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Net Zero Emission – Mission Impossible?

WHITE PAPER

Net Zero Emission – Mission Impossible?

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Key Takeaways

- In this white paper we argue that it is possible to reach the target of net zero emissions of greenhouse gases by midcentury. However, the current policy pathway will not get us to the target. Solely focusing on renewable energy and electrifying everything is bound to fail, and the world needs to recognize that (cleaner) fossil fuels will continue to be part of the energy mix for the rest of this century.

- Instead of very expensive arbitrary subsidies for favored technologies we should keep an open mind and rapidly get CO2 taxes to $50-100/ton across the world to create a level playing field for different abatement solutions. We should recognize that the climate doesn't care how we get to net zero, only that we do. Much more broad-based activation of nature-based carbon sinks like oceans, forests and the soil are required if we want to realize the ambition of tackling climate change. In doing so, we also simultaneously address the issue of collapsing biodiversity across the planet.

Back in 2015 we concluded, that energy no longer was a resource, but rather a technology. Costs of new technologies fall over time, and we expected storage and energy costs would continue to fall. Electricity produced from solar panels and windmills is today the cheapest electricity available in most parts of the world. Over the coming decades renewable energy prices will continue to fall and take most of the market for electricity generation. Electric vehicles saw real acceleration in sales in 2020 and within a few years will be the obvious choice for all when buying a car. A new technology that is cheaper, cleaner, and more reliable than the existing technology will not take a 5% or 10% market share position and reach a happy equilibrium with the old technology – the new technology will eventually take everything.

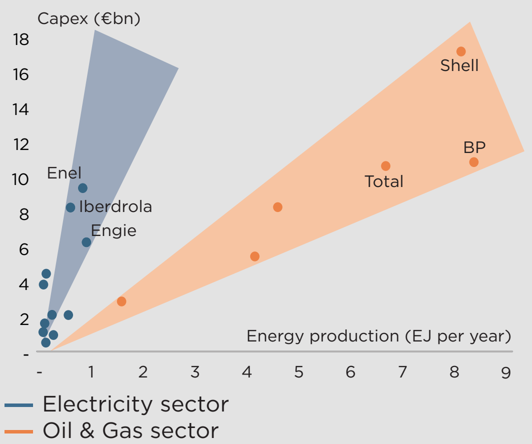
Challenges in the transition

It will, however, be extremely difficult if not impossible to decarbonize the entire world economy with renewable energy like solar and wind over a short period of only 30 years. Today total investments in solar and wind is around USD300 billion per year. This adds 200 GW of capacity generating 360 TWh per year of new renewable electricity production globally in a global energy system of 70,000 TWh[1)]. At this run-rate, it will take 150-200 years for wind and solar to reach 50% of a larger future energy system. Even though renewable capacities are forecast to ten double between now and 2050, solar and wind will still represent less than 50% of the total energy mix by then.

[1)] Of which electricity generation is 27,000 TWh.

Economic advancement has been associated with the use of ever denser forms of energy from the preindustrial revolution era's use of biomass such as wood to the fuel of the first industrial revolution, coal and later oil, gas, hydro power and nuclear. The current narrative tells us that addressing the climate crisis and reaching the net zero targets of CO2 by 2050 involves going back in time to less dense energy forms like wind and sun. The graph below illustrates the challenge:

Figure 1: Capex vs. energy produced



Source: Morgan Stanley as of Nov. 2020

One dollar of investment into the oil & gas value chain produces an output of energy that is 5-10 times larger than the same investment into solar & wind can deliver. According to Morgan Stanley, the oil company BP produced 8.3 EJ[2)] of energy in 2019. The world's largest renewable energy company NextEra produced 0.2 EJ while Orsted, the world's largest operator of offshore wind farms, produced 0.1 EJ in 2019.

Another way to exemplify the challenge is to consider the aerospace industry. Jet fuel has an energy density of 12,000-watt hours/kg. It is one of the densest energy forms we have and makes it possible to lift even the heaviest planes off the ground. Conversely, lithium-ion batteries have an energy density of at best 300 Wh/kg, one fortieth of modern fuels, and will never be able to lift large planes off the ground.

