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Electrification and the bioeconomy: three sides to the story

Discussion brief
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Key messages

Rapidly falling costs and growth in market deployment of solar photovoltaics, wind turbines and lithium-ion batteries are transforming global energy markets. In low-income countries, new opportunities for energy access are opened up by reduced costs of decentralized electricity solutions. In high-income countries, increasing market shares of variable renewable energy, or VREs (principally solar, wind, and wave energy) are putting downward pressure on retail electricity prices, while also creating new challenges when it comes to grid management.

In this brief we discuss different ways in which the bioeconomy – by which we mean all sectors in society based on production and processing of biomass – is affected by and interacts with the rapid developments in wind, solar and storage. We present three different types of interaction: *competitive, complementary* and *synergistic*.

- ***Competitive* interactions: in some cases, the use of biomass for energy becoming less economically attractive as it is increasingly unable to compete on costs with wind and solar.**
- ***Complementary* interactions: despite the transition to an energy system in which electricity – largely based on VREs – looks to become the dominant energy carrier of the twenty-first century, bioenergy still has important roles to play.**
- ***Synergistic* interactions: the ways in which VRE-based electrification can support development of both bioenergy and the bioeconomy at large.**

Reduced costs and increased deployment of VREs are essential components in all credible pathways towards deep decarbonization. It is key that bioeconomy market actors acknowledge and embrace this as an opportunity for business development and value addition.

Cheap renewables enable electrified decarbonization

The rapidly falling costs and associated growth in market deployment of solar photovoltaics, wind turbines and lithium-ion batteries are having substantial effects on global energy markets. Close-to-zero operational costs and rapidly declining capital costs of solar and wind power have led to a situation where these are, even without subsidies, on cost parity with fossil energy in a growing number of energy markets (Hirtenstein 2018).

Perhaps most importantly, the rapid decline in solar energy costs has opened up opportunities to extend energy access to many millions in low-income countries with poor or non-existent electric infrastructure. It has been estimated that about half of all

IMAGE (ABOVE): Ethanol production

the people who should get electricity access by 2030 would be most cost-efficiently supplied through decentralized solutions such as solar home systems or mini-grids (IEA et al. 2019).

Reduced costs of solar and wind energy are also having a large effects in high-income countries. In a wide range of sectors, from personal transport to space heating and steel production, the prospect of lower electricity prices has led to growing interest in electricity-based decarbonization solutions, many of which are not feasible without access to inexpensive clean electricity (Ruhnau et al. 2018).

Developing the bioeconomy – by which we mean all sectors in society based on production and processing of biomass – holds many opportunities for climate change mitigation and fulfilment of the UN 2030 Agenda (Virgin and Morris 2016). The bioeconomy has many interactions with the energy sector, yet there has not been much analysis of its interactions with the ongoing changes in energy technologies and markets. In this brief, we scope different ways in which the bioeconomy interacts with the rapid developments in renewable electricity generation. We structure the discussions by dividing the interactions into three different categories: competitive, complementary and synergistic. These are discussed below.

Electrification of vehicle drivetrains could rapidly disrupt the future outlook for liquid fuel demand.

Competitive interactions: rapid fossil-fuel phase-out or strengthened lock-in?

About a decade ago, biofuels were generally seen as the only feasible route for near-term decarbonization of ground transport. However, in the wake of lower battery costs and "Dieselgate", mass-deployment of electric vehicles is finally beginning. So how does this affect prospects for biofuels?

One advantage of most forms of bioenergy relative to other renewables is that it is often relatively easy to integrate into existing infrastructures designed for fossil fuels. The flipside of this is that more radical system shifts away from fuel-based systems also affect bioenergy. As Brown and Brown (2017) note, electrification of vehicle drivetrains could rapidly disrupt the future outlook for liquid fuel demand, regardless of whether these fuels are based on fossil or biomass resources.

