Converting coal to biomass: Making the energy transition feasible

Ben Moxham

Kurzfassung

Umwandlung von Kohle in Biomasse: Energiewende möglich machen

Derzeit ist eine intensive gesellschaftliche Diskussion zu beobachten, die die nationalen Emissionsminderungsziele in ganz Europa betrifft. In Deutschland ist der Weg zur Reduzierung des Kohleeinsatzes zu einem Kernstück dieser Debatte geworden. Zum jetzigen Zeitpunkt sind die deutschen Kohlekraftwerke jedoch nach wie vor unverzichtbar, um den Energiebedarf des Landes zu decken und Lücken in der Wind- und Solarenergieerzeugung zu schließen, um die Versorgung zu sichern und Versorgngssicherheit zu gewährleisten. Dies unterstützt ein häufiges Argument, Kohle so lange wie möglich im Erzeugungsmix zu halten: Die Verbraucher, einschließlich der energieintensiven Industrie, benötigen sie, um den Energiebedarf unabhängig von den äußeren Einflüssen sicher zu stellen. Aber bedeutet das, dass wir uns einzig auf Kohle verlassen müssen, bis sich Wind-, Solar- und Speichertechnologien als alternative, zuverlässige Energiequellen etabliert haben?

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Currently, we observe considerable societal pressure to reach national emission reduction goals across Europe. In Germany, the pathway to reducing coal generation has become a centerpiece of this debate. However, at this moment in time, Germany's coal plants are still essential to meet the country's energy demand and to bridge gaps in wind and solar generation to secure the supply. This supports one frequent argument in favor of keeping coal in the generation mix for as long as possible: consumers, including energy-intensive industry, need it to cover peaks of energy consumption irrespective of exterior conditions.

But does this mean that we must rely on coal until wind, solar and storage technologies have been fully established as alternative, reliable energy sources?

Biomass conversion offers a real alternative

As sustainability and environmental protection become more and more relevant, new ways are explored to solve the often-cited "energy trilemma": the challenge to meet security of supply, affordability and sustainability of energy supply at the same time. Converting existing coal plants, especially electricity and heat cogeneration plants, to operate with biomass offers a feasible solution to this trilemma that is attractive to a broad range of customers, including energy companies, municipal utilities as well as energy-intensive firms with on-site plants.

Coal-to-biomass conversion projects enable former coal plants to continue operating cost-efficiently with their existing supply, generation and grid infrastructure. Hence, biomass plants are not dependent on grid expansion as e.g. necessary for wind and solar energy. Coal plants converted to biomass are dispatchable and contribute to security of supply even when the sun does not shine and the wind does not blow. This makes biomass plants a viable and reliable complement to intermittent renewable energy sources. In addition, coal assets are a highly valuable source of employment in several communities. Biomass conversion preserves both the jobs at the power station and the ones along the supply chain.

But does biomass make sense from a cost-related point of view? To compare the costs of energy sources, the levelized cost of electricity (LCOE) metric is frequently applied. And per the LCOE, switching to biomass does not seem to be the most cost-efficient way, because other renewable energy sources such as wind and solar energy have exhibited more impressive cost declines in recent years.

However, the LCOE metric gives an incomplete picture of the real system cost of energy sources. This is because it ignores several indicators that affect the economic value of the electricity produced. These include:

- **the value of heat produced:** CHP plants produce heat as a by-product, which creates economic value that is not accounted for in the traditional LCOE estimates. By calculating the amount of decentralized heating replaced by a CHP plant, the value of heat can be estimated. Per unit of electricity, the value of heat produced by a typical coal plant converted to biomass is worth 23 EUR/MWh, which should be accounted for in cost comparisons to other renewables, per a recent analysis by Aurora Energy Research.
- **intermittency costs:** intermittent renewables – wind and solar PV – cannot control when they produce and may produce when demand is low or push down prices during production periods by generating excessive power when it windy or sunny. Both factors cause wind and solar power to be less valuable than the power of dispatchable plants. This is not accounted for in LCOE metrics, which assume that every MWh is of equal value. The weighted average of the wholesale power market price in all the hours of a year when power is delivered by a given technology is called the "capture price". The difference in capture prices of different technologies can be taken as equivalent to a difference in value to the system. Per Aurora Energy Research, the average wholesale price across the whole Germany market averaged over the 2020-30 period is projected to be around 58 EUR/MWh. With an average capture price of around 62 EUR/MWh, dispatchable coal-to-biomass projects offer a higher value proposition compared to offshore wind (52 EUR/MWh), onshore

wind (48 EUR/MWh) and solar power (51 EUR/MWh). Power generated by coal plants converted to biomass is therefore of considerably greater value to the system than those of intermittent renewables.