Because of this challenge it has been suggested that either biogas from waste materials upgraded into liquid transportation fuels or alternatively green hydrogen produced from renewable energy like wind and solar could decarbonize hard-to-abate sectors, such as aviation. However, if these opportunities are to 'move the needle', a vast scale-up would be needed, as the aviation industry consumed 7.9 million barrels per day of jet fuel or 4,840 TWh of energy in 2019[3)].

Decarbonizing aviation using waste materials is completely unrealistic. According to studies, producing 8 mbpd of jet fuel from biowaste would require waste equivalent of 8 times the global mass of corn production every year. Assuming one could source this enormous amount of waste material, it would be 3 times as expensive as the price of regular fuel and only reduce the CO2 emission of aviation by 75%. Producing 8 mbpd of jet fuel from green hydrogen would require an amount of renewable energy that would be 300% of current global production[4)] from solar and wind. It's all very well that governments require – and certain airlines – plan to address their emissions by going "green", but it's totally unrealistic to believe the whole sector can do it.

Huge opportunities despite real challenges

The purpose of this white paper and follow-up papers is to discuss how we move onwards and realize the net zero carbon society by 2050.

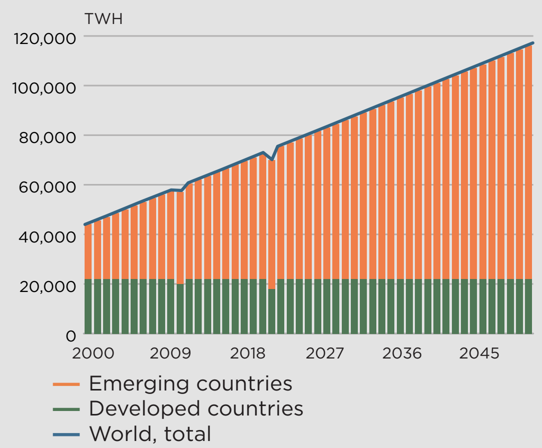
Are there new technologies and processes that will replicate what electric vehicles, solar and wind power has done over recent decades and scale to displace current fossil energy-based processes in hard-to-decarbonize sectors of the economy? What role will hydrogen play and are there any low hanging CO2 abatement opportunities we are overlooking? Finally, as explained below, it is likely that fossil fuels will play a larger role than the current narrative describes, so how do we balance the need for dense energy and at the same time meet the net zero target?

2) Symbol for exajoule, energy equal to 10^{18} joules.
3) Jet fuel demand is expected to rise toward 20 mbpd by 2050.
4) 2,800 TWh end 2020.

The world's dependency on lowly priced abundant energy will not end

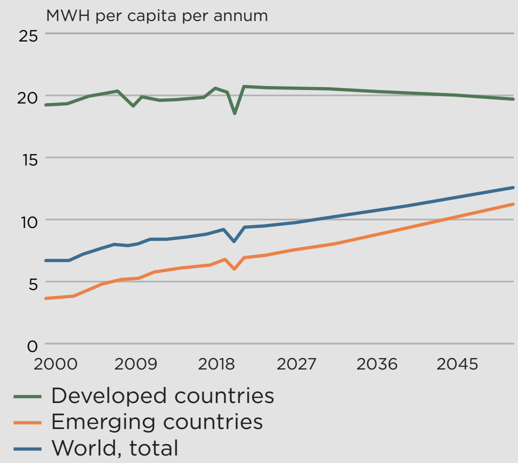
Global energy demand is still growing. The total energy used by mankind stood at 70,000 TWh in 2019 and is growing 1-2 % per year. 40% of the total was consumed by 1.4bn people in the developed world, and the other 60% was consumed by 6.3bn people in the emerging world. In other words, emerging world consumers each used one-third as much energy in 2019 as their developed world counterparts[5]. As the world middle class continues to grow in the coming decades this ratio is set to reach 50% of their developed world counterparts by 2050. Hence all other things being equal, global energy demand will rise by something like 65% to 115,000 TWh[6]. Total greenhouse gas (GHG) emissions are approximately 50 Giga Ton (GT[7]) per year today and without change in production and consumption patterns this would grow to 80 GT per year by 2050. It would be very dangerous to try to avert the growth in emissions by depriving emerging world consumers of the benefits of modern energy at affordable prices. This is the constraint we must adhere to as we move closer to a carbon neutral society.