Having said this, a vast majority of the global vehicle fleet still uses internal combustion engines and liquid fuels will be in demand for quite some time. If this is met with bio-based fuels, it means an earlier phase-out of fossil fuels from ground transport than if we wait for a full systemic shift to electrification. At the same time, too much focus on fuel-switching from fossil to biofuels could strengthen lock-in into the general infrastructure associated with the internal combustion engine and possibly delay the eventual system change to clean electrification.[1]

The issue of lock-in is also relevant for fuel switching in the power generation sector. While converting coal-fired power plants to biomass does entail a fossil fuel phase-out, it also means continued reliance on centralized combustion-based power generation, and could act as a barrier to more innovative electricity technologies such as grid storage and demand response mechanisms.

1 An interesting example of a competitive interaction between electrification and biofuels in the light vehicle sector is how some bioenergy proponents explicitly portray electrification as a threat and in some cases even join forces with fossil fuel lobbyists to do so (Prentice 2017).

Complementary interactions: using bioenergy to fill in the gaps?

Cleaner cooking with better biomass solutions?

In low-income countries, electrification and biomass have historically been diametrically opposed. Lack of access to non-biomass cooking fuels is problematic because people typically cook with open fires or simple stoves that are polluting and inefficient, leading to negative impacts on health and the environment (Masera et al. 2015; Smith et al. 2014). Analyses frequently mention a three-way association between biomass use, electrification and living standards (Legros et al. 2009; Rao and Pachauri 2017). Many developing countries have policies in place with the joint objectives of reducing biomass dependence and increasing access to electricity in order to improve well-being. However, even despite the declines in costs of solar PV, cooking with electricity is still well beyond the means of many who currently rely on inefficient and polluting stoves and traditional biomass for cooking. Hence, a pragmatic path towards cleaner cooking might be to simply continue to strive for better biomass solutions. One such solution is so-called "clean stacking", whereby instead of relying on one single technology for all energy needs, a set of clean energy sources play different roles within a household – e.g. solar for lighting and clean biomass for cooking (cf. Ruiz-Mercado and Masera 2015).

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Bioelectricity in the grid of the future?

Even though costs of wind and solar have come down, both depend on weather and thus are not dispatchable. In contrast, biomass-based electricity generation is dispatchable, and so can have an important role to play in the energy mix; but future bioelectricity generation technologies then need to be designed to make the most of that dispatchability. In other words, flexibility and load-following capabilities will be important characteristics of future plant designs (Sepulveda et al. 2018).

Electrification on the ground, biofuels in the skies?

At the same time as there are highly promising developments in electrification of ground transport, the marine and aviation sectors are different. In these sectors, batteries are sufficient only in certain niche segments, and aviation is a particularly difficult puzzle to solve (ETC 2018). While electric aviation for shorter routes based on batteries could be feasible in the medium to long term (Viswanathan and Knapp 2019), liquid fuels will be necessary in aviation in the foreseeable future. And the only alternatives to fossil fuels are biofuels, or a synthetic electrofuel based on hydrogen and combined with carbon capture and utilization (CCU). The latter, though, is currently cost-competitive only when compared with the most expensive biofuel options (Brynolf et al. 2018). Hence, the aviation sector looks to be a source of growing biofuel demand in the medium to long term.

Biomass and electrification as tools to decarbonize heavy industry

Heavy industries such as steel, cement and petrochemicals are generally seen as facing the largest challenges when it comes to decarbonization. However, as has been shown by, e.g., Bataille et al. (2018), for most of these sectors there are technologies available that could entail thoroughgoing reductions in greenhouse gas emissions at costs that would not be prohibitive. The solutions can be categorized under two pathways: 1) use carbon capture and sequestration (CCS) and existing technologies with some (relatively) minor process adjustments., and 2) make more radical technology shifts to direct or indirect electrification for both chemical processes and process heat.

As it happens, biomass can play important roles in both of these pathways. For example, biomass can be used as a substitute for fossil fuels in processing of raw iron

Threshing sugarcane at a sugar-cane-ethanol complex in Brazil. Dedicated generation of bioenergy will come to struggle economically in an increasing number of markets. A remedy for this is to focus on broad-based bioeconomy business models.

ore into pellets, as well as a fossil-free source of process heat in cement kilns. In the second pathway, biomass can be of use as a source of carbon for processing of iron into steel (see, e.g., www.hybritdevelopment.com).

