New perspectives for bioenergy

Biogas as a component of the energy transition

Dr. Andreas Lemmer has been involved in the generation of energy from biomass for over 20 years. His employer, the State Institute for Agricultural Engineering and Bioenergy, runs the biogas pilot facility at Unterer Lindenhof near Reutlingen. Scientists here work under practical conditions testing new techniques.

Why do we still need biogas plants? Isn't it much cheaper to generate electricity from the sun and the wind now?

Yes, electricity can now be produced more cheaply and with a better greenhouse gas balance using photovoltaics and wind power. But what if there is no wind or sun? We may be able to produce between 80 and 85 percent of our total energy from renewable sources, but we also need to ensure that our power supply is reliable. We therefore need a controllable energy source that can be used to balance the natural fluctuations of the sun and the wind. The huge advantage of biogas plants is that they can provide the energy that we need to stabilise the networks on a decentralised basis using renewable sources. The biomass from organic waste, residual materials and renewable raw materials is a natural energy store that can be used in periods of high demand.

What should the biogas plant of the future look like?

The majority of the approximately 9,500 small- to medium-sized biogas plants in Germany currently have over 8,000 full-load hours per year, i.e. they run almost all year round [a year = 8,760 hours]. They continuously produce gas, which is then used in combined heat and power plants (CHP) to generate electricity and heat. The plants need to become much more flexible to be able to exploit the advantages of this controllable, peak-load energy source. This is because electricity and heating requirements are especially high in winter, when photovoltaic systems generate very little energy. So all these biogas plants do not necessarily need to produce more energy, but energy production does need to be more closely linked to actual energy requirements.

Biogas plants of the future will only have 2,000 to 2,500 full-load hours per year, but their output during this time will be approximately four times higher. In the summer, the plants will only need to operate for one or two hours at night to charge the heat buffers and produce the heat necessary for the microbial processes. The CHP can remain switched off during the rest of the day, because electrical power can be produced much more cheaply and with a significantly better greenhouse gas balance using photovoltaic systems. In the winter, however, the plant’s performance is ramped up. The overall efficiency of the system can be increased significantly by simultaneously using electricity and heat.

What is the technology behind such flexible and powerful systems?

