Overdiep, 'But if you want to install this in an existing home, you'll need to take out all your radiators, put in under-floor heating and install an electric heat pump, which can cost around € 15,000. So this is only really feasible in new housing developments.'

According to Overdiep, anyone working on a new building should first focus on achieving perfect insulation. 'If you have that, you won't need an expensive heat pump – just a small boiler. If you then combine this with a solar water heater, you can reduce your gas consumption further, from 1,700 m^3 to just 600-700 m^3.'

Jörg Gigler, an independent energy consultant and director of TKI Gas, a consortium for knowledge and innovation, agrees. 'You now have seven million households in the Netherlands using natural gas,' he says. 'If you wanted to switch all of them to an alternative energy source, that would require an enormous investment – in heavier electrical cables, for instance.' For newly built houses, says Gigler, it's a very different story. 'They should be built to be energy-neutral. Then you'll only need very little gas.'

Even if only in small doses, gas will certainly still be needed. To illustrate this, Gigler points to the well-known PowerMatching City project in Hoogkerk, the Netherlands, led by DNV Kema, which shows that gas will fit perfectly into the smart energy system of the future. 'The project clearly demonstrates that gas and electricity work very well together. Gas needs to be used in a measured way – during very cold weather, for example. The overall volumes will certainly decrease. We'll use less natural gas and deliver more smart energy.'

Independent energy expert Teus van Eck also feels that the traditional gas boiler still provides significant added value. 'We've convinced ourselves that sustainable buildings will save us money – but in practice, that's often not the case,' says Van Eck, who's been working in the energy sector for more than forty years. 'Insulation often has less of an impact than you'd think. This is because people generally behave differently than we expect. They leave doors open, or simply use more energy. In that context, a gas boiler is often the best and cheapest solution. Even if you're using electricity for everything – including heating – you've still got your hot water to think about. Hot water use is increasing, and it will be difficult to maintain an adequate supply using heat pumps.'

Did you know that gas usage in Dutch households has dropped by 50% in the last 25 years?

THE FUTURE

However, gas won't necessarily be part of the solution in all circumstances, says Van Eck. 'In commercial construction, heat pumps (which can also provide cooling) work perfectly,' he says, 'both in terms of cost and performance. It's in homes that heat pumps offer little in terms of cost or energy savings – unless the building has been specially designed to accommodate them. At the moment, a solar water heater combined with a boiler is the best solution for homes. If the time comes when you can store the heat of the summer for the winter, then you won't need gas anymore. In newly built homes, that is in principle an achievable goal.'

Nonetheless, Simon Blakey is convinced that we will still be using gas to heat our homes in forty years' time, although in a more efficient manner – in the form of combinations of solar panels, gas heat pumps, condensed boilers and combined heat and power (HRe) boilers. '115 million households in Europe now depend on the comforts of gas heating. The quality of gas heating is high, and you don't need to go down to the shop to replenish your supply – it's always available. For the time being, that's not going to change.'

Pierre Bartholomeus, Global Director Gas Consulting & Services at DNV Kema, doesn't see gas disappearing from our homes either – at least not any time soon, and certainly not for the purposes of heating water. In fact, he makes a very different suggestion: 'People are now discussing whether or not we should be connecting the new home of the future to the gas network. You could just as well ask if that house should be connected to the electricity grid.' ●

ENTRANCE A TESTING GROUND IN GRONINGEN FOR DECENTRALISED GAS SOLUTIONS

In Groningen, a unique testing ground is currently being rolled out: the Energy Transition Centre, or 'Entrance'. Entrance is entirely focused on decentralised applications of natural gas. 'The reason we chose this particular focus,' says Wim van Gemert, Lector in Energy Transition at the Hanze University of Applied Sciences, Groningen, 'is that we feel it will play an important role in the future of the industry. Decentralised intelligence is a driving force in the new knowledge economy. The energy sector is following that development.'