Figure 2: Global energy consumption



Source: ThunderSaidEnergy as of Jan. 2021

Figure 3: Energy consumption per capita



Source: ThunderSaidEnergy as of Jan. 2021

Realistically speaking, because coal and lignite are very dirty forms of energy, they should be displaced as fast as possible, and initially be substituted by natural gas, which is a much cleaner form of dense energy. Longer term the associated CO_2 emissions from burning gas could be dealt with via carbon capture and storage, but this would require a more level playing field that considered the associated costs of CO_2 emissions from different alternatives. In fact, probably the biggest game changer from an environmental point of view would be if the world could agree on setting a price on greenhouse gas emissions because it would promote all sorts of clean energy tech solutions, make fossil fuels less competitive and in general incentivize a broad-based shift away from greenhouse gas emitting activities.

Creating a level playing field

CO_2 is what economists call an externality. Emitters derive personal and economic benefits from their emissions, but the climate consequences of their CO_2 emissions are incurred by all the world's 7.7bn inhabitants. The most effective antidote to externalities is to tax them. This would entail emitters paying for their

[5] In reality much less since much of the production - and therefor energy use - of developed world consumption is outsourced to developing economies, especially China.
[6] In reality probably somewhat lower since moving towards a highly electrified energy system will increase energy efficiency, i.e. we will get more economic growth for a given energy input.
[7] Billion Ton.

emissions, and creating a level playing field and moving away from arbitrary incentives.

Political favoritism through arbitrary incentives is inefficient and expensive. At one end of the spectrum, buyers of some electric vehicles in the United States are currently being awarded tax credits up to $7500 under IRC 30D legislation. It is estimated that an electric vehicle in the US saves 22 tons of net CO_2 over its life, compared with a conventional vehicle. Hence this incentive is offering up to $340 per ton of CO_2 that is offset. Similarly, the Blenders Tax Credit of $1/gallon awards the renewable diesel industry the equivalent of $190/ton to offset CO_2. This has resulted in 40% of US corn production being used not as food but as feedstuff for the US biofuel industry today. It is more profitable for farmers to harvest subsidies than to grow food.

The numbers get even more ridiculous in Denmark, where electric vehicles as well as hybrids are given large discounts on the registration tax which, because of the overall very high taxes on cars, leads to carbon offset costs to society that approach $3000 per ton of CO_2 for the most expensive electric vehicles, assuming the same 22 ton displacement of CO_2 as mentioned above[8)].

In contrast, there are industrial efficiency initiatives and nature-based technologies which can save vast amounts of CO_2 but are currently being awarded no fiscal incentives at all. If incentives are specific and levied case-by-case, then policymakers cannot incentivize technologies they do not know about. Technological advancement comes from below and not from politicians or regulators determining what should work.

Keeping energy prices affordable while decarbonizing the energy system will be a requirement for preserving popular support for the multi-decade long decarbonization process. A rising CO_2 price should unlock the lowest cost energy transition to society, as it allows all the different options to compete on cost.

[8)] *Because the Danish energy mix is much cleaner than the US the CO_2 reduction from going from ICE to EV is probably higher, and therefore the cost to society realistically will be lower than $3000/ton but still very high.*

The environment does not care how we get to net zero CO2 emissions

The current landscape of ad hoc incentives looks arbitrary and prone to rent seeking where politicians act as kingmakers for a specific set of favored sub-industries and no incentives at all for other sub-industries that may be equally - or more - capable of reducing total CO2 from the global energy system.

