The Role of Technology in reducing Greenhouse Gas emissions: Will it save humanity?

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Introduction

Humanity has emitted high levels of greenhouse gases since the first industrial revolution (Ritchie, H et al 2022). Industrialization is positively associated with positive economic growth, but often pushes environmental stresses closer to threshold limits (Patnaik, 2018). Developed countries such as the UK, USA and Germany industrialized during the 19th century, while many developing African and Asian countries are industrializing now (Patnaik R, 2018). Economic growth is irreparably linked to the use of fossil fuels (Wang & Chen, 2013), which have been one of the largest causes of climate change.

Climate change is caused primarily by greenhouse gas emissions such as CO2, methane and other NOx gases (Ritchie, H et al 2022). Most of these emissions arise from sectors essential to economic growth such as industry and agriculture. Green technology mediates the need of countries to prosper economically, while protecting the environment (Fujii & Managi, 2019). Technology such as renewables, air capture and biofuels can mitigate and reduce the amount of anthropogenic GHG emissions in the atmosphere. (Du & Li, 2019) The technology exists, however implementation is a slow process due to numerous factors.

Developed and developing countries require different methods of implementing green technology (Bekabil, 2020). International policies recognize the need for green technology if humanity is to stabilize its' GHG emissions below 4°C, (Pielke, 2009), in fact, the Paris agreement depends on air capture and GHG mitigation to feasibly reach its' goals. The Kyoto failed to focus investments on green tech and allowed firms to reinvest profits from carbon trading into fossil fuels. (Wang & Chen, 2013). Green technology forms the crux of many of these policies and guidelines, but none of them provided feasible, practical methods of implementing these technologies to mitigate GHG emissions (Haszeldine et al, 2018).

Green technology balances the demand for economic wealth while protecting the environment. Technology that reduces and captures Greenhouse gases from the air are essential to global policies and guidelines to mitigate climate change (Haszeldine et al, 2018). They have found a place in every single policy that aims on reducing greenhouse gases, however the implementation of these technologies has been slow if not missing. The feasibility of technologies such as air capture, biofuels and renewables will be analysed to determine their actual capabilities in reducing greenhouse gases. Costs, infrastructure and societal willingness to implement technology all play a key role in allowing these technologies to be used. This paper aims to understand the reasons why many green technologies have not been implemented.

Renewable Energy

The Paris Agreement states that reducing emissions from energy production is the first-step towards Carbon neutrality (Haszeldine et al, 2018). It is likely countries will not satisfy this step as renewables is currently a 66$ Billion industry, but the fossil fuel industry amounts to 775$ billion (Wang & Chen, 2013). This is indicative of how the Kyoto Protocol failed to focus investments to renewables. That being said, implementation of current renewables would fail to keep humanity below 450ppm CO_2 emissions (Demirtas, 2013). Solar, hydropower, geothermaland wind power all fall under the term renewable energy, however renewable does not imply sustainable (Harjanne & Korhonen, 2019). Sustainable development balanced the need for economic growth and environmental preservation, (Demirtas, 2013), something which none of these 'Renewables' do. Sustainable development is essential for humanity to reduce GHG emissions while allowing for economic growth.

The most expanded renewable is hydropower (Demirtas, 2013). It is highly efficient (Table 1), converting and utilising 90% of all possible energy, however it is not environmentally friendly. Hydropower effects water ecosystems as well as releases greenhouse gases. GHG are emitted as reservoirs of biomass rot as water is moved during electricity generations (Harjanne & Korhonen, 2019). Climate change is also predicted to reduce the effect of hydropower by 6-10% (Trainer T. 2010), reducing its potential use in the future. Geothermal power is generated from the natural heat of the Earth (Demirtas, 2013). It has a large theoretical potential, however, away from volcanoes, it does nothing more than generate low level heating (Harjanne & Korhonen, 2019).

Green Technology	**Cost**	**Energy Generated**
Hydropower	50$/MWh	10 455 terawatt-hour
Solar	40 $/MW	1 793 terawatt-hour
Wind	41$/MW	3 540 terawatt-hour
Modern Biofuels	74$/MW	1 143 terawatt-hour
Coal	109$/MW	43 360 terawatt-hour
Petrol	0.011$ /MW	9.7 kWh/l.
Diesel	0.014$ /MW	10.7 kWh/l
Carbon Capture	360$/tC	-(250–300) kWh/tCO)