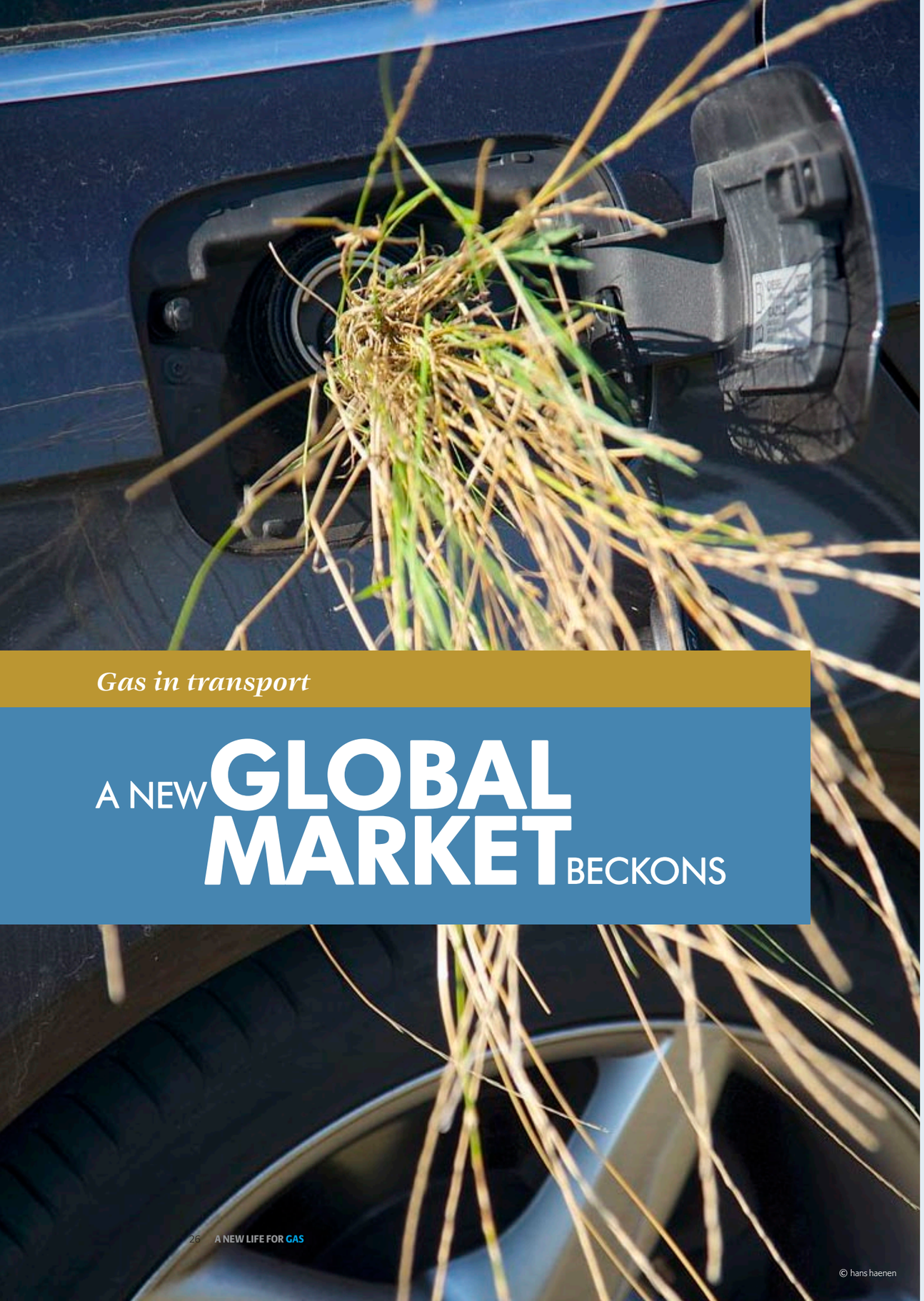
In the past, the energy market was managed from the centre, but with the liberalisation of the market, that path was abdandoned. 'In a free market, people have choices,' Van Gemert points out, 'and what you see now is a democratisation of energy demand. Fossil fuels are becoming more expensive and unpredictable. Users don't like that. So they'll start to embrace decentralised technologies. The market is inclining towards decentralisation. And if you don't follow that trend carefully, you could make the wrong investment decisions.'

