EnviTec Biogas

BIOMETHANE

High time for sustainable transport!

Backgrounder from EnviTec Biogas AG

Opinion

Ignore, for the moment, details such as diesel-free zones or pollutant limits: protecting the climate means protecting humanity's future. As a technology leader, we in Germany could make a real contribution to reversing climate trends. Germany has set itself the goal of lowering its greenhouse gas emissions by at least 40 percent by 2020 and by at least 55 percent by 2030 (based on the country's level of emissions as measured in 1990). According to its 2018 Climate Protection Report, however, total emissions (excluding land use changes and forest management) have fallen only 27.7 percent compared with 1990.[1]

In contrast, the biogas industry has ready-made models for two of the German Government's five sector targets (energy, industry, buildings, transport and agriculture) – namely heating and mobility – that could be implemented immediately. As one example, switching to biomethane as an alternative fuel would enable the achievement of around 60 percent of the climate targets set for the transport sector. The terms 'biomethane' and 'biogas' are used synonymously to mean a gas of natural origin upgraded to standard natural gas quality; the specific manufacturing chain used for biomethane means greater CO2 savings are possible. A recent study published by the Fraunhofer Institute for Systems and Innovation Research ISI, Hamburg University of Technology and the Institute for Resource Efficiency and Energy Strategies[2] confirms that solutions based on the use of bio CNG (compressed natural gas) and bio LNG (liquefied natural gas) perform better both in terms of the carbon footprint and the total cost of ownership than the electromobility solutions as proposed by the German Government.

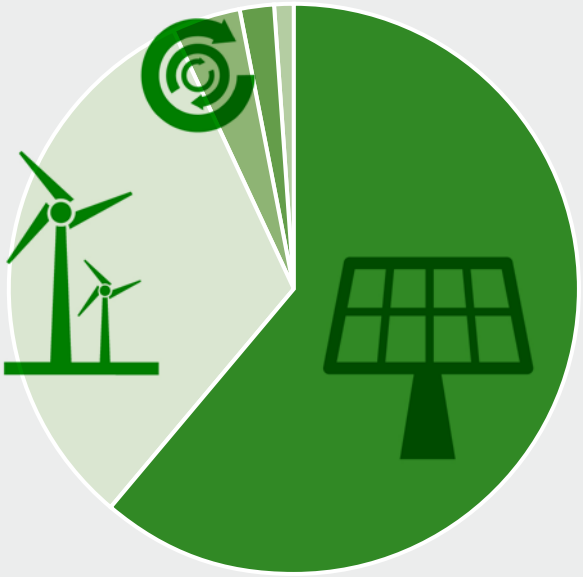
[1] "2018 Climate Protection Report", German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, February 2019

[2] "Carbon footprints, costs and potential of various fuel types and drive systems", Fraunhofer Institute for Systems and Innovation Research ISI, 3 September 2019

»If the biomethane capacities and potential now available were used to the full, we could power up to 18 million mid-range passenger vehicles.«

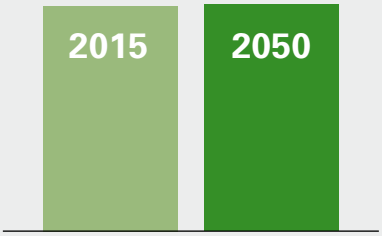
Jörg Fischer, CFO EnviTec Biogas

Simulation: 'A global energy system built entirely from renewable energy sources' in 2050

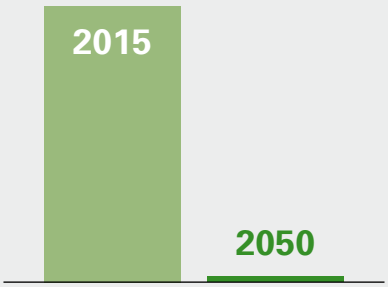


Power generation would be based on the following mix of energy sources: solar power (62%), wind power (32%), hydropower (4%), biomass (2%) and geothermal (<1%).

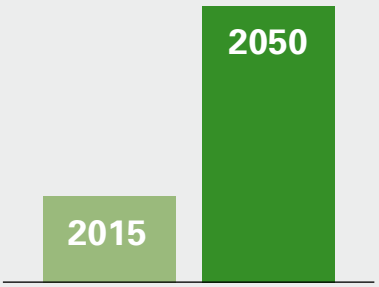
Around 85 percent of **energy from renewable sources** would be generated either locally or regionally.



The **energy costs** for a European energy system based entirely on renewables would be stable at around EUR 50-60/MWh in 2050.



In Europe, annual **greenhouse gas emissions** would decrease steadily from 4,200 million t of CO2 equivalent in 2015 to zero by 2050.



Instead of the 800,000 **workers** required by the European coal mining industry in 2015, over 3 million new jobs would be created in the renewable energy sector by 2050.

Climate protection targets from the German Government

The German Government plans to reduce greenhouse gas emissions by at least 40 percent by 2020 (compared to 1990 emissions) and is even aiming to become largely greenhouse gas-neutral by the middle of this century – at least according to its 2050 Climate Action Plan. The individual targets in this German climate policy are derived from the UN Framework Convention on Climate Change and EU agreements. While the Fridays-for-Future demos have been a prominent outlet for expressing dissatisfaction with the progress made to date by European climate policy, the headline-grabbing protests by school pupils have also been accompanied by greater environmental awareness on the part of adult voters. Gains made by Green parties in the EU elections have pushed climate policy up the political agenda. As an employer and innovator working in the renewable energy sector, we therefore feel duty-bound to make a meaningful contribution of our own, and to review the climate protection targets missed by our own government. In light of the general trends observable for greenhouse gas emissions and Germany's failure to meet its targets, the coalition parties set out their intentions to achieve the 2020 target as soon as possible in a contract signed in March 2018. The government also once again confirmed the reduction targets of at least 55 percent by 2030 and of at least 70 percent by 2040. Other parts of the plan also provided further details of the 2030 goals for the energy, industry, buildings, transport and agriculture sectors.

