Turning around the direction of the fuel-electricity system

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For more than a century fossil fuels have been used to produce electricity. For this activity to be economically viable, the price of electric energy has to be two to three times as high as the energy in the fuel due to thermal efficiency constraints. During the last decade the total electricity production from solar- and wind-energy first become cheaper than producing electricity from fuels, then even cheaper than the energy content of oil, often cheaper than fossil gas and sometimes even cheaper than the price coal per unit energy.[1]

As a result it has become economically feasible to substitute oil in the transport sector with electricity. Low cost electricity can be used to produce fuels replacing liquid fossil fuels where direct electrification is not possible. Finally, hydrogen produced from electricity can be used to substitute coal in the redudtion of iron ore when making steel.

Low cost electricity generation will not only disrupt the electricity sector, but the fossil fuel industry and some of the largest energy intensive industrial sectors.

Cost reductions are possible as the energy sources, renewable wind and solar energy, are for free. As a result, very low marginal costs of generation are possible. But this is not enough for total costs to be low. Low material intensity and the energy conversion being simpler than the, partly thermal conversion of fuel energy in to electricity, have also contributed to making these electricity generation cheaper than thermal power. Making this technological potential into reality has also depended on a process of industrial experience and learning. This learning was described as an opportunity by Clas-Otto Wene, among others, during the end of the 20th century.[2] But overcoming the cost barrier had to be done in practice.

The disruption of the transport sector and process industries depend on other learning processes: We have seen a fall in battery costs resulting from a combination of industrial learning and utilization of economies of scale, as battery manufacturing is increasing with increased demand from the automotive industry. This has opened economic opportunities to

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deploy batteries in the electricity grid. Batteries now can provide frequency stability service, ”synthetic inertia”, as well as power stability in timescales up to hours.

Expected, but not yet fully proven is a similar cost decrease of electrolyzer, the equipment used when turning electricity and water into hydrogen and oxygen. This will further accelerate the transition of the energy system making storage of large amounts of renewable electricity as fuel for future uses economically feasible.

What we see is a development where the 20th century energy system, using fuels produce electricity, storing fuels to produce more or less electric power as demand varies, into a 21st century system that operate in the opposite direction: Electricity is produced whenever solar- and wind-energy is available and the electricity system is balanced by charging more batteries and producing more fuels when supply is in access of primary electricity demand.

The opportunity of such an energy system entirely based on renewable energy appears easier to achieve than a system where renewable energy is only used for electricity, imposing contains that make electricity balancing difficult and expensive.

Still, in 2022 we are not there. Two thirds of global electricity is still produced from non-renewable sources. But the new capacity build is dominated by renewable energy technologies, and according the the International Energy Agency will continue to dominate.[3] So the trend is pointing in the direction envisioned here.

Electrification of the transport sector is rapid and the automotive industry is in rapid transition in that direction.

Battery installations in the electricity grids are increasing clearly visible in the US and Australia but also elsewhere. US plans are even more impressive. [4] Being the largest battery is a short-term achievement.[5]

Finally, the opportunities to produce fuels from electricity, called electrofuels, via hydrogen are appearing.

Within the Hybrit project in Sweden the first sponge iron produced using hydrogen instead of coal in a direct reduction process left the process in June 2021 [6]. In August the first Steel based on this fossil free process was delivered [7], and in October the first vehicle made from this fossil free steel ready [8].

Another company is taking up the competition in scaling up fossil free steel production [8].

Producing fuels for long distance shipping and aviation is also in preparation. Production of ammonia or hydrocarbons require addition of nitrogen or carbon atoms. The latter produces fuels that can directly substitute fossil based fuels. In order to avoid emitting fossil CO2 such fuel production relies on CO2 from biomass processes [9].

While renewable energy systems can be environmentally sustainable, that is not necessar-

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ily the case. In the disruptive transition described above significant mining will be required to build up the societal stocks of metalls used in the batteries and electrical equipment. Mining is not sustainable, but the use of the metals mined may be such that recycling of the elements used makes mining unnecessary once the stock of batteries and generators have been built. The improved material efficiency of battery technologies may even compensate for the dissipation of some elements in the recycling process.

During this century we will not be able do do away with all environmental and resource problems. But the renewable energy industry has provided mankind with the opportunity of avoiding the resource limits and environmental damages caused by conventional thermal power plants and fossil fuel use that was seen as limiting the opportunities for the entire world population to achieve a decent standard of living.

The technologies and results of industrial learning, combined with the system innovation of turning the direction of the fuel-electricity system, has opened this opportunity. Something pioneers in this generation of the energy industry can be proud of.

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References

1. Kåberger, T 2018: Progress of renewable electricity replacing fossil fu- els. Global Energy Interconnection vol. 1, No 1, pp. 48-52. https://www. sciencedirect.com/science/article/pii/S2096511718300069

2. Wene C-O (2000) Experience Curves for Energy Technology Policy. OECD Paris. http://www.wenergy.se/pdf/curve2000.pdf

3. https://www.iea.org/news/renewable-electricity-growth-is-accelerating-faster-than-ever-worldwide-supporting-the-emergence-of-the-new-global-energy-economy

4. https://www.eia.gov/todayinenergy/detail.php?id=51518

5. https://www.energy-storage.news/at-300mw-1200mwh-the-worlds-largest-battery-storage-system-so-far-is-up-and-running/

6. https://www.hybritdevelopment.se/en/hybrit-ssab-lkab-and-vattenfall-first-in-the-world-with-hydrogen-reduced-sponge-iron/

7. https://www.ssab.com/news/2021/08/the-worlds-first-fossilfree-steel-ready-for-delivery

8. https://www.volvoce.com/global/en/news-and-events/press-releases/2021/volvo-launches-worlds-first-vehicle-using-fossil-free-steel/

9. https://www.h2greensteel.com

10. Examples: https://www.liquidwind.se https://industryeurope.com/sectors/aerospace-defence/swedish-partnership-to-explore-synthetic-sustainable-aviation-fuel/

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