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Energy Transition

a new model for bridging the chasm of scale

A white paper in conjunction with

HalliburtonLabs
Advancing cleaner, affordable energy

Introduction

The energy transition, or the transformation of the global energy sector from fossil-based to zero-carbon sources , has emerged as a key challenge of our time. It is a term increasingly used by experts and laypeople alike, yet few have a real notion of the enormity of the concept. Most people are likely aware that a move towards renewable energy systems can help avoid the threat of global warming and support a more sustainable future. However, there is little appreciation of the difficulty and complexity of achieving this switch.

The magnitude of the change is such that it is still uncertain whether current technologies will be sufficient for the job. Until the pathway is clear, we cannot afford to switch off fossil-fuel pow-er systems, which form the bedrock of modern society. Equally, there is no time to lose in seek-ing solutions to the energy transition conundrum. Even if global warming were not an issue, the fact remains that most fossil fuel reserves are expected to have run out by the end of the centu-ry.[ii]

We must find alternatives and bring them up to scale—fast.

Occurrences of the phrase 'energy transition' in literature.

Source: Google Books Ngram Viewer.

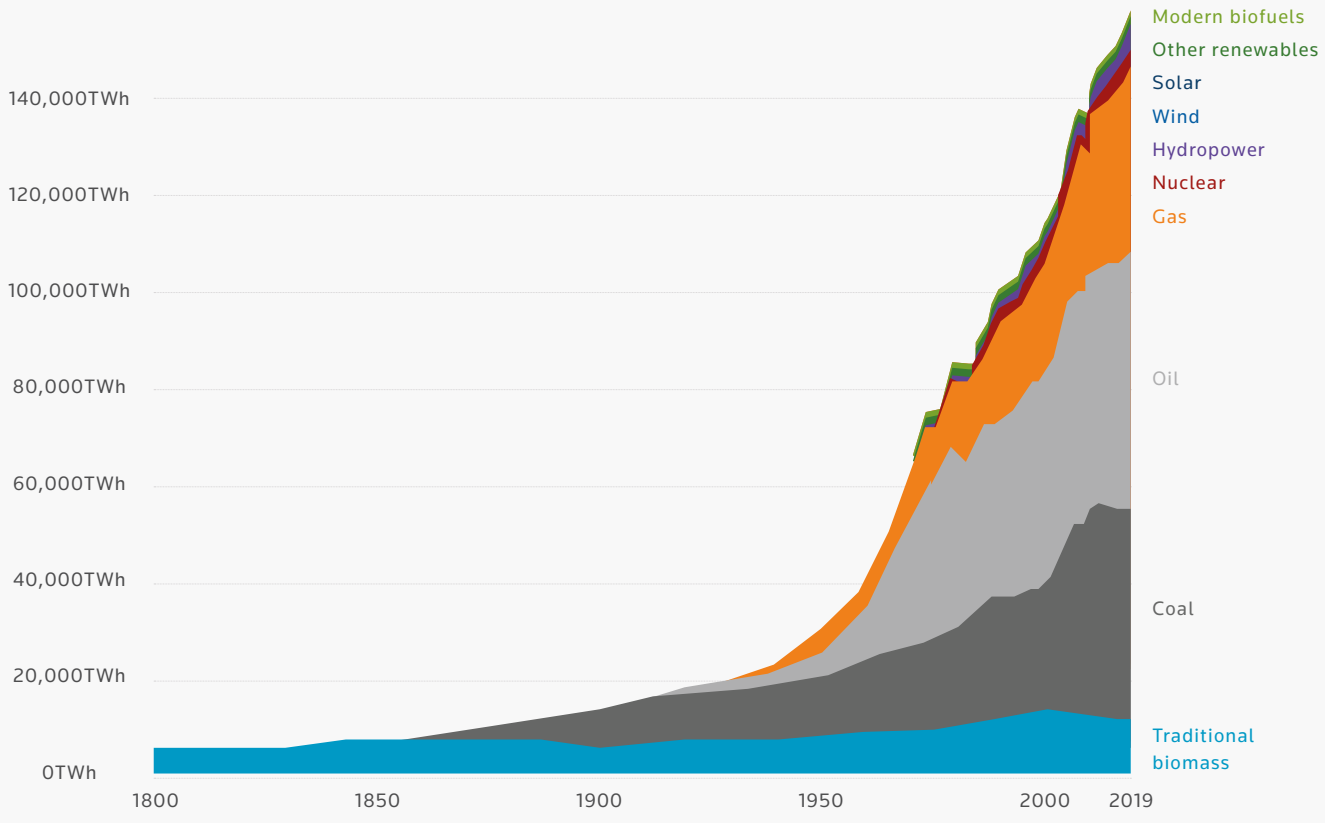
The challenge of scale

Observers frequently point to the rapid uptake of mature renewable technologies, such as wind and solar, as evidence that a global energy transition can be achieved within a matter of dec-ades. Whilst it is true that the growth of these technologies has been outstanding in certain high-profile markets, such as the US, on a global level the picture is far from optimistic.

In the last 50 years, global direct primary energy consumption has risen by 161%. That said, today 86% of all energy still comes from coal, gas and oil. Even worse, the consumption of these fossil fuels has increased by 172% in the last half century—faster than the increase of energy use overall.

Global direct primary energy consumption

Direct primary energy consumption does not take account of inefficiencies in fossil fuel production



Source: Vaclav Smil (2017) and BP Statistical Review of World Energy

OurWorldData.org/energy CC BY

For some experts, it is clear that renewable energy remains a long way away from being able to replace fossil fuels. "The past two decades, the world has spent [according to International En-ergy Agency data] about $2 trillion on building out non-hydrocarbon energy systems," says Mark Mills, a senior fellow at the Manhattan Institute for Policy Research.

"World dependence on hydrocarbons as a share of total supply has over that time declined just 2 percentage points. Put differently, the scale needed is at least 50 times what has been deployed to date."