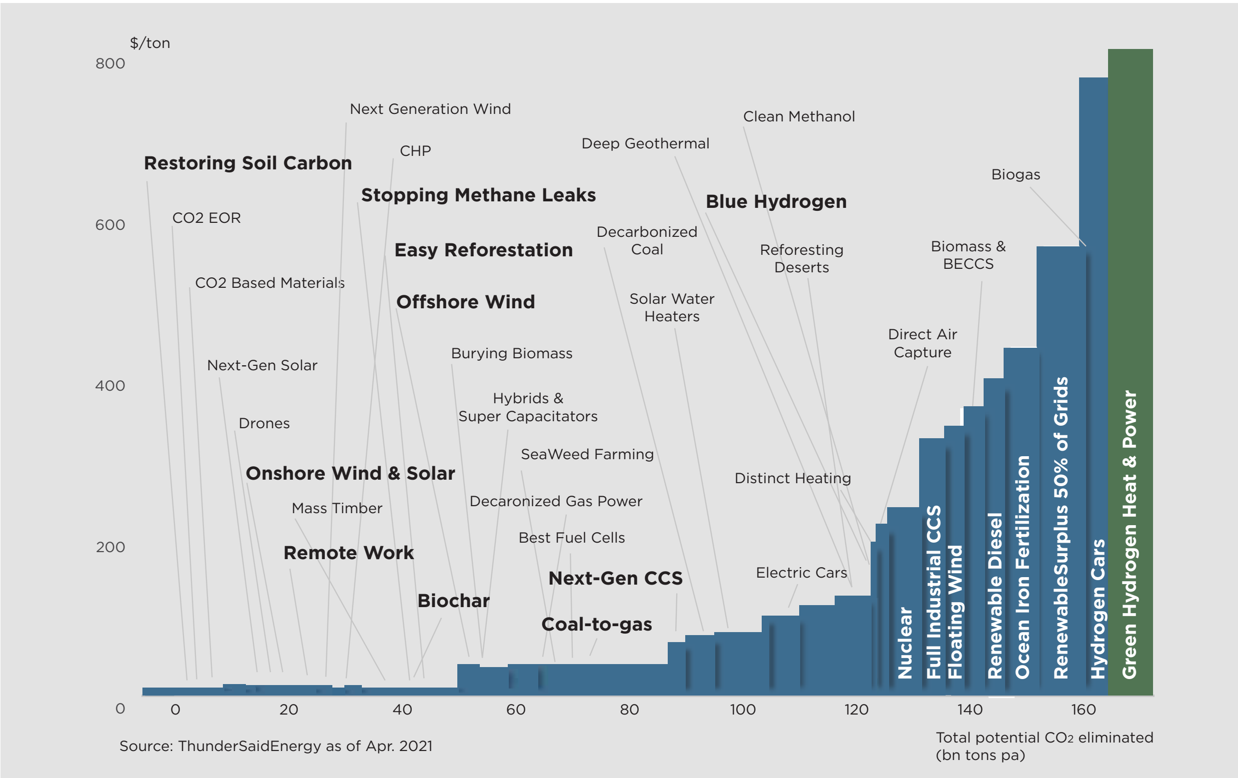
The below graph tries to assess the abatement costs for different technologies and processes. What is the all-in cost of removing 1 ton of CO2 with a given solution? There's a timestamp on this picture, and we should except that as time passes the costs of these solutions will change. At least that's what the experience with wind and solar has shown us. However, there are also very big differences between the cheapest and most expensive abatement solutions today.

The hugely positive conclusion from the analysis presented in the graph is that we can get to net zero and remove up to 80 GT of CO2 per year by 2050 for a total cost to society of somewhere between $50-100 per ton CO2 removed.

A carbon tax would greatly affect the costs of different energy sources and the competitiveness of different technologies and abatement solutions. Under a carbon pricing system, coal and oil lose out, while gas, renewables, and nuclear win. On the other hand, novel technologies that must be at the core of the energy transition like green hydrogen (produced from renewable power), blue hydrogen (produced from gas where the associated CO2 is captured) and carbon capture and storage suddenly become more viable.

A carbon price would affect the costs of products based on the carbon intensity in their manufacturing. Bulk chemical, refining, cement, and steel producers represent some of the most intensive users of energy. Some of these industrial sectors are difficult to decarbonize due to their high energy intensity and because the technologies that could aid their decarbonization, especially hydrogen and carbon capture, utilization, and storage are not yet operating at the necessary scale. Introducing carbon pricing would push these novel technologies in the right direction at a critical point in time in the energy transition.

