2nd International Conference on Negative CO_2 Emissions, May 12-15, 2020, Gothenburg, Sweden

Achieving Net Zero emissions: The oil and gas industry is a major component of the solution

Astley HASTINGS[1#]*, Pete SMITH[1],

[1] University of Aberdeen, 23 St, Machar Drive, Aberdeen, UK.

**Corresponding Author, Astley.hastings@abdn.ac.uk, [#]Presenting Author*

Abstract – The major challenge facing society in the 21st century is to improve the quality of life for all citizens in an egalitarian way, by providing sufficient food, shelter, energy and other resources for a healthy meaningful life, whilst at the same time decarbonizing anthropogenic activity to provide a safe global climate. This means limiting the temperature rise to below 2º C and to do this the world must achieve net zero greenhouse gas (GHG) emissions by 2050. Currently spreading wealth and health across the globe is dependent on growing the GDP of all countries. This is driven by the use of energy, which until recently has mostly derived from fossil fuel, though a number of countries have shown a decoupling of GDP growth and greenhouse gas emissions from the energy sector through rapid increases in low carbon energy generation. Nevertheless, as low carbon energy technologies are implemented over the coming decades, fossil fuels will continue to have a vital role in providing energy to drive the global economy. Considering the current level of energy consumption and projected implementation rates of low carbon energy production, a considerable quantity of fossil fuels will still be used, and to avoid emissions of GHG, carbon capture and storage (CCS) on an industrial scale will be required. In addition, the IPCC estimate that large scale GHG removal from the atmosphere is required to limit warming to below 2º C using technologies such as Bioenergy CCS, and direct carbon capture to achieve climate safety. In this paper we estimate the amount of carbon dioxide that will have to be captured and stored, the storage volume, technology and infrastructure required to achieve the energy consumption projections with net zero GHG emissions by 2050. We conclude that the oil and gas production industry alone has the geological and engineering expertise and global reach to find the geological storage structures and build the facilities, pipelines and wells required. Here we consider why and how oil and gas companies will need to morph into hydrocarbon production and carbon dioxide storage enterprises, decommission facilities only after CCS and thus be economically sustainable businesses in the long term, by diversifying in and developing this new industry.

1 Introduction to a net zero world

The United Nations Framework Convention on Climate Change (UNFCC) Paris meeting in 2015 resulted in the Paris Agreement where 195 signatory nations agreed to undertake ambitious efforts to combat climate change in order to limit global warming to below 2ºC with further ambitions to reduce this limit to 1.5ºC above pre industrial averages (UNFCC, 2016). As global temperature is proportional to atmospheric greenhouse gas (GHG) concentration (CO_2, CH_4, N_2O, fluorocarbons, etc.) and their half-life in the atmosphere varies from decades to centuries, the world has a limited GHG budget to emit into the atmosphere before the 2ºC limit is breached. The IPCC “Global Warming of 1.5 ºC” report indicated that cumulative net anthropogenic GHG emissions post industrialization should not exceed a ~3,000 billion tonnes CO_2 equivalent (GtCO_2 eq.) Carbon Budget (CB) to avoid breaching the 1.5 ºC warming threshold (IPCC 2018). In 2018 only ~1,000 GtCO_2 eq. emissions remained to reach the CB. As currently in 2019 annual anthropogenic GHG emissions are ~40 GtCO_2 eq. per year the world can only emit at that rate for a further 25 years before the CB is exhausted and emissions should be zero. However, in spite of global ambitions to the contrary, currently emissions are increasing each year making an overshoot on the CB likely.

It is impossible to achieve zero anthropogenic emissions as parts of food production, manufacturing and transport cannot be emissions free. However as the atmosphere can be treated as a reservoir of GHG, if these residual emissions can be balanced by GHG removal (GGR) then we can achieve net zero emissions (net zero). In addition in the medium term if net zero cannot be achieved by the end of the CB then further GHG can be removed from the atmosphere to reduce atmospheric GHG concentrations. The leading technologies for GGR are either land based through photosynthesis and storage of carbon in the soil and vegetation or through physical removal and storage in a geological repository. Although changing land management to store soil carbon and afforestation to store vegetation carbon is effective, it has a limited capacity due to land availability and also reaches saturation but it is reversible. This leaves direct air capture (DAC) through physical and chemical devices which are an immature technology and bioenergy carbon capture and storage (BECCS). BECCS is a combination of existing technologies and essentially captures carbon from the atmosphere by photosynthesis, burns the biomass for energy and captures the resulting CO_2. Both DAC and BECCS require CO_2 capture transport and storage in a geological repository (CCS). Decarbonisation of the use of fossil fuels, be they oil, gas or coal based, for electricity, heat, motive power, metal refining or cement production requires that for net zero the CO_2 emitted must be eliminated or captured and stored if their use is to be continued in a net zero economy.