- **security of supply costs:** intermittent plants, generating energy from wind and solar power, offer less security of energy supply than dispatchable plants run on biomass. Solar does not add to security due to low and inconsistent generation at night and in winter. On- and offshore wind power faces similar issues on calm days. In the Aurora study, the cost of providing backup capacity to ensure security of supply is assumed equal to the cost per MW of the Capacity Reserve. Biomass plants gain up to 0.4 EUR/MWh of value by reducing the Capacity Reserve size required, while solar (-3.0 EUR/MWh) and wind power (-2.8 EUR/MWh onshore; -2.7 EUR/MWh offshore) are costlier when taking system security considerations into account.
- **balancing costs:** all generators in Germany submit their expected output to the Transmission System Operators (TSOs) a day ahead delivery. If external circumstances (e.g. the weather) change, the operator then under- or overproduces, forcing other sources of generation to change their dispatch schedules at short notice. The additional costs incurred through this adjustment in the intraday or balancing markets are not accounted for in the standard LCOE estimate. Each additional MW of intermittent wind and solar energy causes the procured volume of balancing capacity to grow and costs to rise. Per Aurora, for solar power this lowers the value of electricity produced by 4 EUR/MWh for on- and offshore wind and by 3 EUR/MWh per solar.
- **transmission costs:** to further increase solar and wind power generation, expansions of transmission and distribution grids are required – these costs can be saved with coal-to-biomass projects when using the existing infrastructure for coal. Grid expansion costs in Germany vary between 14 EUR/MWh for onshore wind and 25 EUR/MWh for offshore wind. Solar in this respect entails costs around 22 EUR/MWh, mostly at the distribution level.

Once these categories of system costs are considered, biomass conversions of coal plants are shown to be highly cost-effective. Incorporating these costs all together, the Aurora study found **the value of wind and solar generation is reduced between 31 and 37 EUR/MWh, while the converted CHP coal-to-biomass plant value increases by 27 EUR/MWh.**

Coal-to-biomass conversion offers thus valuable, dispatchable power and heat that is beneficial to the system from a system cost perspective and complements wind and solar. The cost of biomass is especially competitive considering the value of the heat it produces in cases of CHP.

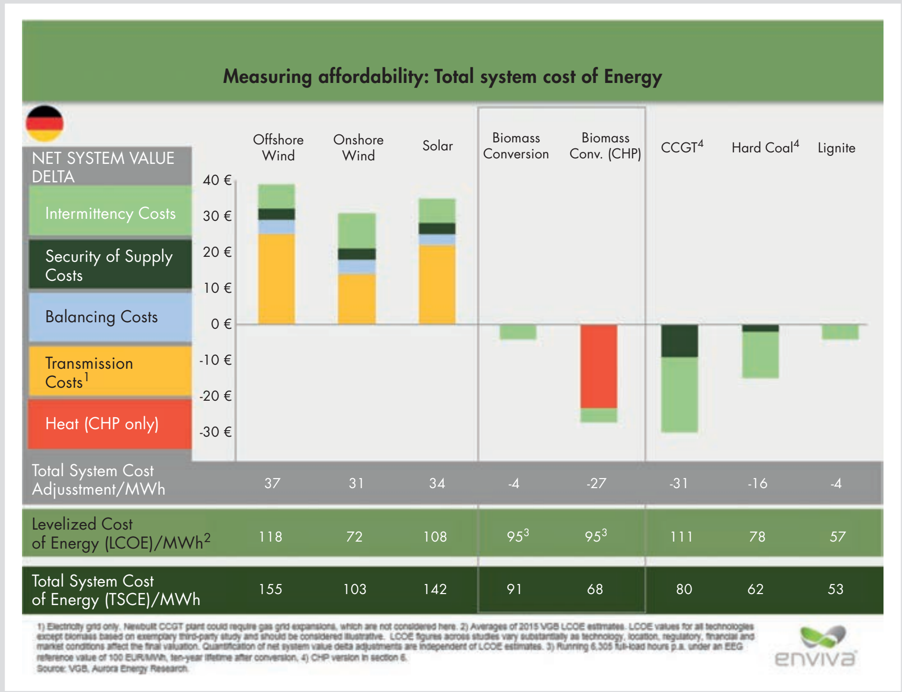

Fig. 1. Total System Cost of Energy

Biomass conversion in practice

Conversion from coal to biomass is currently under evaluation for several German energy providers – but it is already reality and ongoing in several Northern European states. A supportive regulatory and political framework of course plays a major role to undertake respective projects.