Figure 4: CO2 abatement cost



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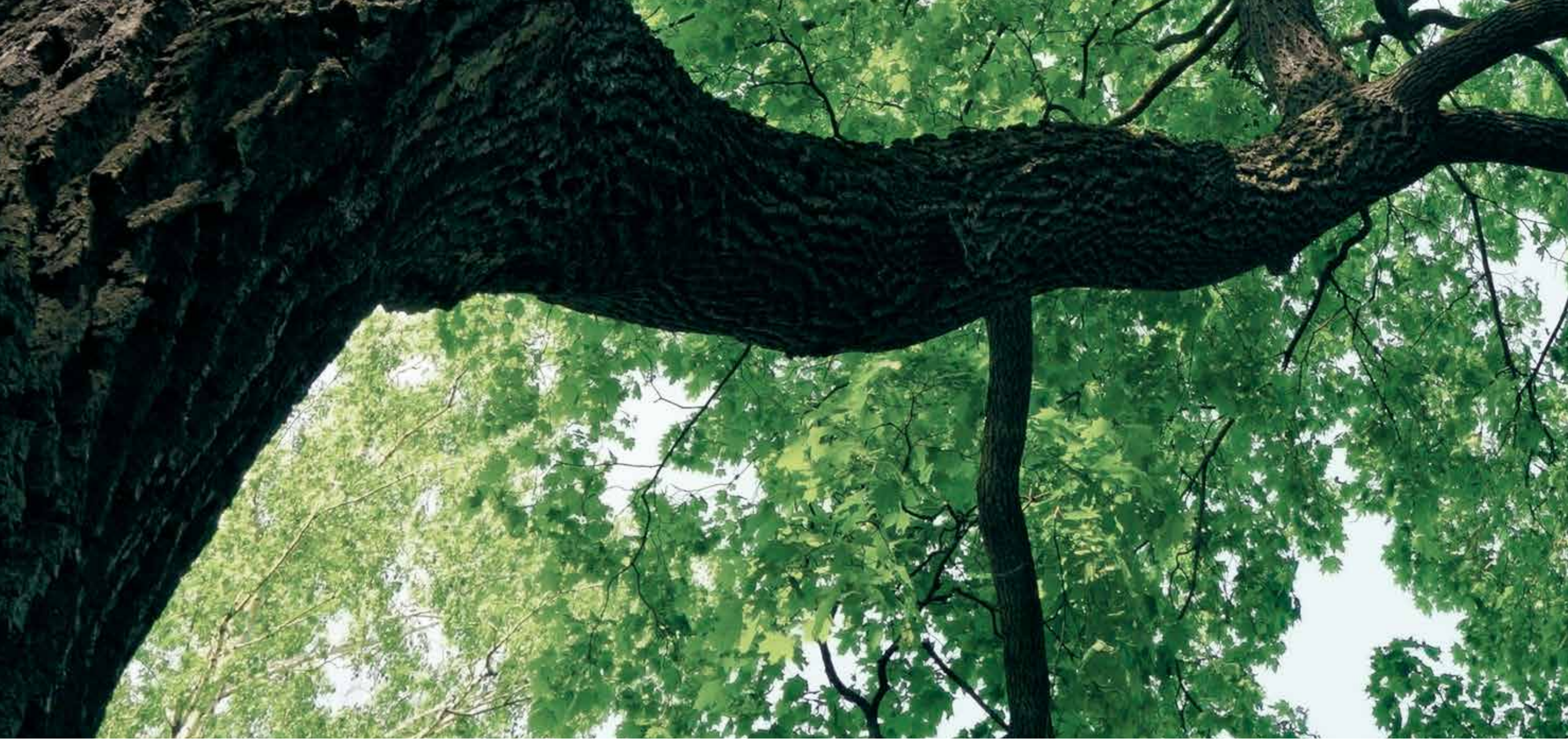
However, the most obvious and overlooked opportunities for abating CO_2 are nature-based carbon sinks. Contrary to the current narrative that we need to employ immature and very expensive technologies to reach net zero, as the graph shows, soil restoration is a large and low cost nature-based solution to climate change. One-third of the increase in the atmosphere's post-industrial CO_2 derives from the degradation of soils, where organic carbon has fallen from 4% to 1-2% due to mechanized agriculture. Ploughing churns up the soil, exposing it to air, accelerating the decomposition of organic material. Academic studies suggest that soil organic matter could be restored to around 4% over c20-30 years, and possibly higher. This practice can sequester 2-5 tons of CO_2 per acre per year, generating carbon credits the farmer can sell to companies in difficult to decarbonize industries. According to academic studies, soil restoration projects could globally absorb 4 billion tons of CO_2 per year. This assumes 1T of CO_2 uptake per acre per year across the world's 4bn acres (1.7bn hectares) of cropland. On top of farming crops, farmers in the future can increase their incomes by also farming carbon credits.