Synergistic solutions – electrification as a bioeconomy boost

Decentralized electrification and value addition in developing bioeconomies

In many low-income countries, establishing bioeconomy value chains is constrained by the absence of supporting technological infrastructure such as irrigation, refrigeration and crop processing – key components in taking agricultural produce from farm to market. However, these technologies often require electricity and its absence could act as a substantial bottleneck to further bioeconomy development. At the same time, the decreasing cost of solar panels in recent years has made solar-based appliances affordable to rapidly widening range of users (Hartung and Pluschke 2018). Similar developments can be seen across other appliances that could perform vital functions in agricultural value chains that are common, e.g. in much of sub-Saharan Africa (FAO 2019).

Renewable hydrogen as a biofuel building block

We note above that there is an element of competition between electrification and the use of biofuels as a means of phasing out fossil fuels from the transport sector. At the same time, advances in electrification can also help reduce emissions from biofuel production, which is set to increase substantially. The Swedish oil refiner and liquid fuels producer Preem has, for example, set an ambition to produce three million cubic metres of biofuels by 2030. A large quantity of hydrogen is needed for refining cellulosic biomass into liquid biofuels suitable to blend with or replace fossil fuels (so-called drop-in fuels) (Grahn and Jannasch 2018). Currently, the dominant means of extracting hydrogen is from natural gas, through steam reforming. An alternative method is electrolysis, in which electricity is used to split water into hydrogen and oxygen, and this is where electrification comes in: lower electricity prices, combined with decreasing costs of electrolyzers are making electricity-based hydrogen increasingly competitive (Glenk and Reichelstein 2019). A shift to electrolysis based on low-carbon electricity could significantly reduce the use of natural gas in the process, and in turn the carbon footprint of the biofuel life cycle.

Discussion and recommendations

Key to success is ensuring that upcoming investments in biofuel production have flexibility built in to technical processes and business models.

In the debate on future energy systems and the role of bioenergy, the latter is often seen as a temporary solution, or a "transition fuel", on the way to electrification. This narrative is a common thread in discussions on cooking solutions in low-income countries, in road transport, and in heavy industry (at least parts of it). It is worth noting there is something of a dilemma related to how the transition from fossil fuel to biomass to electricity will be governed. For this three-stage process to be efficient and effective, proper design of bioenergy and bioeconomy policy is crucial. In particular, it should be designed and implemented in a way that supports, and benefits from, current and future developments in solar PV, batteries and wind. To this end, we have identified some policy recommendations.

- Downward cost pressures on energy, and on electricity in particular, mean that dedicated generation of bioenergy will come to struggle economically in an increasing number of markets. A remedy for this is to focus on broad-based bioeconomy business models, in which generating energy from biomass is just one of several sources of revenue. Such systems could take the form of biorefineries or waste-to-energy systems that act as combined facilities for managing waste and generating energy.
- Brazil offers a well-known example of such an approach. The country has implemented a series of policies over many decades resulted in several thriving industries producing a range of co-products. The nation's sugarcane-ethanol complex delivers variable quantities of refined sugar, ethanol, and electric power depending on market conditions (Solomon and Bailis 2014). Key to success is ensuring that upcoming investments in biofuel production have flexibility built in to technical processes and business models so as to be able to shift output between products and thus be resilient to different paces of vehicle electrification.
- The logic of focusing on flexibility and multi-revenue systems can be applied to feedstock procurement as well. For example, one could foresee agricultural management systems that earn revenue by providing ecosystem services, such as water filtration or erosion prevention. Obviously, this would also require market mechanisms whereby these services could be priced and monetized, but such systems are in any case likely to become important to incentivize climate change adaptation in land use sectors.

In conclusion, reduced costs and increased deployment of VREs are essential components in all credible pathways towards deep decarbonization. It is important that bioeconomy market actors and policymakers alike acknowledge and embrace this as an opportunity for business development and value addition.

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