Natural gas can take on a new life if it takes full advantage of this development, says Van Gemert. 'If you can produce electricity in a decentralised way with natural gas, and use the resulting heat – for example, with an HRe boiler – you can achieve a much bigger output than with centralised energy production.' And there are a number of other potential applications for natural gas in combination with an HRe boiler, says Van Gemert. 'Using fuel cells the size of a refrigerator, you can transform natural gas into electricity with a yield of 60%. But we're also looking at heat-storing systems and communication systems.'

With natural gas, you can achieve an excellent decentralised balance between supply and demand, says Van Gemert. This, he believes, will be an essential component in the success of the Energy Transition, because 'consumers can be just as unpredictable as the wind and the sun.'

Entrance is also unique, says Van Gemert, because of its educational approach. Both schools and universities are working together at the testing ground in Groningen, where the focus is as much on teaching as it is on research. 'Like our research, our teaching at Entrance also has an international scope, which requires a new approach,' explains Van Gemert. 'We're the only university in the Netherlands to offer an internationally recognised Master's degree in Renewable Energy. There are currently eight students enrolled in the programme, from all over the world.'

Industry is also playing a role in the research at Entrance. Fifty different companies, including Gasunie and GasTerra, have already committed themselves to the initiative. 'They don't know yet what direction these developments will take, but they want to be a part of it,' says Van Gemert. 'It's essential that we get as many parties as possible participating in Entrance. Energy is all about systems development, and the energy system is extremely complex. We can only make progress if we work together with others – we can't do it alone.' ●



Gas in transport

A NEW GLOBAL MARKET BECKONS

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The Tesla, the Prius, the Volt – electric cars and hybrids are all the rage. Few people are talking about natural gas as an alternative to other fossil fuels (such as oil, petrol or diesel) in cars, trucks and ships. And yet there are some major developments underway in this area: a new global market is opening up.

Has the time for gas in transport now arrived? A growing number of analysts are leaning in that direction – especially with regard to the use of LNG (liquid natural gas) in trucks and ships. And the prospects for gas in the private car market are now also looking promising.

The leading research organisation IHS-Cera predicts that, in just a few years' time, 400 billion cubic metres of gas will be used in the transport sector every year. That's ten times the total volume used annually in the Netherlands. Countries like the USA and China are working hard to expand their LNG infrastructure for trucks and ships. In countries such as Iran and Russia, investments are also being made in gas-powered private cars. Other countries, including Argentina and Italy, have long been using gas on a large scale in road transport.

As a gas hub and as Europe's most important transport hub, the Netherlands is in a particularly good position to address this new market. In May 2013, PriceWaterhouseCoopers released a report, commissioned by the Ministry of Economic Affairs, in which they stated that LNG in particular is 'an important potential new fuel' for the transport sector in the Netherlands. The study pointed out that, as a transport fuel, LNG could generate billions of euros and thousands of jobs for the Netherlands.

Shell is already investing heavily in LNG for ships and trucks, and Gasunie is now developing, along with Vopak, a new small-scale or 'break bulk' LNG terminal that will be located next to the big GATE (Gas Access To Europe) Terminal in Rotterdam, and which will be suitable for loading ships and trucks. In preparation for this, the Gate Terminal already has mooring facilities for smaller ships at which smaller quantities of LNG can be loaded and unloaded. These can be used for supplying filling stations in Scandinavia, for example, where the transport sector is already in need of a clean fuel such as LNG. The first cargos for Scandinavia have already been shipped – making Gate now also an export terminal.

If all goes according to plan, Rotterdam will take the lead in this development. Until now, Europe has lacked an integrated small-scale LNG chain. The LNG currently arriving from overseas is delivered in bulk and transformed into gas, which is then injected into the natural gas network. The break bulk terminal will make it possible to load ships and trucks directly with smaller quantities of LNG.