Research biogas plant "Unterer Lindenhof" near Reutlingen, where the University of Hohenheim researches and tests needs-based biogas production.
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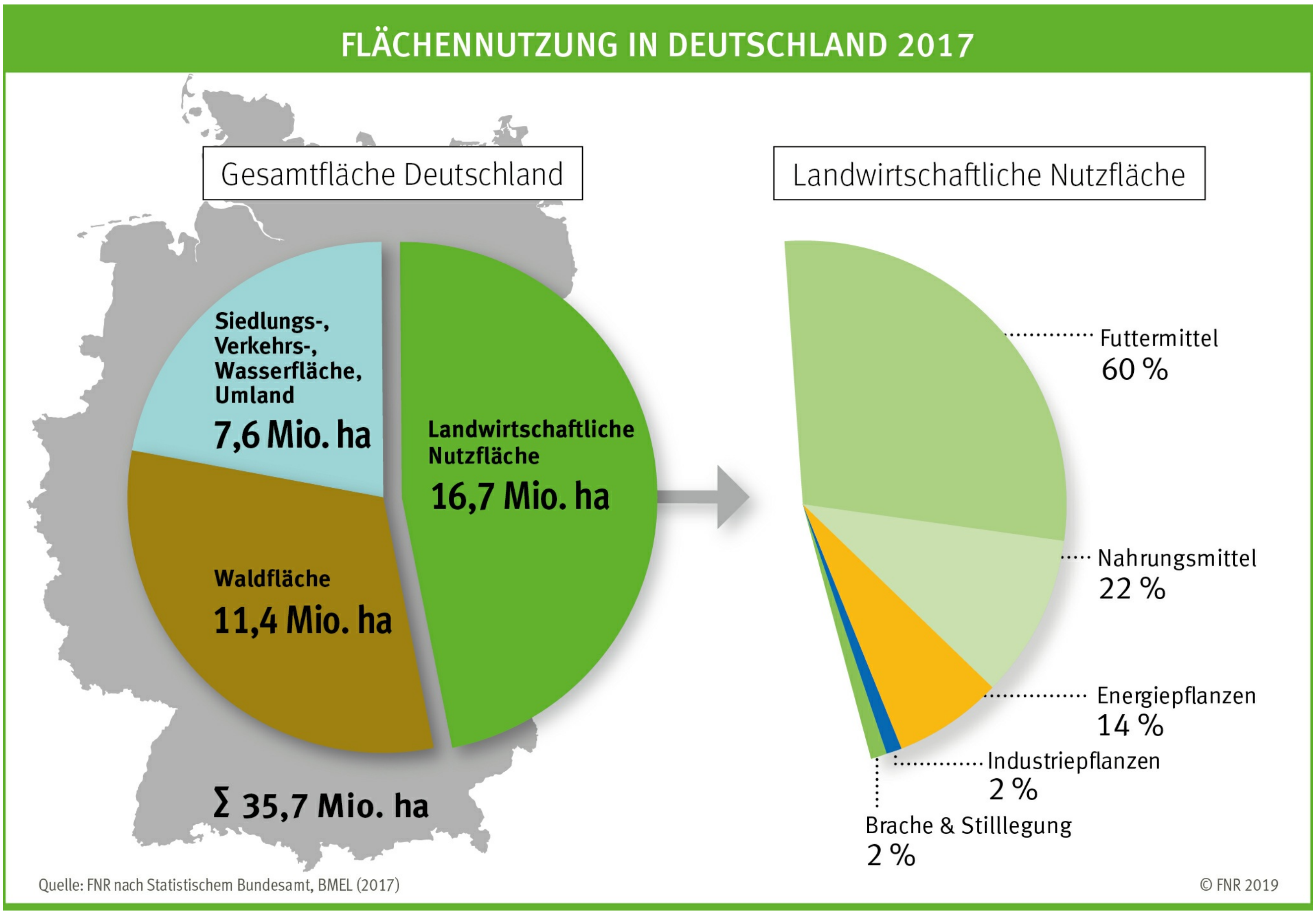
As far as flexibility is concerned, I think we already have a good grasp of the technical aspects. We work with model-based system controls, i.e. we create forecasts for the electricity and heat requirements of a town, district or industrial area. This works very well with self-learning computer models that are fed with historical data. The expected energy yield produced with photovoltaics and wind power can also be calculated; it is not that complicated. We can then use these forecasts to predict relatively precisely the energy a biogas plant needs to produce over the course of the year, and control the plant accordingly. This cannot be done at the push of a button; biogas production is a microbial process, which requires a certain lead time, i.e. around 48 hours, during which the amount of food given to the microbes can either be increased or reduced. To increase the efficiency of a biogas plant, a more powerful CHP, i.e. a gas combustion turbine and a power generator, needs to be installed In addition, the stirring technology has to be adapted and, depending on the system, gas and heat stores also need to be expanded. Some of these are wear parts; a CHP needs replacing after eight to ten years, and a stirrer after five to eight years.

Don't you need more biogas plants and more arable land to grow silage maize?

No, actually we don't. Only a few new plants are currently being built. It is more about making existing systems fit for the future. I am sure that the existing systems can be used for another 20 to 25 years. Making existing systems fit for the future is also a good idea because the high initial investments for such plants have already been made. As far as the type of biomass is concerned, there are quite a large number of new diversification approaches, for example, via flower mixtures, mixed crops, using energy crops in crop rotations and permanent crops such Siphium perfoliatum (cup plant), which are currently being tested on a 2.5-hectare field in Reutlingen.
It takes time to establish these new cultures. The huge advantage of maize was that top-quality maize had been bred for decades and it has an optimal carbon-nitrogen ratio. It is therefore understandable why farmers grow maize. We are currently growing 1.35 million hectares of renewable raw materials to produce biogas at a rate of around 50 tonnes of biomass per hectare. So, we are talking about 67.5 million tonnes of highly energetic biomass. And as far as energy production is concerned, this figure is quite different from the 15.6 million tonnes of biowaste[1] that are collected in brown bins and currently