Case 1: Denmark

Denmark is considered a “first-mover” in the biomass energy business. The converted Ørsted plants Avedøre and Studstrup are prime examples where the regulatory framework made an impact: The Avedøre Unit 2 CHP plant, for example, supplies 585 MW of electricity and 570 MW of heat, respectively meeting the heating needs of 150,000 and electricity needs of 800,000 homes. This plant replaced older and less efficient coal-fired power plants, and operates a converted sub-unit, now fully run on biomass, and hence enabling significant CO_2 savings. Further, Studstrup Unit 3 has been converted to operate fully on wood pellets (350 MWe). The conversion, costing around 160 MEUR, made Studstrup 3 one of the largest biomass-fueled power station units in the world.

With the Energy Agreement of 2012, the Danish Government prepared the ground for a successful energy transition: the agreement offers market premiums or direct subsidies to different renewable energy sources fostering conversions to biomass et.al. New and older power plants running on biomass receive a premium of 15 Øre/kWh (0.02 EUR/kWh). Moreover, the Danish tax structure is key to understand the supportiveness of the regulatory framework. While there are designated heat and carbon taxes imposed on coal-based heat production, heat derived from wood-based biomass is exempt from both of these taxes.

Case 2: France

The Compagnie Parisienne de Chauffage Urbain (CPCU) inaugurated the conversion of a boiler from coal to biomass in Saint-Ouen, Paris on March 10, 2016. In this case as well, the favorable regulatory framework mattered. In 2006, the EU finance ministers have agreed to add district heating, produced from renewable or recovered energy (at a minimum of 50 %), to the list of sectors eligible for a reduced 5.5 % VAT rate. In France, the reduced rate was introduced in 2007. Prior to the introduction of this rate, the VAT rate for district heating was among the highest in Europe, amounting to 19.6 %.

More recently, the government put in place an additional incentive structure, adding to the VAT relief: the ‘tax credit for sustainable development’ (crédit d’impôt pour la transition énergétique, CITE), which applies to refurbishments promoting low-carbon energy.

Case 3: United Kingdom

There are further examples of European energy providers that have switched from coal to biomass. Drax, the largest power station in the UK, representing 7-8 percent of the country’s energy supply, has already converted 50 percent of its 3,960 MW coal units to biomass, specifically wood pellets.

This development was strongly supported by two major UK government renewable incentive programs. German energy companies have taken respective action as well: RWE was active in the UK in converting the 420 MW coal plant in Lynemouth to biomass.

Biomass conversion is sustainable

From a sustainability perspective, switching from coal to biomass goes along with a very significant reduction in greenhouse gas emissions. For example, according to the official EU government biomass carbon calculation methodology, a coal-to-biomass conversion CHP project in Northern Europe with 55 % energy conversion efficiency using wood pellets imported from the Southeast United States would observe carbon emissions of around 85 kg CO_2e/MWh. This accounts for all emissions in the supply chain including shipping across the Atlantic. This magnitude of carbon savings compared with coal is also confirmed in several peer-reviewed papers written by scientific authorities.

This demonstrates that energy security and sustainability are not mutually exclusive. The biomass of choice is wood because of its abundant availability in areas of sustainably managed forests. Examples include the Baltic region of Europe, the Southeast of the United States and Canada. In short: all areas where large timber industries exist that leave behind waste materials and by-products suitable for production into wood pellets and chips.

One major argument in favour of wood is that it does not compete with food production. The so-called "First Food Approach" is voiced by both the German Bundestag and environmental associations when referring to making use of renewables for the economy. Wood therefore offers an advantage compared to sugar- or starch-based biomass.

The prerequisite is of course that wood is sourced and harvested in a sustainable manner. A variety of certifications like SFI, FSC, PEFC, ATFS and SBP credibly and transparently ensure to stakeholders that the sources of biomass comply with the current sustainability standards, notably including requirements that wood is only taking from areas of forest that are growing over time. Moreover, responsible providers of wood-based biomass offer transparency systems that allow utility and industrial customers and their regulators to track every branch of wood throughout the entire supply chain.

Conclusion

Conversion of coal stations to biomass has a role to play in Germany as a low-carbon, dispatchable and affordable complement to wind and solar. This technology has already been proven at scale in several other European counties – in fact, biomass is Europe's single biggest source of renewable energy, even if it is less visible than wind and solar. With a coal phase-out policy to occur in Germany, now is a good time for coal-owning companies to seriously evaluate whether a biomass conversion option is right for them and to learn from case studies of how conversions were supported by governments in other countries.

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