THE CLEAN HYDROGEN SAGA: PART I – THE NEED TO SCALE UP HYDROGEN

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This is part 1 of a four-part series on clean hydrogen and how to bring its costs down.

Most mainstream energy scenarios read like a climate catastrophe. Even with heroic buildout of renewable energy and massive electrification, the growth in total energy demand will mean that even if the share of fossil fuels comes down from 85% to 75% or even 60%, we will still use around as much fossil fuels mid-century as we do today. This means, in practice, that we would be well on our way to a global warming of 3-4^{0} C, with dire consequences both for human civilization and the living environment on our planet.

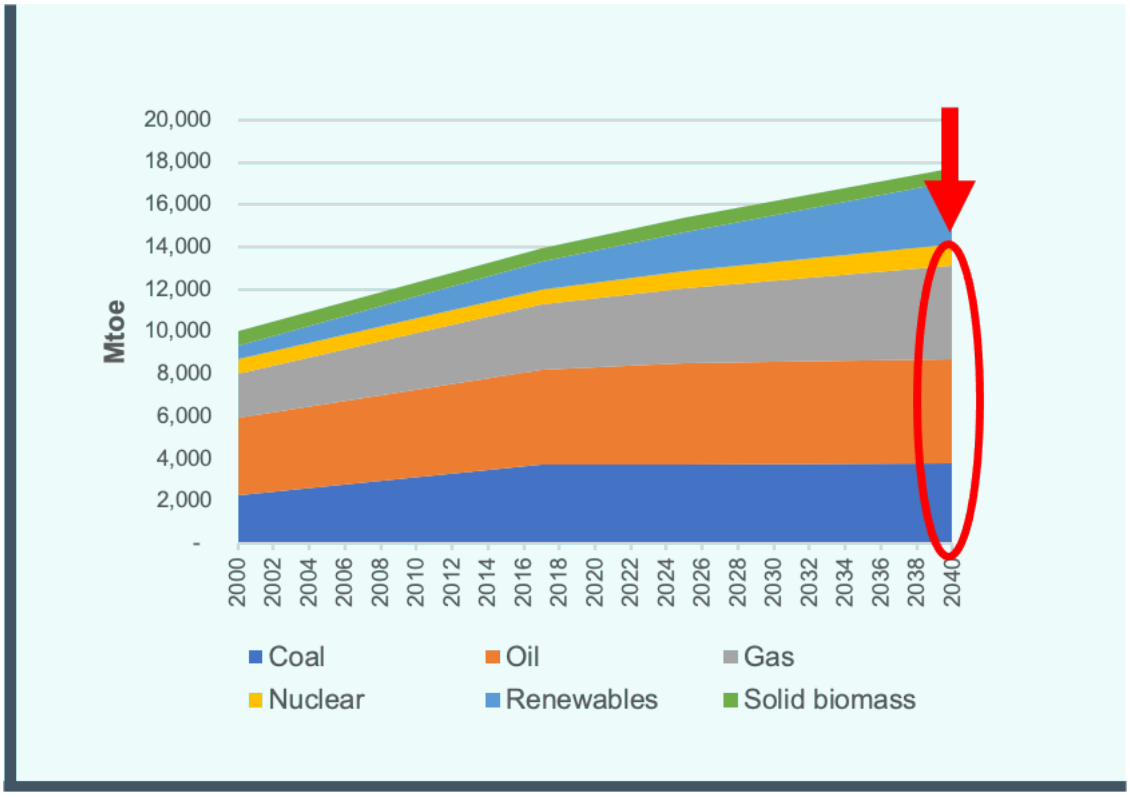

Figure 1: World primary energy by source, according to the Stated Policies -scenario in IEA World Energy Outlook 2018.

Much of these fossil fuels will be used in "difficult-to-decarbonize" sectors, outside the electricity grid. Industrial processes, natural gas heating, international shipping and aviation, long-haul trucking, steel and other metal production, chemical industry feedstock, and so forth.

Hydrogen, and clean fuels we can make with it, are among the most prominent options available to decarbonize these sectors, and drive much of the 60-70% of fossil fuels use we still see in mainstream scenarios by mid-century. If we cannot do it with hydrogen, there is even less chance we can do it with anything else. The first key point to keep in mind is that this undertaking is enormous. It is not a small subsection of our electricity grid. It is several times larger than our current electricity grid.