'Ships powered by LNG have been around for more than forty years,' says Jelle Paulusma of the Port of Rotterdam, speaking on behalf of the National LNG Platform. 'What's changed now is that gas is being used in more places and in greater quantities than ever before, and that we're constantly getting better at making it liquid. And gas in a liquid form is like a floating pipeline.'

ENTHUSIASTIC MARITIME SECTOR

Anyone who talks to the experts on this topic is always given two reasons why we should be optimistic about the prospects for gas in transport:
1) the increasing scarcity of oil combined with the decreasing scarcity of gas, and
2) worries about the environment and climate.

For the shipping industry, the most important driver for switching to LNG is not the scarcity of oil, but, above all, the new environmental regulations to limit emissions of sulphur oxides. These regulations are related to certain regions, known as Sulphur Emission Control Areas (SECAs). These can be found in Europe, principally in the Baltic, the North Sea and the English

For cities, gas is the perfect solution, particularly when you add green gas to it

Channel. However, it's expected that the new regulations will be implemented more widely in due course.

Shipping companies can meet the regulations by switching to diesel, a cleaner product, but one that is almost twice as expensive as the fuel oil that they're using at the moment. Alternatively, they could install washers to remove the sulphur oxides. But washers are expensive and the technology has not yet proven itself. A third possibility is to switch to LNG. 'This is a very attractive option,' says Tor Christian Sletner, head of Environment, Innovation and Safety at the Norwegian Shipowners' Association. With LNG, a ship doesn't emit sulphur, and hardly any nitrogen or soot, if any at all. The ship itself even becomes a lot cleaner, says Sletner: 'You can walk around the engine room in your dinner jacket!'

For the time being, LNG will first penetrate in inland waterways and coastal traffic. This is because it is difficult to keep LNG at the required temperature of -167°C for more than two weeks. But this has not tempered the enthusiasm in the sector. Every day, reports appear in the trade press with announcements about new LNG bunker stations. Analysts expect that in 2015 there will be five hundred ships sailing on LNG, and more than a thousand in 2020.

However, these LNG fuelling facilities have yet to be built. At the moment, most ships using LNG as fuel are fuelled from tanker trucks, and there is one LNG fuelling ship for vessels in Europe, located in the Swedish port of Nynäshamn. Rotterdam and Antwerp are expected to follow in 2015, and ports in southern Europe in the years after that. Furthermore, there are plans for LNG fuelling stations for inland waterway vessels in Poland, Estonia, Lithuania, Germany, Sweden and Finland.

In the Netherlands, Vopak and Gasunie, owners of the Gate Terminal in Rotterdam, are developing a break bulk terminal. The plan is that two loading stations will be built to fetch LNG for heavy goods vehicles, and one for ships. In January 2014, the first loading station for heavy goods vehicles will be ready, and the complete terminal should be ready at the end of 2015.

Besides this infrastructural challenge, LNG also poses a climate challenge. Using LNG as a fuel for ships leads to, on average, 20–30% fewer emissions of greenhouse gases, but this does not take account of the evaporation of methane from engines. A new study by the International Council on Clean Transportation (ICCT) shows that the average greenhouse gas benefit of LNG in shipping at this moment is about 10%, but this could rise to 30% if leakage of methane (a stronger greenhouse gas than CO_2) is adequately combatted throughout the chain.

For the time being, electric cars have won the communication battle

SOLUTION FOR ROAD TRANSPORT

The climate benefit of gas is a very much more important argument in the road transport sector than in the shipping sector. Not that environmental benefit does not count in road transport. On the contrary. Catrinus Jepma, Professor of Energy and Sustainability at Groningen University in the Netherlands and scientific director of the Energy Delta Institute (EDI), argues that 'driving on gas is much better for the environment than driving on diesel. Soot is the biggest killer, much more than CO_2. You don't have this with gas. And you also get rid of noise pollution. For cities, gas is the perfect solution, particularly when you add green gas to it.'