Table 1: Cost of Green technology

Wind and Solar Power present the issue of low energy density, requiring more materials and land to generate relatively minimal energy (Harjanne & Korhonen, 2019). Solar power, does have the potential to provide enough electricity for annual global use (Demirtas, 2013). The problem lies with the photovoltaics used to convert solar energy to electricity. Solar power is not the same as solar thermal power, which can only be used for low level heating. Photovoltaics only harness 30% of all possible solar energy(17. They also require tellurium and indium to build, both of which are rare, mined elements (Harjanne & Korhonen, 2019). Solar power will also weaken during winter, when energy requirements are at their highest (Trainer T. 2010). Transport and storage of Solar power also pose another issue (Trainer T. 2010). Wind turbines also require rare earth materials to build (Harjanne & Korhonen, 2019), however, they are still considered the most feasible energy alternative. Wind energy does not release any GHG emissions throughout the entire process and is currently receiving high amounts of monetary investments (Demirtas,

2013) due to it’s comparatively low costs and high electricity generation (Table 1). Wind farm require large amounts of land and not many places have strong enough winds to utlise turbines (Harjanne & Korhonen, 2019). The requirements of rare materials drive up the cost of renewable energies compared to coal, (Table 1), however long-term costs of renewables are lower than current fossil fuel prices (Trainer T. 2010).

Sustainable growth according to the United Nations is ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’ (Harjanne & Korhonen, 2019). It is clear than none of the abovementioned ‘Renewables’ are sustainable. Reducing GHG emissions requires technologies that are sustainable, not renewable. Policies that focus on renewables have already failed as Renewables are not the solution to reducing humanities greenhouse gas emissions. 14% of global energy production is generated from biomass, which is a renewable (Demirtas, 2013) . It has also largely been developed while ignoring sustainability (Solomon, 2010)

Biofuels

Biofuels are often seen as a solution to Greenhouse gas emissions, however research and development in the area has primarily ignored sustainability (Solomon, 2010). Biofuels are defined as any fuel derived from living matter, such as plants, primarily used in the transportation industry (Demirbas A. 2007). Many biofuel crops need to be grown on fertile land that is currently utilised in agriculture. The same crops are also used in animal feed (Demirbas A. 2007). The balance between food security and fuel competition has been one of the larger barriers to implementation (Solomon, 2010). Perennial, cellulose-based biofuels avoid this barrier as it can be grown in vast barren lands, where agriculture cannot occur (Hamelinck & Faaij, 2006). Biofuels such as bioethanol, biodiesel and biomethanol undergo series of chemical reactions that are energy-intense (Demirbas A. 2007). This raises the question on whether biofuels are a sustainable, cost efficient alternative to fossil fuels, as both criteria must be satisfied if biofuels are to be implemented into industries. Biofuels are primarily seen as an alternative to petroleum and diesel used in cars (Demirbas A. 2007). According to Table 1, Biofuels are more expensive and less efficient than modern day petrol and diesel, making them unlikely substitutes.

Transport represents 27% of Energy consumption (Hamelinck & Faaij, 2006) . Using biofuels can thus significantly reduce GHG emissions from fossil fuel-based energies. Problems arise however due to engine compatibilities with biofuels. Many engines in the 1800s were originally designed to run on ethanol based fuels instead of petroleum (Solomon, 2010). Current fossil fuels already utilize bioethanol additives, however ethanol can be corrosive to metals inside vehicle engines (Hamelinck & Faaij, 2006). Modern Hybrid cars can be run on advanced biofuels (Hamelinck & Faaij, 2006), instead of fossil fuels which will produce a carbon neutral transport solution. Biodiesels derived from vegetable oils can also easily substitute diesel (Demirbas A. 2007) in engines without any modification. Slightly modified engines and biofuels provide an eco-friendlier alternative to hydrogen-based or electric cars (Hamelinck & Faaij, 2006) , although if bioethanol is to be feasible, more efficient pre-treatment technology must be implemented to reduce costs and GHG emissions (Demirtas, 2013).

Biofuels are an excellent substitute for fossil fuels provided that they are environmentally safe, biophysically feasible and the socio-economic structure of society allow for it to be implemented (Solomon, 2010). Sugar beets, cornstarch and other potential biofuels require rich agriculture lands to cultivate, (Demirbas A. 2007) thus cellulose-based perennial biofuels are the only feasible alternative if global food security is to be maintained. Lignocellulose biofuels produce more fuel per hectare and require less growth before it can be harvested (Hamelinck & Faaij, 2006). This means the cost of lignocellulose biofuels is less than other traditional ones as less investment is needed. Small changes to car engines will allow them to run entirely on biofuels (Hamelinck & Faaij, 2006) if need be and most cars can run efficiently on a mix of biofuels and fossil fuels. According to (Trainer T. 2010), the amount of agricultural land required for biofuels to make a significant impact is 30-40% of all land, which is not feasible, even by optimistic standards. The alternative way to reduce Greenhouse gas emissions from biofuel production (biomass combustion) is to implements Carbon Capture and Storage technologies during the process (Haszeldine et al, 2018).