Lacking Ambition

The need for clean hydrogen has been gaining momentum in recent years, but so far, the propositions have been sort of backwards. Clean hydrogen has been proposed to be made largely from surplus wind and solar, to help with their inability to meet demand, due to their weather-dependent production profile. Hydrogen has been seen primarily as a fix for the problems of integrating variable renewable energy into our electricity system.

For sure, it can be used to solve that problem, but this is a completely different proposition to what we need: truly massive scale up of clean and affordable hydrogen. The fact that something is made from a limited surplus leaking

from a system that is already much smaller than the system that needs to be decarbonized make these propositions underwhelming at best, and risky and irresponsible at worst.

You cannot use zero-cost surplus energy of a smaller system (electricity) and expect to make a significant dent on a much larger system (liquid and gaseous fuels use). Intermittent surplus production from already intermittently producing energy sources like wind and solar is bound to be extremely limited in scale. In addition, if the surplus is used, it is no longer surplus, and therefore will attract a price. Also, if there would be no price for it, nobody would invest in new capacity because, well, there would be no reason to, as much of the production would be worthless. There is no free lunch.

Shifting Perspective to the Real Challenge

Instead of looking at what can be had from surplus renewable energy, we need to look at this situation from the other direction: How much clean hydrogen and e-fuels we need to decarbonize the gas and liquid fuels sector. From that perspective, the hydrogen discussion takes a completely new appearance. Instead of trying to solve a small problem of finding some use for small amounts of surplus production, we are now solving an extremely large problem of decarbonizing whole sectors of our economy.

Decarbonizing hundreds of exajoules worth of relatively cheap fossil fuels needs to be the main priority of the discussion. It will need solutions that scale way beyond what is currently being discussed. We need massive, dedicated projects that produce clean hydrogen and make synthetic fuels from it. Furthermore, the cost of hydrogen needs to fall below $1.50 / kg quickly and below $1/kg in the next decade or two, for these fuels to be able to push their fossil counterparts out from the market at scale and on time. This is a tall order by any measure, and that is exactly why it needs to be seen for what it is.

A Dedicated Energy System

As noted above, the required hydrogen/e-fuels system will be much larger than our current electricity system. Therefore, it makes no sense to discuss or design it to run as a small subsection of electricity generation. This is like planning to move house and using the glovebox of your car to move all your stuff, when you really need a truck.

Therefore, we should start designing the hydrogen and e-fuels system as more of a separate, dedicated system. Sure, it should still have limited connection to the electricity grid when this is valuable for both systems, but it would not be a good idea to use primarily the grid to deliver the amounts of energy needed. The grid is much too limited in capacity for that, and has been built for a different purpose and scale.

We need dedicated energy parks or platforms, offshore or onshore, to produce massive amounts of hydrogen, and preferably to make clean e-fuels with it for easier transportation and storage. By “massive”, I mean tens of terawatt hours’ worth of annual production per park – similar to electricity consumption of small countries such as Denmark. This is the scale that gas and oilfields operate on.

The project proposition we are looking at is quite different in many ways from regular electricity projects. For one, scale is much bigger, so costs can come down, with benefits of scale, serial production at manufacturing lines, learning-by-doing and vertical integration. Second, the market is not a local or a regional grid, but global, as the products can be stored and transported easily with pipelines and supertankers, and potential buyers are ubiquitous.

We will investigate some concepts for these “energy parks” in more detail in future parts of this article series. In the next part, we will learn what the key cost components of producing clean hydrogen are, and how low we need to get with the cost in order to tap into certain markets at scale.

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Endnote: images and data are from: Missing Link to a Livable Climate – How Hydrogen-enabled Synthetic Fuels Can Help Deliver the Paris Goals. LucidCatalyst 2020. The author of this article was a contributor to this report. https://www.lucidcatalyst.com/hydrogen-report.

ABOUT THE AUTHOR

Rauli Partanen

Rauli Partanen is an award winning science writer and analyst, focusing on energy, the environment and human society. His books include the Climate Gamble, published in five languages. He is the co-founder and CEO of Think Atom, a think tank focused on decarbonizing our energy systems with small nuclear reactors. Rauli and his family of five live in the beautiful countryside of Finland. In his off-time he gives Capoeira-classes.

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