This is likely to be an underestimate, he says. Since renewables have lower capacity factors than fossil fuel generators, and require additional infrastructure for transmission, distribution and en-ergy storage, "it would be more like 100 times the spending to date: more than $200 trillion," Mills says.

Even if the money for this buildout could be found, it remains unclear whether current technolo-gies are sufficient to fully decarbonize the grid. In 2009, for example, Cambridge University's Prof. David MacKay estimated that the entire world's wind resources would only deliver 24 kilowatt-hours (kWh) of energy per person per day, significantly below the 80-kWh needed for an average European lifestyle.[iii]

The challenge of time

The scale challenge seems to imply that humanity needs more innovative solutions to achieve a full energy transition. Such solutions are in train. Carbon capture, utilization and storage (CCUS), for example, promises to head off the threat of global warming while creating the foundation for a circular energy system based on synthetic fuels. And fusion could offer potentially unlimited clean energy forever.

The problem with these transformational technologies is that they are still at an early stage of development—and may turn out to not be viable. The World Energy Council, for example, does not expect CCUS to start scaling until at least around 2040. But in one of its three future energy scenarios, the tipping point is not until a decade later. In another, the tipping point never comes.[iv] For fusion, meanwhile, there are optimistic predictions that test reactors could start delivering energy into the grid in the early 2030s.[v]

However, since the technology is still at a pre-commercial stage, such forecasts could easily be out by several decades. Even many promising nearer-term technology innovations, from tidal stream generators to compressed air energy storage, have been under development for most of the 2000s without an appreciable growth in scale.

Such sluggish progress would not be a problem if society had plenty of time to carry out the energy transition. But that does not appear to be the case. To combat climate change, the United Nations has called for net zero emissions by 2050, a target which is likely impossible to achieve at current rates of increase.

And even ignoring the climate threat, it is likely that economically viable reserves of fossil fuels will run out well ahead of the end of the century. The business case for some present-day hydrocarbon extraction activities is already in doubt.[vi]

The challenge of scaling rapidly

What emerges from a consideration of the energy transition's scale and time challenges, is not that there is a problem with innovation, but there is a problem with scaling innovation fast enough. For context, the solar and wind industries that are starting to take off today are based on technologies that were around in the 1950s.