As far as the climate is concerned, the EU aims to cut CO_2 emissions from road traffic by 60% by 2050. According to a report by NEA, ING and Transport and Logistics Netherlands, the use of LNG in trucks gives a benefit of about 10–15%. This is perhaps not unduly impressive, but according to Annemarie Timmermans, LNG Project Manager at Vos Logistics, it's still worth the effort. 'Our sector is seen as very polluting,' she says, 'and our clients are pressing us to introduce improvements here. We have little alternative other than LNG, because biodiesel and electricity have so far not been developed for trucks.'

In due course, the transport sector hopes that biogas (whether or not in the form of bio-LNG) will provide a solution. 'Natural gas is a transitional fuel,' says Rob Aarse of Transport and Logistics Netherlands, and one of the authors of the report. 'It receives support, because many people believe it's a bridge to biogas.' Using biogas derived from waste would make it possible to reduce the emissions from trucks by some 70%, says Aarse.

And what about the prospects of using gas in cars? Matthias Maedge, who heads the EU office of the global lobby group Natural & Biogas Vehicle Association (NVGA), is convinced that it will take off in Europe, in the form of CNG (compressed natural gas), which is most suitable for cars and lighter goods vehicles. As diesel becomes more expensive and environmental standards are tightened, carmakers will need CNG and LNG to present as a 'new success story' to follow up the great success of diesel, he says. Maedge also thinks that the acceptance of LNG will partially depend on the success of CNG. There are already over a million CNG cars on the roads in Europe, plus 2,800 CNG filling stations, particularly in Germany and Italy. The NVGA expects the number of CNG cars tol rise to some 15 million in 2020, which would be 5% of the total. In terms of volumes, this would mean a rise from 2 billion m^3 now to 30 billion m^3 in 2020 – a substantial market.

CHICKEN-AND-EGG PROBLEM

Just as in the case of the shipping industry, the availability of sufficient infrastructure for LNG and CNG remains a difficult point. At the moment, there are about 23 LNG and LCNG (LNG/CNG) filling station in the EU, particularly in Spain and Italy. In the Netherlands, there are currently 8 LNG stations for trucks, and almost 100 CNG filling stations.

Earlier this year, the European Commission announced an ambitious strategy for tackling the chicken-and-egg infrastructure problem, including for electric cars. The Commission's proposals, which are currently being discussed by the member states and the European Parliament, involve every member state creating a national policy framework for the development of 'alternative fuels'. Objectives have also been laid down for the expansion of LNG-CNG stations along motorways, at sea ports and for the inland shipping sector. Funds are available from (for instance) the EU's TEN-T (Trans-European Networks for Transport) Programme and the Truck of the Future Programme in the Netherlands.

In 2014, the EU will also draw up standards and guidelines for LNG and CNG filling stations, which will need to apply in all countries. The Commission is also considering promoting LNG to the general public. Matthias Maedge of the NVGA is positive about the proposals. 'This is the political support we need. I think that we can now reach the LNG and CNG objectives even before the legislation has been introduced everywhere.'

Local legislation is also important. Rob Aarse from Transport & Logistics Netherlands says that the Dutch

With LNG, the ship itself even becomes a lot cleaner – you can walk around the engine room in your dinner jacket!

central government should provide better guidelines to local and provincial governments on the question of issuing permits for LNG stations.
Jelle Paulusma from the Port of Rotterdam expects that a positive impetus for the LNG market will also come from the other side of the Atlantic. In the USA, where gas prices are low, LNG is already cheaper than heavy fuel oil. As a result, American vessels will increasingly visit European ports, which will encourage ports to offer LNG facilities.

RETURN ON INVESTMENT

Gas may be cheap in the USA, but in Europe it is not. PwC therefore expects that in due course the greater supplies of gas on the world market will put pressure on gas prices in Europe. For transport companies, this remains an uncertain factor.