»As an employer and innovator, we feel ourselves duty-bound to make our own contribution to achieving the climate targets.«

Olaf von Lehmden, CEO

Emissions for the action areas included in the target definition

Action areas	**1990** (in million t of CO2 equivalent)	**2014** (in million t of CO2 equivalent)	**2030** (in million t of CO2 equivalent)	**2030** (reduction in percent compared with 1990)
Energy	466	358	175 to 183	62 to 61
Buildings	209	119	70 to 72	67 to 66
Transport	163	160	95 to 98	42 to 40
Industry	283	181	140 to 143	51 to 49
Agriculture	88	72	58 to 61	34 to 31
Subtotal	1209	890	538 to 557	56 to 54
Others	39	12	5	87
Total	**1248**	**902**	**543 to 562**	**56 to 55**

Source: German Federal Environment Ministry,
"Climate Action Plan 2050 – Germany's long-term emission development strategy"

The status quo in the transport sector

As a biomethane plant construction company, our primary market is the transport sector, with a secondary market in heating. According to the government's plan, the transport sector needs to achieve reductions of 40 to 42 percent (vs. 1990) to meet the 2030 climate target. The plan envisages a series of 'climate concepts' with measures to achieve these reductions. The concept for the road transport sector, for example, will set out the strategy for reducing greenhouse gas emissions in this sector by 2030. This strategy will cover emissions from both passenger vehicles and light/heavy goods vehicles, and provide answers to questions about greenhouse gas-neutral energy sources, the infrastructure necessary to support them and sector coupling (by electromobility). Other important aspects relevant for the transport sector include alternative drive systems, public transport, rail transport, the promotion of cycling and walking, as well as an overall strategy for digitalisation. While Germany was once a climate champion, however, its environmental policy failings have earned it a poor 27th place in the latest 2019 Climate Protection Index – far behind front-runners Sweden, Morocco, Lithuania and Latvia.[3] "Total emissions expressed in carbon dioxide (CO2) equivalents (excluding carbon dioxide emissions from agricultural use, land use changes and forest management) fell until 2016 by around 342 million tonnes or 27.3 percent. For 2016, total emissions reported amounted to 909 million tonnes – the second consecutive increase."[4]

For the transport sector in particular, the 2050 Climate Action Plan envisages a reduction in harmful greenhouse gases of 40 to 42 percent by 2030 (compared to the 1990 baseline) with the proportion of energy from renewable sources rising to 10 percent by 2020 and as much as 14 percent by 2030. While the German Federal Environment Agency reports significant reductions in greenhouse gas figures since 1990 in terms of total emissions, much work still seems to be needed before this trend is also established in the mobility sector. Statistics here are influenced by our choices as consumers: we still tend to select the car with the bigger engine. Overall traffic volumes are also increasing. High time, then, to initiate a turnaround. While the German Government has not yet published a programme for promoting a green gas mobility strategy, it is nonetheless essential, given traffic forecasts for 2030: compared with 2010 figures, freight traffic in Germany is set to rise by 38 percent (inland waterway freight by 23 percent) and passenger transport by 13 percent.[5]

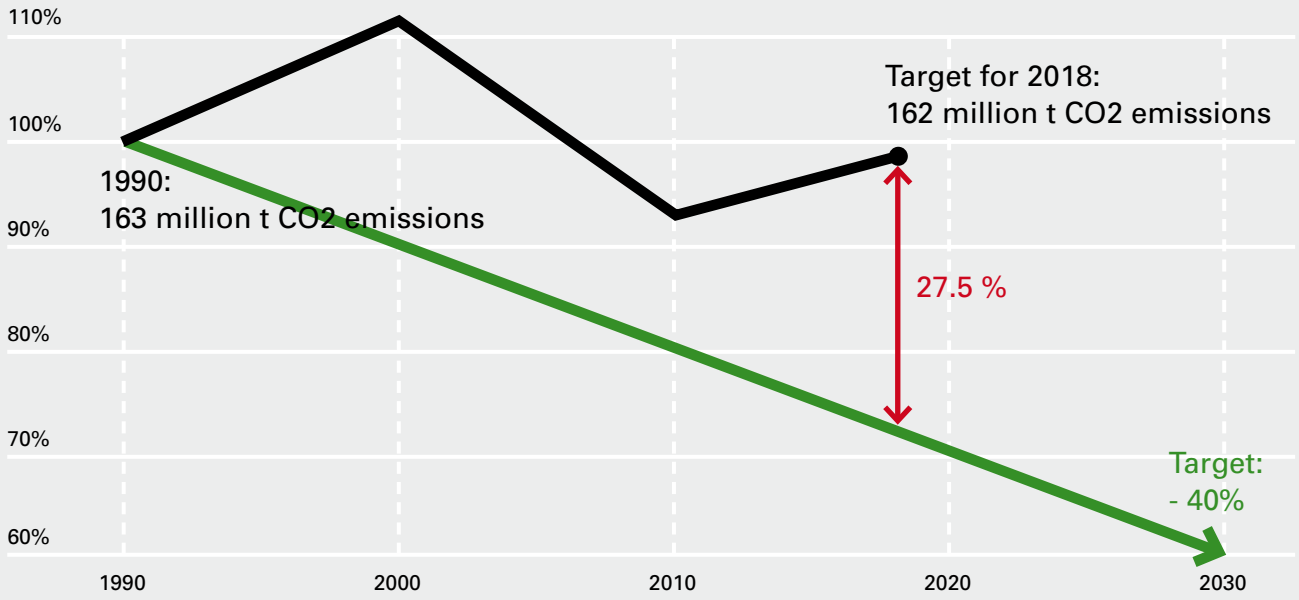
As a mid-size company and technology pioneer in biogas plant engineering, we see many missed opportunities here. Use of existing gas infrastructure could offer quick wins for the transport sector in particular – a major CO2 emitter still reeling from the effects of 'dieselgate'. In our view, one key driver for achieving the Climate Protection Plan targets is biomethane in the form of bio CNG (compressed natural gas) and bio LNG (liquefied natural gas). Bio CNG can be used by standard gas-powered vehicles in the same way as conventional natural gas. These vehicles emit a much smaller volume of exhaust pollutants, and are also more economical to drive due to their reduced vehicle tax and lower fuel costs. Without a proper policy framework in place, however, the market penetration of biomethane as a fuel has fluctuated between sluggish and stagnant. Yet biomethane is the best alternative to any other biofuel for the transport sector: its average reduction in emissions of a hefty 91 percent puts it in the vanguard of environmentally friendly drive systems.