2 The size of the opportunity for CCS

The IEA new policies scenario (IEA, 2018), which includes new measures and policies that promote energy efficiency and low carbon technologies (including a large growth in renewables and nuclear), projects that total global energy demand will grow by 21% between 2018 and 2040. This scenario includes not only current but future planned energy investment by global governments. In this scenario, coal demand is projected to rise from the current 6,000 Mtce to 6,350 Mtce by 2040, oil consumption is projected to increase from current levels by 14Mb/d to 104 Mb/d, gas consumption will rise by 50% to 5.4 Tcm (liquefied natural gas alone increases from 300bcm to 540bcm). The BP Energy Outlook 2019 makes similar forecasts (BP, 2019). Clearly the IPCC objective of reducing GHG emissions to zero is at odds with the current IEA and BP projections for fossil energy use, as by 2040 emissions should have reduced to zero, instead the IEA projects them to be 36.7 per year and BP between 18 and 45, unless all the projected CO2 emissions are geologically stored. These estimations of emissions only consider burning fossil fuel and do not include the emissions from metal refining, cement manufacture, agriculture and land use change. Clearly for both the energy consumption and the net zero objectives to be achieved by 2050, then at around 40 Gt CO2 per year needs to be captured and stored from annual fossil fuel use. In addition as current slowness to implement a reduction in emissions will result in significantly exceeding the CB, the excess CO2 in the atmosphere will need to be removed by DAC or BECCS technology and afforestation, in addition to the agriculture emissions that cannot be avoided. The IPCC estimates that the BECCS component will amount to ~10 Gt CO2 y-1 to reduce warming to 1.5 ºC. This means that the total CCS requirement is ~50 GT CO2 y-1.

There are 3 purely CCS assets operational globally of which Snøhvit in the Norwegian Sector of the N Sea is a typical example. It uses an amine separation system in an onshore LNG plant, a 153km pipeline to transport the CO2 offshore, a single horizontal well that injects around 0.7 Mt of CO2 a year into a saline aquifer, with a total capacity of 23Mt (Equinor, 2020). To achieve net zero with current projections of fossil fuel use and emissions would require the operation of 71,000 facilities globally similar to Snøhvit, indicating a huge market for CCS wells and facilities, construction and operation.