Secondly, and probably unknown to most, biochar has big potential as a CO_2 sink. Biochar is a porous, carbon-rich material, produced by heating biomass in an oxygen-starved pyrolysis reactor. Thus, biochar is a solid, charcoal-like residue, like the one we burn when barbecuing, after biogases and bio-liquids have been drawn away. Biochar can lock up carbon for centuries, keeping it out of the atmosphere, whereas 99% of waste biomass would otherwise have decomposed within 4 years, thereby returning its carbon to the atmosphere. A key property of biochar is its porosity, which enables it to store water, bind nutrients, filter toxins, and house beneficial soil microbes. As a result of these properties, biochar has beneficial effects in agriculture. It is almost presented as a 'miracle substance' by its proponents. In soils, biochar increases water and nutrient retention by around 20%, while decreasing the need for fertilizers and simultaneously increase yields by at least 10%. In animal feed, biochar has health benefits and reduces methane emissions from livestock. It is said that 1 ton of biochar can bind 2 tons of CO_2 or methane that would otherwise be released into the atmosphere. Adding 1-3% biochar to cattle feed reduces methane emissions from cows by around 20%. It also appears to increase the rate of nutrient uptake and weight gain in cows by 20-30% at the same time.

The limit to biochar is sourcing feedstock and evaluating the abatement potential is very difficult. In any case biochar results in greater CO_2 avoidance than biofuels, and at vastly superior economics. To our knowledge, the recent suggestion by the Danish government that biochar will be a central pillar in the greenhouse gas reduction plan for agriculture towards 2030 is the first formal recognition of the potential of biochar.

Finally, 15 GT of annual incremental CO_2 could be sequestered by reforesting 3bn acres, or c8% of the world's landmass, restoring forests that have been lost since preindustrial time. Reforestation also feels intuitively right that the natural world is valuable and that its degradation should be restored. Today, forests cover 30% of the world's land today, or around 10-11bn acres. 200mn acres of forests have been lost since 1997 and deforestation is still occurring at a pace of 0.1% per year, reducing every year the world's natural ability to sequester CO_2. We need to reverse this trend and actively manage our forests because forests can be close to permanent carbon sinks if managed correctly, for example by increasing the usage of wood as a construction material in the future: it can store the carbon from sustainable forestry for centuries, while it also displaces more CO_2 intensive construction materials such as steel and concrete. Hence one recent study estimated that Europe could save up to 1.3 GT of CO_2 emissions by 2040



if wood were used as the primary construction material in 80% of new buildings[9].