[3] "2019 Climate Protection Index", Germanwatch e.V., December 2018
[4] "Greenhouse gas emissions in Germany 2017", German Federal Environment Agency, April 2019
[5] "Traffic integration forecast 2030", Federal Ministry of Transport and Digital Infrastructure, June 2014
[6] "Final energy consumption and transport energy efficiency", German Federal Environment Agency, May 2019

In 2017, fuel consumption figures – based on calorific value (excluding electricity) – were 26.2 percent for petrol, 53.4 percent for diesel, 15.7 percent for aviation fuels and just 0.7 percent for liquefied gas and natural gas.[6] There's a lot of room for improvement here.

The situation is similar in the heavy freight traffic segment, where bio LNG offers a readily deployable alternative fuel that could improve urban air quality by reducing nitrogen oxide, fine particulate and sulphur emissions in both the road and maritime freight traffic segments (see page 9).

German Government emissions targets: the transport sector status quo



Expected increase in traffic in Germany by 2030 vs. 2010

CO2 studies: bio CNG and LNG are a better option than electric vehicles

In the public debate about environmentally friendly mobility, electric vehicles (EVs) – thanks to support from carmakers and policymakers alike – are often touted as the only viable solution. In 2018, German car club ADAC published the first set of full CO2 figures for all passenger vehicle drive systems. The authors were unable to recommend any one drive system as offering the best carbon footprint overall and also noted several problems with allegedly 'green' electric vehicles.[7] These findings have now been reinforced by the ADAC's latest study: according to a lifecycle analysis published by Joanneum Research, CNG-powered vehicles have the lowest carbon footprint of all commercially available drive systems. In the hatchback segment, figures for CNG cars were clearly superior to those for petrol or diesel vehicles, as well as EVs – when using the current energy mix. Electric vehicles only achieve better figures than other types of drive system once the electricity they use is taken exclusively from renewable energy sources. Put another way: EVs won't be green until the energy transition is complete.[8]

Similar conclusions have been drawn by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. In an analysis published in January 2019, the ministry considered the footprint obtained by using the standard German energy mix – i.e. not generated solely from renewable sources – and while considering the entire vehicle lifecycle of production, use and disposal.[9] The report concluded that, run on today's energy mix, EVs are not more climate-friendly. The study 'Driven by coal, wind and diesel'[10] by Hans-Werner Sinn, Christoph Buchal and Hans-Dieter Karl goes even further than this: the facts provided by the three researchers support many arguments from the biogas industry about the use of bio CNG as an alternative fuel for the transport sector that have yet to be taken seriously by policymakers, and describe EVs as a 'step backwards' for climate protection.

A recent Fraunhofer study, which was commissioned by the Biogasrat+ e.V. association, draws similar conclusions.[11] Researchers from the Fraunhofer Institute for Systems and Innovation Research ISI, Hamburg University of Technology and the Institute for Resource Efficiency and Energy Strategies took a detailed look at the entire lifecycle of EVs, diesel vehicles and CNG-powered passenger cars. In this paper, which was published in September 2019, the authors conclude by saying that biomethane is not only able to contribute to achieving Germany's climate protection targets but can even help to reduce pollutant emissions as well. The team of researchers headed by Professor Martin Wietschel, Project Leader at Fraunhofer ISI, investigated the alternatives to the traditional combustion engine currently available for cars and trucks in Germany. In their study, the researchers made comparisons between passenger vehicles using a hybrid diesel/biofuel mix, battery vehicles, natural gas vehicles, and vehicles using biomethane/synthetic methane. For trucks, diesel-powered vehicles were compared with those running on a gas-based fuel: fossil natural gas, biomethane or synthetic methane. The entire vehicle lifecycle – from production to usage phase and recovery/recycling ('well-to-wheel' approach) – was also factored into the study.

[7,8] "Waiting for the energy transition: the carbon footprint of EVs", ADAC, October 2019

[9] "How climate-friendly are EVs?", German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, January 2019

[10] "Driven by coal, wind and diesel: EVS and their CO2 footprint", Institute for Economic Research (ifo), April 2019

The study's results are crystal-clear: biomethane has the best figures in terms of greenhouse gases. In fact, deploying biomethane in the mobility sector could even result in negative trends for greenhouse gases if credits for the generation of biomethane from liquid or solid manure are taken into account as per relevant EU legislation (RED II).

In terms of costs, the biomethane pathways for cars are only slightly more expensive than the fossil fuel diesel both now and for 2030. When compared with drive systems powered by other renewables, including e-mobility, biomethane fuelled vehicles lead the field in terms of a life-cycle cost analysis.

Fuel costs are a much bigger factor for trucks than for cars. Accordingly, the study concludes, heavy trucks run on liquefied natural gas (LNG) made from biomethane incur much higher costs than trucks using fossil diesel/LNG. Compared with drive systems using other renewables, however, biomethane-fuelled trucks are much cheaper, both now and in the future.
In the long term, the researchers found, only electric vehicles would have the potential to achieve the cost effectiveness of biomethane.
As another benefit for sustainable mobility discovered by the study authors, up to 18 million mid-range passenger vehicles – amounting to over a third of the current volume of cars on German roads – could be powered by using the biomethane capacities now available plus the biomethane capacities capable of being developed.

»Biomethane massively reduces pollutant emissions and has the best figures in terms of greenhouse gases.«

Jürgen Tenbrink, CTO EnviTec Biogas

Biomethane in Germany: the status quo

The German Government has so far failed to appreciate the potential role biomethane could play in achieving climate protection targets – despite the fact that biomethane generation in Germany could be increased tenfold in the future, from the 10 terawatt-hours at present to 100 terawatt-hours by 2050. These are the findings of a strategy paper prepared on the basis of recent study data by the Biogas Partnership run by the German Energy Agency (dena).[12] Such an expansion would require improvements to the general conditions for the use of biomethane in the transport, heating and electricity sectors. Biomethane is generated by upgrading biogas to natural gas quality: it can be stored easily and used in many applications – just like conventional natural gas. Sources for generating biomethane include waste materials, animal excreta and energy crops.

