Why we need to develop this technology

The restraint in aggressively addressing anthropogenic warming through weaning humanity off fossil fuels masks some harsh realities pertaining to:

Economic burden

The world has a thorny issue to deal with global demand for energy, both for livelihood and for pure economic growth, as well as an existing, sizeable, carbon-intense infrastructure, a technology that is fundamentally incompatible with the present-day set of targets such as the 2030 UN Agenda for the 17 Sustainable Development Goals and the Paris Agreement. A low carbon future in terms of the stranded assets will have a profound impact on countries, industries and companies. Some studies suggest that globally a third of oil reserves, half of gas reserves and over 80% of coal reserves would have to remain unused before 2050 for us to have a chance of staying below the 2°C limit. Citigroup[1] has examined the issue of unburnable carbon and stranded assets, in particular in which countries, industries and companies they are located. They have found that, at current prices, around $100 trillion of assets could be "carbon stranded," if not already economically so.

Conversely, much of the current energy provision and consumption comes from coal at a price that people can afford thus; it is an appealing fuel and is in widespread use and will continue to do so far into the future. Then, if we ended fossil fuel use too abruptly, the costs of a transition to clean energy would be substantial and might, at least for a certain time, rise energy and food prices and consequently impede the poverty reduction goal. At present on the whole, green energy is more expensive than electricity generated through fossil fuels and legislation mandated increased use of wind and solar only exacerbates green energy poverty. The high costs of green energy are most evident in areas which used legislation to force expensive green energy on consumers. For example, German electricity prices have gone up 50 per cent over the 10 years that they've been doing renewables, in Britain, customers saw a 15 percent hike in electricity rates in spring 2017 and in California, where state law requires increased use of renewable energy sources, electricity rates are 40 percent higher than the national average.

Energy poverty

Recent estimates suggest that more than 50 million Europeans are affected by energy poverty and just as many Americans can't afford higher electricity prices. For example, it has been found that the 39% of all Mississippi households allocated 24% of their incomes to energy in 2015. In some parts of the country, low income families spend half of their income on energy. This is the case for much of Maine and the Dakotas. The large share of after-tax income devoted to energy poses difficult budget choices among food, health care and other basic necessities.

However, of the greatest imperative is the risk to human survival. Nearly 600 million people in Africa and more than 300 million people in India live without access to any electric power. Failure to recognise that energy poverty is an endemic can prove to be calamitous. As a result of global increases in both temperature and specific humidity, heat stress is projected to intensify throughout the 21st century. Some of the regions most susceptible to dangerous heat and humidity combinations are also among the most densely populated. Consequently, there is the potential for widespread exposure to wet bulb temperatures (WBT) that approach and, in some cases, exceed postulated theoretical limits of human tolerance by mid- to late-century. In the coming decades heat stress may prove to be one of the most widely experienced and directly dangerous aspects of climate change, posing a severe threat to human health especially in regions where people have little access to air conditioning[2].

Renewable and *power security supply*

Modern assessments of renewable energy potential are based on the current state of the planet's climate and don't consider changes in climate patterns due to increasing atmospheric greenhouse gas concentrations due to the challenges involved in modelling wind and cloud cover changes at the necessary spatial scales.

Thus, the rapidly growing wind energy industry may be challenged by changes in locations of wind resources. A new study published in Nature Geoscience concludes climate change could shift wind production from the Northern Hemisphere to the Southern Hemisphere[3]. Moreover, scientists have found changes in cloud patterns that include poleward retreat of mid-latitude storm tracks, expansion of subtropical dry zones and increasing height of the highest cloud tops. Clouds substantially affect Earth's energy budget by reflecting solar radiation back to space and by restricting emission of thermal radiation to space[4].

New research provides evidence that a key cog in the global ocean circulation system hasn't been running at peak strength since the mid-1800s and is currently at its weakest point in the past 1,600 years. If the system continues to weaken, it could disrupt weather patterns from the United States and Europe to the African Sahel, and cause more rapid increase in sea level on the US East Coast[5].

Climate changes

Climate models appear to be trustworthy for small changes, such as for low emission scenarios over short periods, say over the next few decades out to 2100. But as the change gets larger or more persistent, either because of higher emissions, for example a business-as-usual-scenario, or because we are interested in the long term response of a low emission scenario, it appears they underestimate climate change[6].

In recent years, scientists have been able to correlate the amount of global warming to cumulative carbon emissions from the burning of fossil fuels - a relationship that became the basis of the Paris Agreement on climate change that guides policies of most world nations to limit their carbon emissions. A new study demonstrates that a correlation also exists between cumulative carbon emissions and future sea level rise over time - and the news isn't good. Even under the most optimistic scenarios outlined in the Paris Agreement - keeping the overall warming of Earth to 1.5 degrees (Celsius) - sea levels will continue to rise by several meters over the next few thousand years. If humans continue to burn fossil fuels so that temperatures meet the 2-degree (Celsius) threshold outlined in the Paris Agreement, global mean sea level rise may exceed nine meters, or nearly 30 feet[7].