At the moment, LNG contracts are being offered on the European market at some 60–75% of diesel prices – in other words, considerably cheaper. However, using LNG involves making investments that can only be recovered if sufficient distances are driven. Fuel forms about half the cost of a truck that travels 100,000 km a year. 'We haven't reached enough kilometres yet to be able to recoup our investment,' says Annemarie Timmermans of Vos Logistics. 'That's because there are so few LNG stations.' Nonetheless, Timmermans believes that LNG will eventually become economically viable.

Shipowners are also confronted with an aditional expense. To run a ship on LNG, modifications to the engines are required, explains Tor Christian Sletner of the Norwegian Shipowners' Association. That makes it cheaper to opt for diesel, which doesn't require any modifications.

An important factor affecting the use of LNG in transport is the stability and level of excise duties. These have recently been somewhat uncertain in the Netherlands. Plans to increase duties were announced in 2012, which naturally made using LNG for trucks less attractive. In fact, sales of trucks running on LNG came to a complete standstill. Then, in September 2013, the Dutch government announced that the planned increase was being postponed for at least five years, removing, for the time being, the crippling uncertainty. Meanwhile, the European Commission has initiated a review of European energy duties. In due course, Brussels wants these duties to be based on energy density and environmental performance, which may lead to big shifts in the transport sector. It is not yet clear when these changes will be implemented, but it is not likely to be for a number of years.

THE NETHERLANDS – A MULTI-PURPOSE HUB

The growth of gas as a transport fuel is an interesting development for the Netherlands. The Dutch government plans to make the country the 'gas roundabout' of North-West Europe (see box). At the same time, the Netherlands is Europe's biggest transport junction, with a very substantial share in the inland shipping sector.

Unlike other ports where LNG is handled, the Gate Terminal in Rotterdam is located at the heart of the port's bunkering and shipping activities. If proposed plans are implemented, both inland and sea-going vessels will soon be able to bunker LNG on a large scale in Rotterdam. All of North-West Europe can be served from here. In fact, two of the Netherlands' strong points come together here: the Port of Rotterdam and the country's gas infrastruture. The rise of small-scale LNG is important not only in helping to solve the environmental consequences of road and waterway traffic, but also in creating opportunities for trade. The Gate Terminal can grow into a trading hub, where traders can temporarily store LNG.

We haven't yet discussed biogas. Raymond Gense, Director of Future Technology and Public Affairs at car company Pon, is positive about the potential of biogas for transport in the Netherlands, thanks to the country's highly advanced agricultural sector and gas infrastructure. Gense believes that 20% of transport in the Netherlands could be fuelled by biogas. Twelve million cows for eight million cars? With the power-to-gas technology as now embraced by Audi, you're no longer stuck with methane; you can also switch to hydrogen.'

If gas is to be the fuel of the future, it should be sold as such – as a winner

According to Gense, gas can already compete with other fuels, without needing any big subsidies. This cannot yet be said of electric transport. However, for the time being, electric cars have won the communication battle. 'The zero-emissions story of electric cars is easier to tell than the story of manure being converted into CO_2-neutral gas.' If gas is to be the fuel of the future, says Annemarie Timmermans of Vos Logistics, it should be sold as such – as a winner. 'It takes time to make people aware and to win them over to gas.' ●

THE NETHERLANDS AS A GAS ROUNDABOUT

How important is the development of the Netherlands into the 'gas roundabout' of North-West Europe? According to Pierre Bartholomeus, Global Director of Gas Consulting & Services of DNV Kema, this concept is of great strategic importance to the Netherlands.

The gas market is becoming increasingly international, he explains. 'National and regional markets are merging. At the same time, gas itself is becoming more sustainable. Within the European energy market, gas will be a crucial supplier of flexibility – by offering storage and transport, linking up markets and providing back-up for sustainable energy. Adequate gas provision in Europe will therefore be essential. The Netherlands has the potential to develop into the backbone of Europe's gas provision. The economic and strategic significance of this position is, I think, underestimated.' ●

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