The various studies agree that biomethane could make a significant contribution to the energy transition without competing with the production of food and animal feed. The strategy paper evaluated a total of 16 studies published from 2012 to 2017: these studies investigate a wide variety of alternatives to achieving the energy and climate policy targets set by the German Government.

To achieve short- and medium-term reductions not just to greenhouse gas emissions but also to pollutants (carbon monoxide and fine particulates), gas-powered vehicles that run on biomethane or other renewable gases are a cost-effective option that can be implemented quickly. As one example, we calculate that switching to biomethane as an alternative fuel – but with the same physical properties as conventional natural gas – would enable the achievement of around 60 percent of the climate targets set for the transport sector.
Yet demand from the general population is weak – as is also shown by the small size of the vehicle and filling station market: according to figures from the German Renewables Agency (FNR), sales of biomethane as a fuel in 2018 totalled 401 GWh.[13] Converted to vehicle numbers, statistics from the Federal Motor Transport Authority (KBA) show that only 80,757 CNG-powered passenger cars were registered in Germany as of 1 January 2019. This amounts to just 0.173 percent of total car registrations (46,466,347 vehicles).[14] Confusion about unit pricing at the gas pump is another problem for vehicle drivers. While conventional fuels and LPG are priced per litre, a kilo of natural gas provides about one and a half times as much energy as a litre of unleaded (95 octane) petrol. This means that consumers cannot simply compare prices for petrol, diesel, LPG and natural gas but have to first complete a time-wasting conversion. Potential cost savings are therefore not apparent at first glance.

Use of CNG by goods and utility vehicles is also modest compared to other drive systems. Of a total of 80,519 buses registered as of 1 January 2019, only 1,106 were CNG-powered (a year-on-year decline of 4.7%), while only 13,783 of 3,149,263 registered trucks used a CNG drive system (a year-on-year decline of 3%).[15]

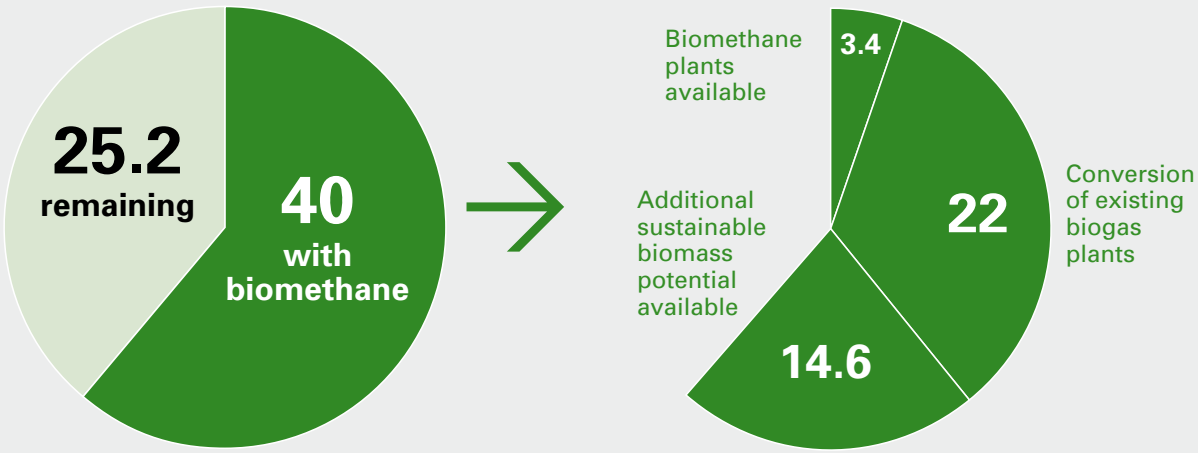
"Compared with Euro 6 diesel cars, natural gas vehicles cut emissions of nitrogen oxides by over 95 percent and CO2 by around 23 percent while halving fine particulate emissions. Benefits for the climate are also clear compared with direct-injection petrol engines: CO2 cut by 35 percent, nitrogen oxide cut by 67 percent and

[11] "Carbon footprints, costs and potential of various fuel types and drive systems", Fraunhofer Institute for Systems and Innovation Research ISI, 3 September 2019
[12] "Biomethane's role and contribution to climate protection – now and in 2050", German Energy Agency (dena), October 2017
[13] "Base data for renewable biofuels", German Renewables Agency (FNR), February 2019
[14] Statistics from the German Federal Motor Transport Authority (KBA), vehicle registrations by environmental attributes, 1 January 2019, p. 18

»Switching to biomethane could enable the achievement of around 60 percent of transport sector climate targets.«

Olaf von Lehmden, CEO EnviTec Biogas

Over 60 percent of the CO2 reduction targets for the transport sector could be achieved with biomethane (in million t of CO2).



Government reduction target: 65.2 million t CO2.
Contribution to target by using biomethane: 61%

Biomethane potential (in million t CO2)

fine particulates cut by 99 percent" – according to the 'Zukunft Erdgas' initiative.[16]

A switch to gas-powered vehicles on the part of private car owners and municipalities alike would therefore help to reduce the levels of urban pollution. In the agriculture and forestry sectors, local potential for biogas could be exploited to have tractors and other kinds of heavy machinery run directly on biomethane. As mentioned above, biomethane has the same physical properties as conventional natural gas but has a better CO2 footprint than natural gas because of the way that it is produced. Ensuring pricing is readily understandable by consumers at the pump is also another important step towards motivating them to purchase a gas-powered vehicle.[17]

The high energy density offered by biomethane means that it can easily power vehicles on long-distance journeys – and unlike EVs, today's vehicles already feature the storage technologies required.