Almost half of Germany's land surface area (47%) is used for agriculture. 14% of the agricultural land is used for cultivating energy crops, 22% for cultivating food and 60% for animal feed.
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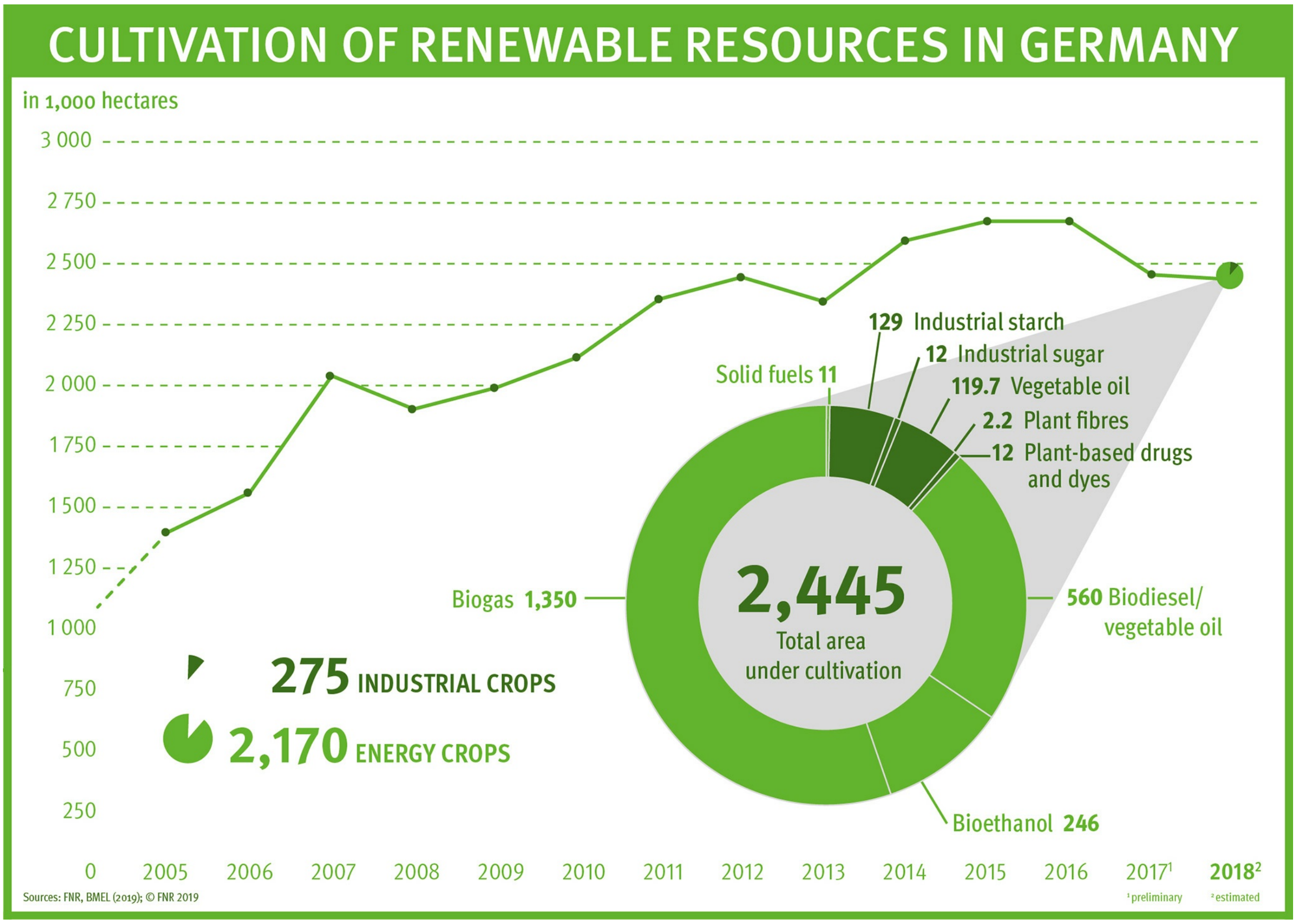
mainly end up on compost heaps. We also have to use residual waste such as biowaste. And there is no question that from an energy point of view, there is no better way of using biowaste than producing biogas. But if we want biogas to make a significant contribution to stabilising power grids, we have to use about the same amount of renewable raw materials as we do today.

Why can’t biogas be fed directly into the natural gas network?