Carbon Capture

The Paris agreement requires several countries to have negative emission rates to reach the desired GHG levels in the atmosphere (Haszeldine et al, 2018). One such method to achieve that is to implement air capture technology. Carbon capture and storage is fundamental to policy (Pielke, 2009) if humanity is to stabilise GHG emissions below 4°C. Air capture focuses mainly on capturing CO_2 which means little to no research has been done on capturing Nitrous oxide even though it is 300 times as potent as CO_2 (BBC) since Methane emitted from manure and fertilizer have largely been captured and reused (Tausef S.M et al 2012)

Biogas digesters that are to used capture and reuse methane exemplify the features air capture technologies need to be successfully implemented into global economies. Biogas digesters are inexpensive to build and provide a return on costs by generating electricity while eliminating waste (Tausef S.M. et al 2012). The design of the digesters is also simple enough to allow farms (primary methane emitters) run by illiterate owners to successfully understand and use them. (Tausef S.M et al 2012)

There are several ways to capture carbon. Carbon sinks and photosynthesis are the natural way to do so, but they often release captured CO_2 back into the air after a short time period. Technological methods prove to have better long-term carbon storing capabilities. Carbon capture and storage (CCS) works by separating and purifying CO_2 once it has been captured, compressing it for transport to the storage area and then injecting the CO_2 into some geological reservoir (Haszeldine et al, 2018). This process is time consuming and costly(Table 1). Other methods include using lime and Sodium hydroxide and many other that have not yet been commercialized (Pielke, 2009). The technology to capture carbon is here, however many have not yet been commercialized and implemented due to monetary reasons.

The costs of carbon capture are much higher compared to capturing methane. It is also more complex and requires more thought, making carbon capture a more difficult to implement. The cost of air capture ranges from $100US- $500US to capture one ton of carbon currently, however it is projected that with aggressive mitigation action, stabilizing CO2 levels below 450ppm using Carbon capture will cost less than 1% of Global GDP in 2050 (Pielke, 2009). The long-term cost of carbon capture is cheap, however it is expensive in the short-term. Utilisation of carbon capture technology will drive up electricity costs for consumers by around

50% (Riemer P, 1996), inciting backlash from the public. Carbon capture also uses a lot of electricity to capture carbon, this further research is needed to make this technology carbon negative as currently it is carbon neutral (Table 1). This cost could be reduced with more research, (Riemer P, 1996) but policy failures such as Kyoto has failed to direct funding towards air capture, with the IPCC only mentioning it in passing.

Installing air capture plants is currently as controversial as installing nuclear or coal plants (Pielke, 2009), since they imply the continued increase in CO_2 emissions for the foreseeable future. The technology is costly and requires long-term investments, which often implies poorer developing countries will not be able to utilize them. This technology is mostly used in developed countries, however the lack of monetary incentives prevents this. Many carbon capture technologies are available to reduce GHG emissions, the same, however, cannot be said for nitrous oxide. Regardless of the feasibility of air capture, lack of focus, funding and incentive to implement it means it will not play a role in mitigating Greenhouse gas emission.

Conclusion

The role of green technology in climate change is complex. Policies are extremely dependent on technologies that are expensive, difficult to implement and inefficient. The recent Paris Agreement depends on CCS technology, which has been found to be economically and energetically expensive. The GHG emission associated with electricity usage will likely offset the positive effects of Carbon Capture. Funding for CCS research is minimal with more money spent on finding alternatives for fossil fuels thus, the technology is slow to develop and improve.

Renewable energies that are perceived as sustainable, green alternatives to coal-burning electricity stations are neither sustainable nor green. They are also inefficient and not economical to implement. Biofuels are face similar issues. Plant-based fuels are expensive due to production as well as implementation costs. This, coupled with the lack of available land makes biofuels an unviable alternative to fossil fuels.

Alternative, sustainable substitutes for coal, petrol and diesel do not exist. Technologies used to capture GHG are not sustainable nor carbon negative. Table 1 indicates that alternative technologies that could be used to replace current GHG emitting ones are inefficient and expensive. Research in sustainable green technologies is slow due to a lack of funding, resulting in slow and often complex implementation plans. Lack of funding and the 'unsustainable' path on which research has been led, indicate that current green technology is not the solution.

Green technology currently has no role in reducing greenhouse gas emissions. If technology is to assist humanity in GHG reduction, research must reflect sustainable development goals. Technologies must be developed with consumption, cost and feasibility in mind as many available technologies fail to meet the criteria for successfully implementation. This can only happen if the necessary funds are available to do so. The failure of Green technologies to reduce GHG emissions reflects the failures of policy, society and humanity in general to reduce emissions.

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