"How far can I drive on ten euros' worth of fuel?" asks the website run by pro-natural gas campaigners 'Erdgas e.V.'. The answer speaks volumes about the high energy density of natural gas: "In theory … a gas-powered vehicle would make it to the 200 km mark. A petrol engine vehicle would run out of juice after about half the distance. Only diesel can keep up with natural gas – at least in terms of kilometres driven and the current low price of diesel fuel. But if you look at the levels of pollutants in the exhaust, you can see just how expensive this 'keeping up' really is."[18]

Biomethane is also a practicable low-emission alternative for freight traffic carried on roads and at sea: a recent study published in May 2019 by the German Energy Agency (dena) argues that bio LNG could help to make significant reductions in GHG here by 2030.[19] This can be achieved by increasing the efficiency of drive systems and by using alternative fuels. In these road and maritime freight traffic sectors, diesel engines are the typical drive system used, while battery-powered vehicles are only found in niche applications. New EU legislation is putting increasing pressure on heavy freight traffic operators, however: by 2030, average GHG emissions from newly registered heavy commercial vehicles must be 30 percent lower than present levels. The extent to which renewable fuels can help to achieve this target is being investigated until 2022. However, due to its high energy density, Bio LNG is certainly an excellent option for the heavy freight sector. In Germany, demand for LNG-powered trucks is increasing while shipping companies are also switching to LNG, the study reports. The successful introduction of bio LNG for trucks and maritime shipping could account for around 7 million t of CO2 – or around 10 percent of the necessary reduction in GHG. Securities would need to be offered to investors to achieve short-term acceleration of bio LNG production, however: one option would be an exemption from the German Renewable Energy Sources Act (EEG) levy for green LNG producers. This could lower costs by between 4 and 9 percent.

[15] Statistics from the German Federal Motor Transport Authority (KBA), vehicle registrations by environmental attributes, 1 January 2019, p. 29 f.
[16] "Leaving fine particulates in the dust", Zukunft Erdgas e.V.
[17] "Biomethane's role and contribution to climate protection – now and in 2050", German Energy Agency (dena), October 2017
[18] "Going places with natural gas", Zukunft Erdgas e.V.
[19] "Bio LNG: a renewable, low-emission alternative for road and maritime freight traffic", German Energy Agency (dena)
[20] Modelled on the position paper "A green gas mobility strategy: groundwork for a sustainable energy transition and successful climate protection in the transport sector", Biogasrat+ e.V., December 2018

Advantages of biomethane as a fuel:

- → **Burns cleanly and has no technical barriers to deployment**
- → **Virtually CO2-neutral and renewable**
- → **Proven compatibility with any natural gas engine**
- → **Can be pumped directly from the plant to the filling station via the natural gas grid**
- → **Expandable infrastructure of 860 filling stations already available**

»Biomethane offers an immediate response to unanswered questions after dieselgate and the current debate about pollutant limits.«

Olaf von Lehmden, CEO EnviTec Biogas

Biomethane facts and figures for 2017[20]

- → **210 biomethane plants**
- → **EUR 4.5 billion of invested capital**
- → **9.84 TWh of feed-in capacity, marketed as follows: 7.6 TWh in the electricity segment, 0.46 TWh in heating, 0.45 TWh in transport and 0.18 TWh for export**
- → **3.4 million t CO2 equiv. of emission savings**
- → **Potential for sustainable biomethane generation by 2030: 11 billion Nm³ (120 TWh feed-in capacity)**

Overview of biomethane in the transport sector:

Year	Potential as a fuel	No. of mid-range passenger vehicles[21]	GHG savings/year
2020	5 TWh Biomethane	705,000 vehicles	1.72 million t CO_2-eqiv.
2025	30 TWh Biomethane	4,235,000 vehicles	10.37 million t CO_2-eqiv.
2030	60 TWh Biomethane	8,470,000 vehicles	20.74 million t CO_2-eqiv.

Bio CNG is on the move

Don't put all your eggs into one basket, as they say. Even German carmaker VW is no longer focusing solely on improvements to electric drive systems. While the Wolfsburg-based automotive giant intends to electrify 40 percent of its vehicles by 2030, it is also now working on developing a climate-friendly gas-powered engine. Although adding EVs to fleets is currently a popular way to cut emissions, an awareness of the poor climate performance of electric vehicles when viewed over their entire lifecycle has been raised by other sources than the Fraunhofer study cited here. By the end of 2019, VW aims to have 19 models with gas engines on the market. And VW subsidiary SEAT is also now testing a CNG model using biomethane.[22]

Another flagship project for biomethane was launched by the municipal public utility of Augsburg in 2011: some 90 percent of the city's buses are now running on biomethane. The City of Koblenz will follow suit in December 2020, when it will deploy 29 buses powered by biomethane engines for public transport.[23] In Sweden, too, over 180 buses are now being powered by the green biofuel in Stockholm.

A major study focusing on public bus services, commissioned by Zukunft ERDGAS and authored by Professor Ralph Pütz (BELICON GmbH, Institute for Applied Commercial Vehicle Research and Exhaust Gas Analytics at Landshut University of Applied Sciences) and Dr Frank Snaga (PricewaterhouseCoopers GmbH) concludes that, from an ecological and economic perspective, a biomethane-powered bus is the best alternative to the diesel bus, both now and in the medium term up to 2030.[24] These results are based on analysing an average fleet of 20 modern standard buses using a variety of drive systems: diesel, diesel hybrid, natural gas, biomethane, fuel cell hybrid and electric battery (opportunity charger, overnight charger and trolley hybrid).

To assess the environmental impact of the various drive systems, a 'well to wheel' approach was used – as was the case with the Fraunhofer study mentioned above. Bus manufacture and maintenance were considered alongside bus operations, as well as the provisioning of fuel and energy. Actual pollutant emissions (CO2, NOX and particulates) were measured during bus operations. Costs were evaluated by looking at the total cost of ownership, which includes both the respective infrastructure costs as well as external costs incurred by the environmental impact.