The biogas produced by bacteria during fermentation has a methane content of 50 to 60 percent. In order to achieve the quality of natural gas, i.e. a methane content of over 90 percent, the biogas has to be desulphurised and CO_2 removed[2]. After odorisation, pressure adjustment and, if necessary, calorific value adjustment, this pure biomethane can be fed directly into the natural gas grid. The natural gas grid is an incredibly powerful transport and storage medium, as it is able to absorb renewable electricity at times of excess supply and provide energy at times of higher demand, and has much higher transport capacities than the electricity network as a whole. Energy can thus be provided whenever and wherever needed. However, this advantage can only be achieved through costly technologies and high power consumption during production. Turning biogas into gas with a methane content of over 90 percent therefore only makes sense for larger biogas plants.

We currently have around 230 plants in Germany that are able to feed pure biomethane into the grid. It is estimated that this number could be increased to between 1,000 and 1,500. As for other biogas plants that cannot be used to directly feed biomethane into the grids, the best option is to convert unpurified gas into energy on site in the plant’s CHP unit. Ideally, the electric power would then be used to stabilise the local power grid, and for heating nearby buildings via local heating networks.

Where else can biogas sensibly be used?



Almost 2.5 million hectares are used for cultivating energy crops in Germany, of which 1.35 million hectares or 8% of total agricultural land is used for producing biogas.
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Decentralised production of fuels from biogas is particularly interesting in the agricultural sector. In September, we launched a pilot project called ProBioLNG together with the DVGW research centre at the Engler Bunte Institute of the Karlsruhe Institute of Technology (KIT) and industrial partners. The process of pressure methanation produces fuel-compatible biomethane, which can then be used as bio-CNG gas in tractors and other agricultural machinery. Or, by adding fine cleaning and liquefaction processes, we can generate BioLNG, i.e. liquefied biomethane, which can then be used as truck fuel. This is a possible solution towards the energy transition in the heavy goods transport sector, where electromobility is still a long way off.

What is your analysis of the political framework?

The controllable, flexible energy produced from biogas is a system service. On the one hand, we can produce electricity cheaply with photovoltaics and wind power, although the disadvantage is huge weather-related fluctuations. On the other hand, biogas is a balancing energy source that can be produced at times when the sun is not shining or the wind not blowing. However, using biogas as a balancing energy source would make electrical energy more expensive, because stabilising the grids is an additional service. At the moment, this is not reflected in the EEG compensation scheme, so it is an issue that needs to be addressed. Previously, we only had a small number of power stations that produced electricity. This has changed with the advent of renewable energies. We now have hundreds of thousands of small power-generating plants and there will be even more in the future. Therefore, it would make sense for us to shift grid stabilisation away from the large transmission system operators to local and regional electricity suppliers and make them responsible for their grids. If they stabilise their grids with locally produced biogas, they could be exempted from the corresponding EEG surcharges such as CHP surcharge, offshore surcharge etc. in return for the electricity within their own grid. They would then only have to pay surcharge fees for the electricity purchased. This would help us to significantly reduce the current massive network expansion. More market-based instruments would then be incorporated into the electricity market - which at the moment is completely over-regulated. Unfortunately, as far as I know, there are currently no political moves in this direction.

What other political decisions would you like to see?

Biogas plants can use a wide variety of biomass. Perennial plants such as the Jerusalem artichoke (photo) or Siphium perfoliatum are gaining in importance. This increases the diversity of arable land and promotes insect life.

We need more support for decentralised approaches. Take a farmer who runs a larger photovoltaic system and a biogas plant on his farm, for example; in the north he may also have a wind turbine. If industrial companies are in close vicinity, which is not unusual, the farmer could be a reliable local energy supplier through his ability to combine wind power, biogas plant and PV and lay a cable or a local heat pipe to the nearby companies. However, legally, this is completely inconceivable at the moment. The current legal requirements are so onerous that this just couldn't happen.

Are you brave enough to take a peek into the future?

Technically, there is huge potential for energy transition. Fuel cells could conceivably be installed in our houses. I can also imagine our houses with either an electricity or a gas connection, rather than both. Using a heat pump or local heating network would do away with the need for an oil tank or a gas connection. Residential buildings could be equipped with a CHP power generation plant and a photovoltaic system on the roof. In this case, the residents may not need electrical connections, and battery energy storage systems may become more widely used. The necessary technologies are already available; it would therefore be possible upscale them.

References

[1] Federal Environment Agency (UBA 2017): www.umweltbundesamt.de/daten/ressourcen-abfall/verwertung-entsorgung-ausgewaehlter-abfallarten/bioabfaelle#textpart-1

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Article

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The article is part of the following dossiers

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