A new analysis using changes in cloud cover over the tropical Indo-Pacific Ocean showed that a weakening of a major atmospheric circulation system over the last century is due, in part, to increased greenhouse gas emissions. The findings from researchers at the University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science provide new evidence that climate change in the tropical Pacific will result in changes in rainfall patterns in the region and amplify warming near the equator in the future[8].

Researchers from North Carolina State University have described rapid and dramatic clearing of low cloud cover off the southwest coast of Africa. This newly observed phenomenon of changing large cloud areas (more than twice that of California) has not been documented before. The cloud was not pushed away by the wind, and solar heating does not cause these events. How it happens is still a mystery, although they theorize that atmospheric gravity waves are the most likely mechanism. Scientists are interested in anything that changes the area of low clouds over the ocean because these clouds reflect sunlight and cool the Earth. Understanding how this happens will help predict what might happen to clouds in a warming climate[9].

Global temperature and atmospheric CO_2

Global surface temperatures surged by a record amount from 2014 to 2016, boosting the total amount of warming since the start of the last century by more than 25 percent in just three years, according to new University of Arizona-led research[10]. At the same time, a new NASA study provides space-based evidence that Earth’s tropical regions were the cause of the largest annual increases in atmospheric carbon dioxide concentration seen in at least 2,000 years. Researchers conclude that impacts of El Niño-related heat and drought occurring in tropical regions of South America, Africa and Indonesia were responsible for the record spike in global carbon dioxide[11].

Other factors that have an exacerbating effect, include the fact as the Earth warms, permafrost, ground that has been frozen for thousands of years, is beginning to thaw, releasing carbon to the atmosphere in the form of carbon dioxide and methane. The Earth’s permafrost, to put this in perspective, contains almost twice as much carbon as is present in the atmosphere. Carbon emissions from thawing permafrost will accelerate climate warming, so the potential exists for a catastrophic, self-reinforcing cycle of warming and thawing permafrost[12]. Furthermore, changing climate in northern regions with resulting permafrost thaw presents major implications for the global mercury (Hg) cycle. Researchers have discovered that permafrost in the northern hemisphere stores massive amounts of natural mercury, a finding with severe implications for human health and ecosystems worldwide[13].

In the ocean's twilight zone, tiny organisms may have giant effect on Earth's carbon cycle. Deep in the ocean's twilight zone, swarms of ravenous single-celled organisms may be altering Earth's carbon cycle in ways scientists never expected, according to a new study from Florida State University researchers. In the area 100 to 1,000 meters below the ocean's surface -- dubbed the twilight zone because of its largely impenetrable darkness -- scientists found that tiny organisms called phaeodarians are consuming sinking, carbon-rich particles before they settle on the seabed, where they would otherwise be stored and sequestered from the atmosphere for millennia[14].

Human-induced global warming of 2° C may trigger other Earth system processes, often called 'feedbacks,' that can drive further warming – even if we stop emitting greenhouse gases. Collective human action is required to steer the Earth System away from a potential threshold and stabilize it in a habitable interglacial-like state[15].

There is more to warming than just increased concentrations of carbon dioxide. The nitrous oxide may contribute to global warming. Predicting how the nitrogen cycle might evolve in response to future oceanic redox changes is an important goal, and can be investigated from the study of rapid environmental change events in the geologic past[16].

Policies in environmental governance

The are three big concepts have been used to derive policies in environmental governance: ***economic optimization*** - act to maximize your expected profit, with discounted future, ***sustainability*** - act to always stay above a minimum standard of expected profit, with discounted future, and the ***Planetary Boundaries*** - act to always stay within the safe space for humanity to ensure the functioning of the Earth's life-supporting systems. However, a formal comparison between these three policy paradigms is still missing, and there is no consensus on a master paradigm leaving policy makers uncertain which paradigm to apply[17]. In mean time "if emissions continue at their present rate, human-induced warming will exceed 1.5°C by around 2040," according to the draft of the final a Sixth Assessment Report (AR6) of the U.N.'s Intergovernmental Panel on Climate Change (IPCC) obtained by Reuters and dated June 4, and due for publication in October 2018.

Conclusion

Taking into account these uncertainties and challenges can fossil fuel use be entirely avoided? The high-reliability fossil plant maintains the potential to be the least disruptive or costly option on the way to a sustainable energy future. The continued use of carbon-derived fuels in an environmentally carbon-neutral manner allows application and distribution of this option across people and sectors along multiple dimensions of societal well-being. It includes marginalized people, sectors and countries in social, political and economic processes for increased economic, social and environmental sustainability, and human empowerment.

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