[21] Average mileage of 20,000 km/year

[22] "Volkswagen steps on the gas for a cleaner environment", Volkswagen AG, June 2019

[23] "Koblenz to get 29 biogas buses", antriebspunkt.de, April 2019

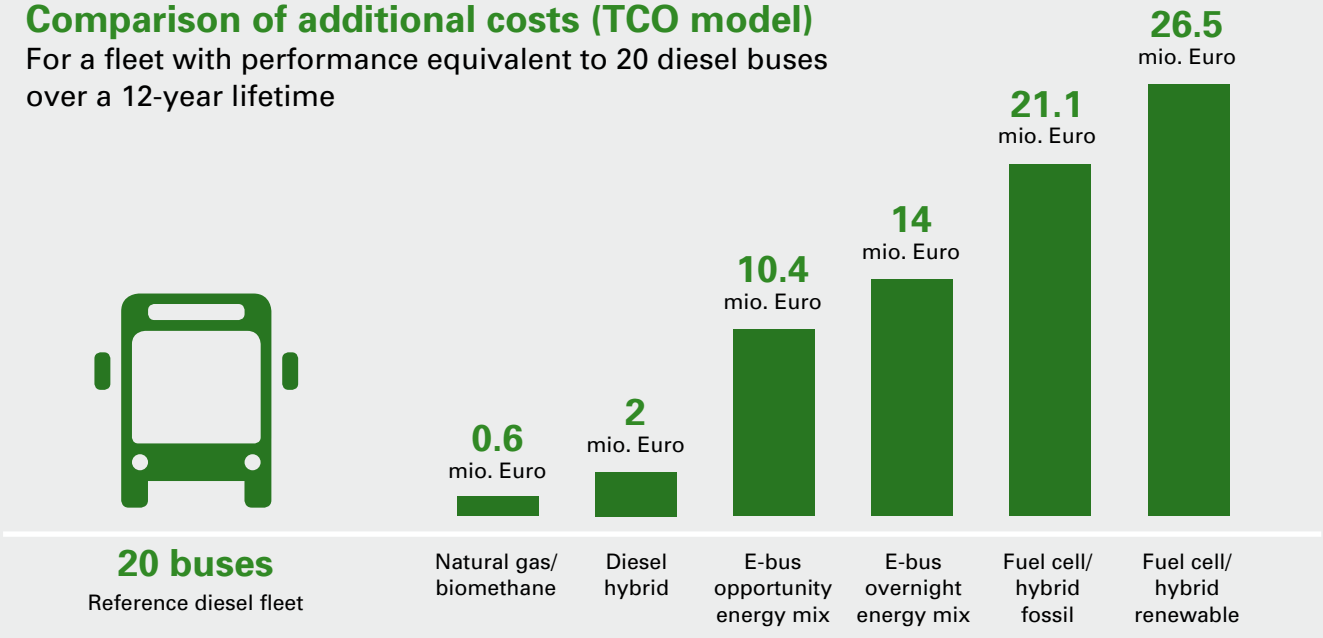
[24] "Public bus transport", Zukunft ERDGAS e.V., October 2019

»Public transport services using buses running on biomethane are already establishing a countertrend to the one-sided focus on EVs.«

Jörg Fischer, CFO EnviTec Biogas

Comparison of additional costs (TCO model)

For a fleet with performance equivalent to 20 diesel buses over a 12-year lifetime



Best practice developed in-house

We are using our own ‘Drive Biogas’ business model to promote the use of bio CNG. This innovative and integrative approach to marketing biogas as a fuel in the transport sector received an award from the German Energy Agency (dena) in late 2017. The model brings plant engineers EnviTec nearer to the end consumer, giving both the company as well as operators of biogas and gas upgrading plants the option of making the upgraded biomethane that they produce available as a fuel. To promote this integrated approach, EnviTec signed a cooperative agreement in early 2017 with the company Bauer Kompressoren, an established supplier of components for CNG plants. EnviTec Anlagenbau integrates these components into the project-specific design tailored to the respective requirements. From organic waste to the pump – this partnership makes it possible for us to supply and operate all of the processes and components required from a single source.

EnviTec Biogas has continuously improved its EnviThan gas upgrading technology since its market launch in 2012. To date, no less than 39 plants have been planned and completed in five countries with this efficient, environmentally-friendly membrane process. Thanks to its flexibility, the technology can be used for made-to-measure applications worldwide.

The bio CNG can be used as a fuel by any of the vehicles designed to run on natural gas that are now commercially available. Apart from producing significantly fewer exhaust pollutants, these vehicles are also more economical to drive due to their reduced vehicle tax and lower fuel costs. Our model is also intended to improve the currently rather hit-and-miss nature of Germany’s CNG filling station infrastructure. This is a significant contribution to the transition to sustainable transport.

FRANCE: Europe’s biggest agricultural nation

EnviTec plant in Ferti Oise, northern France, operational since 2018

Investor-friendly climate with feed-in tariffs fixed for 15 years. Reduction in fossil fuels of 40 percent by 2030, CO2 neutrality by 2050.

- 33 million ha of arable land
- Feed-in tariffs of EUR 0.08 – 0.12/kWh, depending on plant size
- Target: 1,000 biogas plants by 2020

Special features

Highly dynamic market: the current proportion for renewables of 14.2 percent needs to be boosted to 32 percent by 2030. The foundation was laid in 2011 with the introduction of higher feed-in tariffs. Variations in gas quality in the regions are creating harmonisation problems for gas providers.

Challenges

Whether large or small, gas volumes must be processed and fed in at high pressure. Since the approval procedure is faster for small plants, expansion projects are initiated in stages. Raw gas treatment has to be configured with a range of filters, since a wide range of waste materials are used as input.

DENMARK: large-scale industrial plants

EnviTec plant in Sindal, North Denmark Region, operational since 2017

The Kingdom of Denmark awards investment grants for biogas and gas upgrading plants. Value chains benefit local communities.

- 2.5 million ha of land used for agriculture
- by 2020, 50 percent of liquid manure should be used for generating biogas and biofuels should make up 10 percent of all fuels used

Special features

The biomethane sector is also influenced by the heavily industrial nature of the market. Gas upgrading output varies between 400 and 1,500 Nm³/h, with some even larger plants. On average, plants are fed with up to 200,000 t/year: energy crops make up only 12.5 percent of this total, with the rest being liquid/solid manure and other wastes.