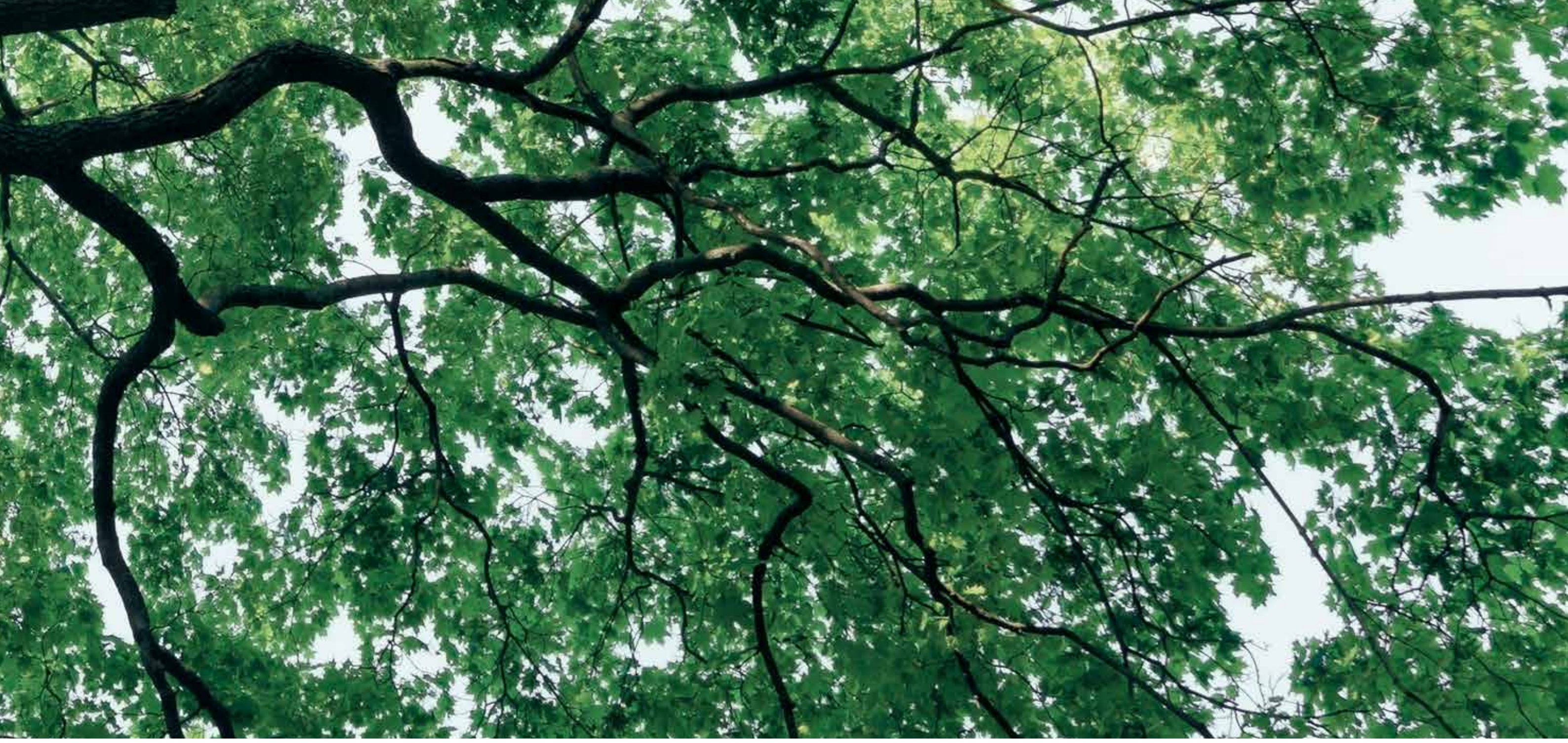
> Agriculture and the forestry supply chain have big monetization opportunities as over time they can build new annuity like business models

The consequences of the world turning to the use of these nature-based carbon sinks could be significant. Planting trees is a nascent new carbon abatement business opportunity and furthermore matters for investors and companies, as nature-based carbon sinks can help companies decarbonize inexpensively and push more expensive and complex energy technologies off the cost curve. More companies are realizing this and choosing to protect nature through investments into reputable reforestation funds rather than paying for higher cost new technologies. Several of our portfolio companies are pursuing this as part of their overall effort to decarbonize. Agriculture and the forestry supply chain have big monetization opportunities as over time they can build new annuity like business models. Finally, more broad-based usage of nature-based carbon sinks allow for the continued use of (cleaner) fossil fuels in difficult to decarbonize industries like aviation while simultaneously reaching the goal of net zero emissions.