Based on such timelines, current innovations such as CCUS might not begin to have a significant impact on the energy system until the end of the century. To be useful, the scale-up rate needs to be at least two or three times faster. This raises the question of whether current scale-up routes are sufficiently effective. The answer is unclear. One review of 50 promising US venture capital-backed cleantech startups revealed that only one—Tesla—had succeeded in achieving global scale after a decade.[vii]

Part of the reason for this low success rate is that startups have to go through all the stages of growth, from research and development to mass-market acceptance, largely on their own and frequently in an intensely competitive market environment. This process may be beneficial in ensuring survivors are robust and highly competitive. But given the energy transition's time constraints, it might pay society to look for shortcuts.

In particular, established corporations could play a key role in helping startups to scale, says Carmichael Roberts, founder and managing partner of Material Impact and a member of Breakthrough Energy Ventures, the clean energy funding group founded by Bill Gates. "There's a lot of money going into this area, but to scale we need large companies," he says. "There's not enough investor capital or time to do this organically. With climate change, every week, every month, every year matters."

Breakthrough Energy Ventures is looking to deal with the challenge by backing innovations that can cut emissions by at least half a gigaton of carbon a year. Trying to scale up technologies the traditional way is unlikely to get results in time, Roberts says. "It's not that it's not possible," he notes. "It just isn't practical."

Towards a new model

Of course, it is true that large corporations are already involved in fostering innovation. Many have in-house innovation teams and business incubators, for example. Even more act as early-stage investors in startup companies. In the energy space, notable examples of this activity in-clude Enel's Enel X unit, which fosters transformational concepts such as energy storage and electric vehicle charging, and Shell Ventures, which backs startups in the power, resources, fuels and mobility sectors.

However, these initiatives tend to be closely aligned to corporate interests and thus may fail to spot blue-sky 'big bets' of interest to Breakthrough Energy Ventures and other transformational funding parties. Such moonshot startups have typically been incubated in university or govern-ment labs, with Alphabet's X innovation arm representing a rare corporate example.

While good for innovation, these labs do not fare so well with the pressing issue of scaling up because the organizations hosting them sit outside the energy infrastructure ecosystem. What is needed, according to Scott Gale, executive director of Halliburton Labs, is an incubator model focused more specifically on how technologies can be scaled from within the energy space. For this, it helps to have prior experience.

At Halliburton, for example, "We've seen a lot of things in terms of our supply chain at scale, and understand what it takes to move materials," Gale says. "As you go from 10 kilograms to 10,000 tons a month, there's an environmental footprint. You can't ignore that."

Large energy corporations are aware not just of supply chain issues but also a whole host of other challenges that can emerge as technologies achieve scale, such as end-of-life disposal and recycling. The corporations are also already plugged into global manufacturing and service de-livery networks, providing a means for rapid, highly scalable transformation.

An example of this can be seen in the automotive industry, which is preparing for the energy transition by retooling manufacturing facilities to deliver electric vehicles. Until now, such capa-bilities were rarely within reach of small, innovative companies.

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Outlook and conclusions

The energy transition is creating the need for a new model of interaction between startups and enterprises. Whereas the former will continue to focus on 'will it work?', the latter need to have a greater say in 'will it scale?' Halliburton Labs was set up with this mission in mind.

Although the venture takes a small equity stake in the startups it selects, the main purpose of the relationship is not to deliver funding but to provide access to the kinds of resources, from intellectual capital to industry contacts, that are not usually available to startups. "It's 'Can our Network help this company?'" says Gale. "I like to think of Halliburton Labs as bringing resources, knowledge and capability, and packaging it up in a unique way so it becomes an enabling milestone on their journey."

For corporations to act as scale-up facilitators like this could help speed up the energy transition in two ways. First, the corporation can apply its operational experience to assess whether an innovative concept has the potential to work efficiently at scale. This immediately narrows the field of potential market aspirants to those that have a real chance of making a difference.

Second, by bringing a startup under its wing the corporation can allow an innovation team to focus on developing its concept, rather than being distracted by issues such as fundraising and competition. This can help speed up the development cycle. For the formula to work well, though, it is important that the corporate partner has a hands-off management approach and does not try to second guess winning concepts beyond selecting those that can work at scale.

This approach is welcomed by climate change fund managers. "Halliburton Labs is creating a nest and they don't know what the eggs are going to be," says Roberts. "I don't think they should be creating the eggs themselves."

For Greg Powers, innovation mentor at Halliburton Labs, that's not a problem. The idea isn't to back a particular horse in this race, he says. Instead, "We're trying to figure out: is this going to be a good horse?"

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