Challenges

Fluctuations in biogas quality make adjustments to raw gas treatment necessary. Calorific values need to be adjusted if gas grid operators require a higher quality of gas for direct feed-in to the gas grid. As a maritime nation, rising demand for LNG is to be expected in Denmark, especially from heavy freight operators and shipping.

CHINA: huge growth in investment projects

EnviTec plant in Dingzhou, Hebei Province, northern China, operational since 2017

Variations from region to region prevent uniform subsidy programmes. Environmental awareness increasing, however, as well as market potential – for biomethane in particular.

- 135 million ha of arable land
- Most gas to be sourced from renewables by 2030
- Biogas plant capacity to be expanded to 8 billion m³ by 2020, 20 billion m³ by 2025

Special features

China is expanding its green energy capacities, with the mobility sector leading the way – especially in major cities. Accordingly, all five of the biogas plants built by EnviTec in China are used to upgrade biogas to biomethane, which is then used as bio CNG fuel.

Challenges

Since conditions vary from region to region, this makes quick and effective market development virtually impossible. Difficult input materials often make specialised treatment equipment necessary, such as Kreis-Biogas-Dissolver mixing technology or raw gas scrubbers. The various climatic requirements to be met by the systems used also have their own challenges.

Recommendations for action[25]

Apart from the proper incorporation of biomethane into climate protection targets, as mentioned above, we also recommend adopting the following measures to accelerate the achievement of these targets.

The rate of reduction for greenhouse gases (GHG) must continue to be raised to 20 percent by the year 2030. This successive increase by 2 percent every year supports the market development of renewable, low-GHG intensity fuels, while also helping to decarbonise the transport sector.

The introduction of an ambitious sub-rate for advanced biofuels of 0.3 percent from 2019: the current target of 0.05 percent from 2020 is too low and offers no incentives for promoting the use of advanced biofuels. These 'advanced' biofuels are biofuels made from raw biomass materials from which a smaller negative impact on land use change processes is expected than is the case for 'conventional' biofuels (e.g. those manufactured from rape, cereal crops or palm oil): these advanced biofuels are produced instead from wastes or residual materials.26 Legislation should be introduced to mandate a 7 percent use of conventional biofuels from 2020 onwards.

Efforts should be made to raise consumer awareness of green gas mobility options. Successful market integration can only be assured by using instruments that drive an increase in demand for vehicles powered by CNG and LNG. This includes measures such as fair pump pricing that clearly indicates cost savings. The company car tax relief for electric vehicles in Germany (0.5 instead of 1 percent) must also be applied to gas-powered vehicles.

If bio LNG usage were to be increased with a blending rate, savings on GHG emissions for inland waterway traffic could be achieved of up to 25 percent by 2030 (1990 baseline). This would reduce the emission of harmful substances by over 80 percent. This is to be combined with a promotion of the use of renewable fuels such as bio CNG and bio LNG in public procurement. The best price/performance ratio is offered by gas-powered buses that run on biomethane. In addition, CNG-powered vehicles must be treated in the same way as electric vehicles in terms of fleet calculations.

[25] Modelled on the position paper "A green gas mobility strategy: groundwork for a sustainable energy transition and successful climate protection in the transport sector", Biogasrat+ e.V., December 2018

[26] https://www.natur-und-erneuerbare.de/projektdatenbank/projekte/fortschrittliche-biokraftstoffe/

»It makes economic and ecological sense to utilise existing gas infrastructure and vehicle technologies – but the government needs to act to improve the conditions here.«

Olaf von Lehmden, CEO EnviTec Biogas

Summary of our recommendations for action:

- → **GHG emission reduction rate increased annually by 2 percent to 20 percent**
- → **Introduction of a sub-rate for advanced biofuels of 0.3 percent from 2019**
- → **Legislate to ensure mandatory 7 percent use of conventional biofuels from 2020 onwards**
- → **Continue to raise consumer awareness of green gas mobility options**
- → **Adoption of a blending rate to ensure greater use of bio LNG for inland waterway traffic**
- → **Promotion of use of renewable fuels such as bio CNG and bio LNG in public procurement**
- → **Continued expansion of CNG and LNG filling station infrastructure**

Glossary / list of abbreviations

Blending rate

The blending rate is set out in the German Biofuel Quota Act (BioKraftQuG). The 'Act to Introduce a Biofuel Quota by Amending the Federal Immission Control Act and Amending Legislation on Energy and Electricity Taxation', to give it its full title, sets out the minimum proportion of biofuels that must be present as a percentage of all fuel sold in Germany. The Act was adopted in 2006 and the mandatory minimum proportion of biofuels in fuel became law on 1 January 2007. This minimum level was increased in 2009. To date, biodiesel is the biofuel in greatest demand in Germany, followed by bioethanol, which is either processed to make the additive ETBE or used as the main component in ethanol fuel. When calculating the biofuel rate, both unmixed and blended biofuel volumes are taken into account.

Bio CNG

A renewable variant of the conventional CNG (compressed natural gas) made from fossil natural gas. Bio CNG is manufactured by compressing biomethane at high pressure. Physically, it is identical to natural gas, which means it can be blended with natural gas in any proportion. Pro-natural gas campaigners Erdgas state that one in four CNG filling stations in Germany now offer bio CNG at various blending rates.

Bio LNG

Upgrading biogas to biomethane is also the first step in making bio LNG. The volume is then significantly reduced in another process step: it takes 600 cubic metres of gaseous biomethane to make about one cubic metre of bio LNG – which can then be stored in mobile tanks, for example. The storage capabilities of bio LNG make it a versatile fuel that offers a market for post-subsidy biogas plants (after the German EEG expires) and could be used to supply non-pipeline regions. For heavy freight traffic in particular, bio LNG offers a useful approach to achieving climate targets.

Biomethane/renewable natural gas

Biomethane is a natural product that is created by upgrading the biogas obtained by digesting organic residues and energy crops. The difference between biogas and biomethane lies in the methane content of each gas. While raw biogas has a methane content of 40 to 65 percent, biomethane is upgraded to achieve a methane content of at least 96 percent. This gives biomethane the same chemical properties as fossil natural gas, which means any quantities of biomethane can be piped, stored and used as natural gas in tanks and the gas grid.