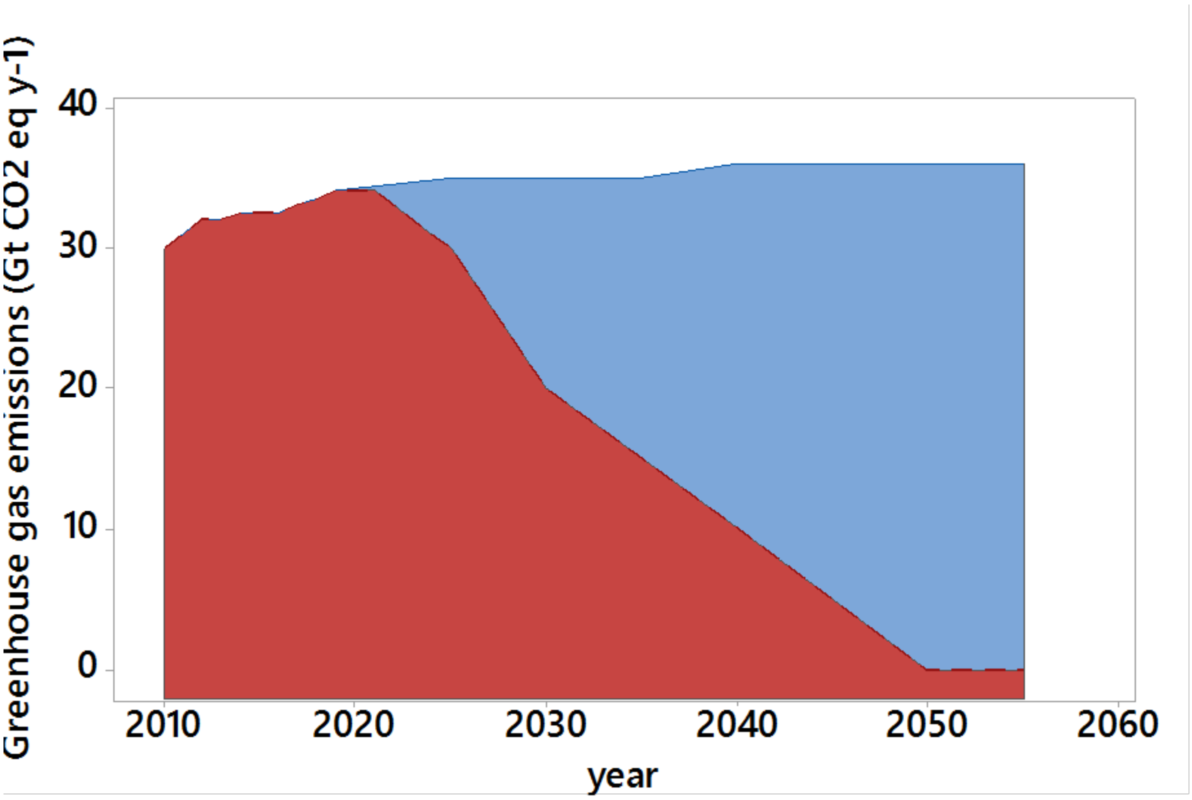

Figure 1: This is a graph of projected emissions to 2055 using IEA new policies scenario. The area under the red curve is the IPCC projected net annual emissions pathway (RCP 2.6) to keep global warming below ~2 ºC, reaching net zero by 2050. The area in blue is the difference between the projected emissions from the IEA for current stated policies and the desired net zero pathway. This is the potential CCS requirement.

3 The market for CCS

CCS OPEX and CAPEX include many of the components pertaining to E&P activity. Well-site and offshore oil and gas processing is replaced by injection compressors, injector well completion tends to be simpler than producing wells, the metallurgy of the infrastructure is required to be CO2 corrosion resistant, and there would have to be some monitoring for posterity of the safety of the storage facilities/reservoir, which is somewhat similar to the needs of nuclear waste disposal sites. The cost metric would be storage cost in $ t CO2-1. The total cost of CCS would be the gas separation cost at the point of emissions plus the transportation and storage cost plus a mark-up for profit. Cost will be sensitive to distance between capture plant and geological storage and the depth of the geological formation. The section of the transport pipeline system on land will be more costly per km due to the complex planning systems.

The UK government's study estimated electricity costs (2016) per MWh for new generating capacity commissioned in 2025 would be: First of a Kind (FOAK) combined cycle gas turbine generation with CCS (CCGT-CCS) - $143 MWh-1, reducing to $108 for an N'th of a Kind (NOAK). This is competitive with the current strike price of new nuclear ($124MWh-1 for Hinkley Point) and offshore wind (which ranges from $75 to $232.5 MWh-1). Currently, a UK coal fired power station emits between 750-900kg CO2 MWh-1. This makes the cost of transporting and storing CO2 around $79.5 t-1 CO2. The CCGT emits about half the CO2 per kWh and hence the cost is ~40 t-1 CO2. In comparison, BP estimated that for the In Salah CCS land site, the separation, transportation and storage cost was $10 t-1 CO2, however the ongoing monitoring costs were not included. The US DOE (2015) estimates a FOAK cost of adding CCS to a super critical thermal power unit to be $124-133 MWh-1 and an NOAK for $108 MWh-1. This gives a cost of avoided CO2 of $74-83 t-1 CO2 for FOAK and $55 for a NOAK. They further gave estimates of the cost of avoided CO2 for other industries for different counties depending on the access to geological storage. For countries with access to storage, like the USA, this cost per tonne of CO2 avoided emission is: Iron and Steel – $77, Cement - $124, fertiliser – $26 and biomass to ethanol - $22.

Most of these costs for avoided emissions are less than are less than $80 per tonne of CO2, with cement being the most expensive. This is equivalent to the current carbon tax paid in the Norwegian Sector of the N sea, which includes the ETS. These carbon values have been used in Integrated Assessment Models (IAM's) to evaluate the Socio Economic Pathways (SSP's) to achieve Representative atmospheric GHG Concentration pathways (RCP) to limit global temperature rise to 2ºC (RCP2.6) and 1.5ºC RCP(1.8). All the models show that large quantities of CCS are required to reduce ongoing emissions and both afforestation and BECCS are required to remove 10GT of CO2 y-1 to achieve net zero by 2050. This highlights the urgent need to start the CCS industry, and get on top of the technology, in order to ramp up to the scale required by 2050. At $80 t-1 means that in 2050 the new CCS industry will have a turnover of 4 trillion dollars.