The EU Emissions Trading System as a lever to global change

Today, there are globally 64 carbon pricing initiatives either already implemented or scheduled. The EU Emissions Trading System is the oldest, largest, and most liquid carbon market globally. The scheme covers ~40% of the EU's greenhouse gas emissions covering sectors like power and heat generation, energy-intensive industry sectors like oil refineries, steel, aluminium, cement, chemicals, and commercial aviation between member states. From 2022 it is expected the system will be expanded to also include maritime transportation, and there is growing political willingness to further expand the scheme to larger parts of the economy over time. Recently both The Greens as well as the CDU in Germany have proposed radical makeovers of Germany's tax system wanting to introduce a general and high CO_2

[9] *Amiri. A. et al. (2020). Cities as carbon sinks—classification of wooden buildings. Environmental Research Letters, 15, 094076.*



tax that is consistent with climate targets. Many other European countries are having similar discussions. At the same time, the EU parliament is discussing a Carbon Border Adjustment Mechanism that basically would put imports on an even basis with products produced in the EU by levying a tax scaled to the CO_2 intensity of the imported goods. This will be tricky as it could violate World Trade Organization rules, but both recent Chinese commitments to becoming CO_2 neutral by 2060 and President Biden's election win increases the likelihood that CO_2 pricing somehow will be integrated into cross border trade flows longer term, most likely by more countries introducing carbon taxes.

> **The EU could soon become the first geography that would operate under a CO2 price sufficiently high to ensure longer-term compliance with 2050 targets of net zero emissions**

Whilst carbon prices globally vary materially, nowhere are prices yet high enough to incentivize a net zero pathway. In an academic study co-authored in 2020 by Noah Kaufman, who is serving in the Biden-Harris Administration, the necessary price of carbon for achieving net zero by 2050 is estimated to be $50/ton by 2025, increasing to $100/ton by 2030. Elsewhere, the IMF has estimated that $75/ton is necessary to meet the Paris Agreement target of limiting global warming to 2°C over preindustrial levels. This seems consistent with the analysis shown in chart 3 above, indicating that at around $75-100, solutions would be available to abate 80 GT per year by 2050, i.e. realizing a net zero carbon world by midcentury.

The EU Emissions Trading System is closest to achieving this, trading above €50/ton currently. This represents a very large increase from prior years and reflects the fact that the system is constructed in such a way that scarcity increases over time. Furthermore, a revision of the EU Emissions Trading System is planned by July 2021 to ensure it is in line with the increased 55% emissions reduction target by 2030. Several changes are also expected that will reduce the allowances even further, giving good reason to expect that the carbon market has entered a multi-year structural deficit, driving up prices. The next three years threaten to deliver a shortage that has never been seen before in the carbon market. That deficit, combined with draconian penalties to companies that are non-compliant, could mean prices could go to extreme levels without political interference.

It is likely, therefore, that the EU could soon become the first geography that would operate under a CO_2 price sufficiently high to ensure longer-term compliance with 2050 targets of net zero emissions. High CO_2 prices would ensure rapid power sector switching from coal to gas (going from coal to gas reduces emissions by 60%) and accelerate investments into energy efficiency technologies, renewable energy, blue & green hydrogen, and carbon capture technologies. However, in order to reach the end goal, the world needs to realize that reforestation projects and other carbon sinks like soil and oceans will be required to meet the 2050 target of net zero CO_2 emissions.

What exactly is a ton of CO2?

A ton of carbon dioxide is a one-way trip between Paris and New York by plane. In terms of volume, this represents a cube the size of a three-story building, or 8.20 meters in edge length.

Conclusion

The transition to a sustainable future will be the biggest investment theme of our lifetime. Value creation and destruction will be massive across industries and countries. The current policy setting is not capable of getting us to net zero, but hopefully – and sooner rather than later – policy setters will realize we need to reactivate and nudge the earth's climate system in the right direction by the stimulation of natural carbon sinks that have been lost over the last 200 years of industrialization and population growth.

Today, our investment focus is primarily on companies that develop renewable power equipment and utilities with growing renewable energy capacity. Within a couple of decades, it's almost a given that the market for carbon credits will be amongst the largest commodity markets and that companies that facilitate the transition to a sustainable future will be amongst the largest in the world. We are working hard on identifying these companies ahead of time.

Active Investments

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