Biogas plant

The basic principle of a biogas plant is relatively simple. Renewable raw materials from the farming sector – such as animal excrement and wastes from the food/agroindustry – are used by biogas plant operators as input materials. In temperature-controlled, airtight fermentation tanks, known as 'digesters', the organic substances in the input materials are broken down by bacteria to make biogas. Various anaerobic microorganisms are involved in this process, whose ratio of populations varies according to the starting materials, pH, temperature curve and rate of digestion. The main products of this digestion are energy-rich methane and carbon dioxide. These gaseous compounds separate out from the digester substrate to form the primary components of biogas. Biogas consists of 50 to 75 percent methane and 25 to 50 percent

carbon dioxide, plus trace gases such as hydrogen sulphide.

Biogas upgrading

Before biogas can be fed into the natural gas grid or used as a fuel, it must first be upgraded to conventional natural gas quality in a biogas upgrading plant. To do so, EnviTec Biogas uses the innovative and efficient EnviThan membrane process. During membrane upgrading, selective membranes are used to separate out the primary components of methane and carbon dioxide in an efficient and environmentally friendly way. After treatment, the biomethane produced has a methane content of 97 to 99 percent and is therefore equivalent to natural gas quality 'H'. In Germany, a regional distinction is made between the two natural gas qualities 'H' and 'L'. CNG vehicles can typically be filled with either of these types, and newer CNG vehicles configure themselves automatically to the right type.

CNG (compressed natural gas) and LNG (liquefied natural gas)

Natural gas is processed into compressed natural gas (CNG) for use as a vehicle fuel on the one hand, and into liquefied natural gas (LNG) as a fuel for shipping and heavy freight traffic on the other. CNG made from biomethane or synthetic methane produces virtually no pollutant emissions and fewer CO2 emissions than petrol or diesel.

Renewable energy

Renewable energy is energy that is generated from sustainable sources, and includes hydropower, wind power, solar power, biomass and geothermal. Unlike fossil fuels such as oil, natural gas, coal and lignite, these sources of energy are unlimited—'renewable'—and are not used up as they are consumed.

GHG (greenhouse gas)

Greenhouse gases are gaseous components of the atmosphere. These gases absorb the longwave radiation (thermal radiation) radiated out by the Earth's surface, clouds and atmosphere itself. Normally, much of this type of radiation is radiated out into space. Greenhouse gases reflect this heat both into space and back onto the Earth's surface, however, which has an additional heating effect on the lower atmosphere. Greenhouse gases are both naturally-occurring and produced by human agency. Accordingly, we classify greenhouse effects as either natural or anthropogenic (caused by human activity).

GHG/CO2 intensity

The CO2 intensity defines the volume of carbon dioxide emitted expressed as a proportion of a country's GDP. Accordingly, the indicator measures how much CO2 is emitted as a proportion of the national economy's production and consumption.

Greenhouse gas (GHG) reduction rate

In 2015, the biofuel quota in Germany was converted to a GHG reduction rate. This rate is intended to achieve greenhouse gas emission targets. Biofuels must achieve a GHG reduction rate of 35 percent—and biomethane meets this criterion. To improve greenhouse gas accounting for diesel and petrol in line with emissions targets, these fossil fuels are blended together with defined proportions of biofuels. The greenhouse gas footprint from biofuels is calculated using a uniform set of criteria.

Further reading

Zukunft Erdgas e.V. (pro-natural gas campaigners) – CNG and biomethane as fuels
→ https://zukunft.erdgas.info/studien/verkehrswende

Greenhouse Gas intensity from natural gas in transport
→ http://ngvemissionsstudy.eu

Natural gas engines: an alternative to electric vehicles?
→ https://www.ingenieur.de/technik/fachbereiche/antriebstechnik/erdgasantrieb-ist-das-die-alternative-zum-elektroauto/

Gas, electricity or biofuels: which is better for the environment?
→ https://mobilitymag.de/welches-auto-ist-umweltfreundlicher/

A direct comparison between EVs and biogas vehicles
→ https://magazin.energie360.ch/2016/06/10/elektro-und-erdgasbiogas-autos-im-direktvergleich/

Gas-powered vehicles: an underrated alternative
→ https://www.br.de/nachrichten/deutschland-welt/unterschaetzte-alternative-erdgasautos,R10M2TN

→ https://www.erneuerbareenergien.de/archiv/biomethan-verkanntes-potenzial-fuer-strom-waerme-und-verkehr-150-437-99424.html

→ https://www.dena.de/newsroom/meldungen/2017/biomethan-erzeugung-von-erneuerbarem-erdgas-kann-verzehnfacht-werden/

→ https://www.bmu.de/pressemitteilung/klimabilanz-2017-emissionen-gehen-leicht-zurueck/

→ https://www.adac.de/infotestrat/umwelt-und-innovation/abgas/oekobilanz/default.aspx?ComponentId=317354&SourcePageId=47733

→ https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2019/dena-Studie_Bio_LNG.pdf

→ https://www.seat-mediacenter.de/storiespage/newstories/von-der-biotonne-in-den-tank.html

→ https://www.gibgas.de

→ http://lngbc.eu

→ https://zukunft.erdgas.info/gas-im-markt/gas-im-verkehrssektor/lng-verfluessigtes-erdgas

→ https://vm.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/verkehrssektor-droht-klimaschutzziel-2030-zu-verfehlen/

→ https://www.industr.com/de/vollversorgung-mit-erneuerbaren-energien-2382013?sc_ref_id=2851081005&sc_usergroup=1221&utm_source=newsletter&utm_medium=E40&utm_campaign=2019-38-259

→ https://www.bdew.de/media/documents/Awh_20190426_Gas-kann-gruen-Potentiale-Biogas.pdf

Johanneum Study
→ https://www.adac.de/-/media/pdf/tet/lca-tool---joanneum-research.pdf?la=de-de&hash=F06DD4E9DF0845BC95BA22BCA76C4206

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