4 Public Perception and cost to society

Currently public perception of climate change is that “something needs to done” and the high media profile of a Swedish teenager Greta Thunberg and the galvanism of organizations like Extinction Rebellion and Greenpeace have created a sense of urgency about “doing something”. However the world economic system is wedded to continuous growth which is driven by consumers wanting more experiences and more stuff cheaper. The concept of polluter pays is lost in the fear of having to actually change consumption habits or having higher prices for energy use. In addition, the millennium goals aim for an equitable standard of living for all humans and human nature interprets this as levelling up. Politicians are wary of changing policies about houses, energy use and transportation that curtail growth for fear of reducing disposable income and not being re-elected. As a result it is easy for NGO’s and political parties to blame large corporations who produce the energy, materials, manufactured product and food and demand they decarbonize so people can continue with their consumerism. This leads to the demonization or the fossil fuel industry, which is provides the energy for the economy to run, when in fact the oil and gas industry holds all the skills, expertise, capital and assets that have the ability to decarbonize fossil fuel use. If “Big Bad Oil” steps up to the plate to kick start the CCS industry it will transform its image into the “Saviour of the Climate” and avoid having its shares divested by well-meaning organizations.

5 The petroleum industry transition to net zero

A report by SNC-Lavalin’s Atkins Business called Engineering Net Zero (2020) quantified the challenge of moving to net zero whilst maintaining economic and social progress in the next 30 years. It identified that to decarbonizing building heating and transport of all kinds would require a massive investment on both electricity and hydrogen (H2) production. Renewable electricity form tidal, wind and solar would increase but as it is intermittent it require dispatchable power source such as CCGT –CCS which can be quickly switched on, with Nuclear providing a base load and black start capability. H2 would be used for decarbonizing transport using fuel cell technology for HGV’s, busses, trains and possibly aircraft that cannot be easily electrified. H2 will also be required for industrial process and building heat using the has grid. H2 can be made though electrolysis of excess renewable electricity but the majority will be made by reforming methane and using CCS.

From this it can be seen that most end used for fossil fuels will require CCS so if Companies that produce the oil, gas and even coal also store the resulting carbon from their use they will become carbon neutral companies. An alternative for this is a viable carbon trading system that ensures net zero to the atmosphere. All the skills and technology for well drilling and engineering, reservoir management, structure pipelines and processing currently resides in the oil and gas industry so this transition could be seamless.

6 Implications for decommissioning

Currently oil and gas facilities and reservoirs are being decommissioned without regard for the carbon cost of doing so, both in terms of the potential re-use of the assets and actual deconstruction costs. In addition wells are being plugged and abandoned with the well sealing system being designed for the current status, reservoir fluids in place and the reservoir pressure, which is usually depleted. No regard is made of the potential re-use of the structures and reservoirs for CO_2 storage, which will usually mean re-pressuring the reservoir to its initial pre-production pressure. If the well plugging does not consider potential de-pressurizing then that reservoir will not be able to be used for CCS. The structure will have the weakness of the abandoned wells which will be very difficult to re-mediate after the wellhead is cut below the mudline. Due to the large future requirement for CCS all well abandonments should be designed with this in mind.

7 Conclusions

It is clear that CCS is technically feasible and that in order to achieve both net zero and the requirements for more energy production, this industry must be up and running at a large scale by 2050. Already electricity generation using CCGT-CCS is estimated to be of comparable cost to nuclear and renewables so its use will not adversely impact millennium goals. Only the Petroleum Industry has the skills to start up and maintain this huge CCS industry. If it grasps this opportunity its image will be transformed from climate pariah to global saviour.

8 Acknowledgements

This work was supported by UK NERC: ADVENT (NE/1806209), ADVANCES, FAB-GGR (NE/P019951/1) and UBERC Phase 4 project funding.

9 References

[1] UNFCC. 2016. Paris Agreement. United Nations Treaty Collection.
[2] IPCC. 2018. Global Warning of 1.5º. IPCC Reports. https://www.ipcc.ch/sr15/.
[3] IEA (International Energy Agency) World Energy Outlook 2018. http://www.worldenergyoutlook.org. (Accessed 8th Jan 2020).
[4] Equinor: Our CCS Projects https://www.equinor.com/en/what-we-do/new-energy-solutions.html (Accessed 8th Jan 2020).
[5] HM Department for Business Energy and Industrial strategy – Electricity Generating Prices Nov 2016. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/566567/BEIS_Electricity_Generation_Cost_Report.pdf (Accessed 16th Jan 2020).

[6] L. Irlam. 2017, Storage costs of carbon capture and storage: 2017 update. Global CCS Institute, http://hub.globalccsinstitute.com/sites/default/files/publications/201688/global-ccs-cost-updatev4.pdf (Accessed 13-jan-2020).

[7] UK Government BEIS, Contracts for Difference Second round allocation results. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/643560/CFD_allocation_round_2_outcome_FINA (Accessed 16 Jan 2020).

[8] US DOE (Department of Energy). 2015. http://energy.gov/fe/articles/does-carbon-utilization-and-storage-atlas-estimates-least-2400. (Accessed 3st January 2020).

[9] Atkins. 2020. Engineering Net Zero. SNC-Lavalin. http://explore.atkinsglobal.com/engineeringnetzero/ (Accessed 3st January 2020).