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Carbon Capture and Storage: The perspective of oil and gas producing countries

1. Introduction

Carbon capture and storage (CCS) involves the trapping of man-made CO2 underground in order to avoid its release into the atmosphere. Because of the scale with which it could be applied, CCS is identified as a critical technology to reduce CO2 emission to achieve global climate goals. The Intergovernmental Panel on Climate Change (IPCC, 2018)[1] shows that most of the 1.5ºC pathways assume significant CCS. The latest Joint G20 Energy-Climate Ministerial Communiqué acknowledges the important role of carbon capture, use and storage (CCUS) stating that given 'fossil fuels still play a significant role in the energy mix, we (G20) recognize the need for investment and financing for advanced and clean technologies, including CCUS/Carbon Recycling' urging 'all members to formulate such long-term strategies that set out pathways consistent to achieve balance between anthropogenic emissions by sources and removal by sinks'.[2] Also, in a recent paper, we argued that CCS could play a central role in oil and gas exporters' low-emissions development strategies.[3] The deployment of CCS could provide them with an opportunity to continue to monetise their reserves while meeting climate goals and retain the competitiveness of their oil and gas sectors and energy intensive industries in a net-zero emissions world. CCS is climate mitigation action which caters to the assets (in terms of geological storage capacities and existing infrastructure) and the technical skills (i.e., expertise in subsurface technology) of oil and gas producers.

While investing in CCS reduces margins and increases the complexity of the current business strategies of oil and gas exporters, it also increases the resilience and competitiveness of a strategic sector at times when the world is transitioning to net-zero emissions.[4] Since the benefit of reduced emission accrues to all the stakeholders along the oil and gas supply chain, it is reasonable that the cost for large-scale CCS deployment should be shared. The common global goal of avoiding the dangerous

[1] IPCC. (2018). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, & T. Waterfield, Eds.). Cambridge University Press.
[2] See 'Energy Transition and Climate Sustainability Working Groups', Joint G20 Energy-Climate Ministerial Communiqué July, 23 2021.
[3] See Fattouh, B., W. Heidug and P. Zakkour. 2021. 'Transitioning to Net-Zero: CCUS and the Role of Oil and Gas Producing Countries', OIES Energy Insight 90, June. Oxford: Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/06/Insight-90-Transitioning-to-Net-Zero-CCUS-and-the-Role-of-Oil-and-Gas-Producing-Countries-.pdf
[4] See Poudineh, R., and B. Fattouh. 2020. 'Diversification Strategy Under Deep Uncertainty for MENA Oil Exporting Countries'. OIES Energy Insight 69, May. Oxford: Oxford Institute for Energy Studies.

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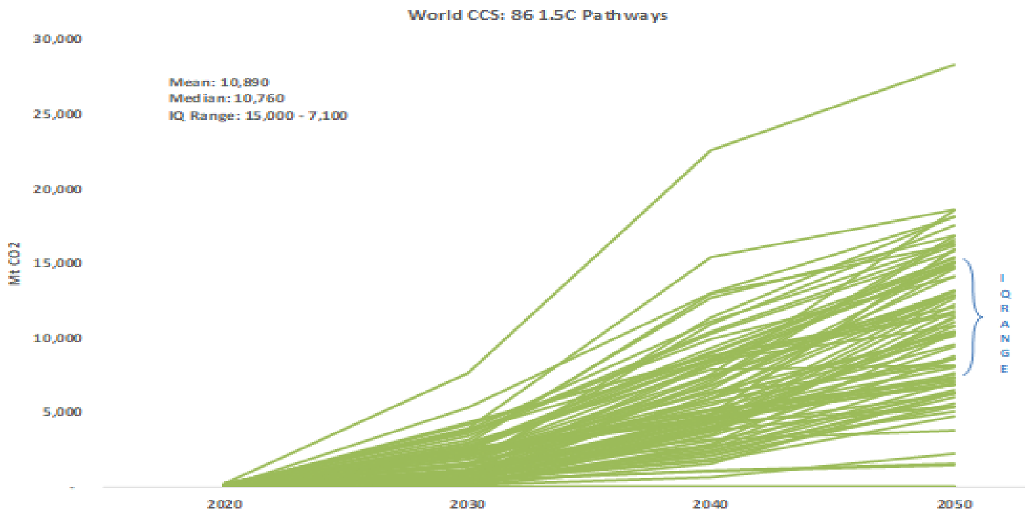
impacts of climate change means that the cost of CCS should be shared between producers and end users, rather than be focused on one or the other resulting in, probably, sub-optimal deployment of the technology. Given the international dimension of the oil and gas business, it is therefore imperative that policies and mechanisms are put in place to generate revenue for CCS deployment that would offset part of the associated costs.[5] A key role here falls to the Paris Agreement which offers many opportunities for collaboration either through bilateral or multilateral initiatives including the creation of clubs with common interests. The challenge is to create effective incentive schemes to turn these opportunities into actions.[6]

Figure 1: 1.5°C Pathways with CCS



Source: OIES based on IPCC (2018)

This paper is divided into Six sections. Section 2 discusses briefly the main challenges associated with financing CCS. Section 3 examines the limitations involved with existing carbon pricing mechanisms while Section 4 explores innovations that oil and gas exporters could pursue to enable large scale deployment of CCS. Section 5 argues that a key limitation of existing carbon pricing policies is their tendency to focus on reducing emissions on the consumers' end without putting in place effective supply side strategies that could enable oil and gas producers to contribute to addressing the climate change challenge. This limits the ability to utilise the subsurface competencies, skills, and assets required for CCS and which lie in the hands of oil and gas producers. In Section 6, we focus on mechanisms that could allow the cost of CCS to be shared by importers/users. Such cost sharing mechanisms could globally optimise deployment of CCS especially at times when the trading systems are being transformed in response to carbon pricing initiatives driven by the Paris Agreement.

2. Financing CCS

Several characteristics make financing CCS projects challenging for governments and the private sector alike:

- Deployment of CCS is exclusively driven by climate change mitigation goals. There are no revenues associated with CCS (as is the case for renewable electricity generation) that can

[5] See Fattouh, B., W. Heidug and P. Zakkour. 2021. 'Transitioning to Net-Zero: CCUS and the Role of Oil and Gas Producing Countries', OIES Energy Insight 90, June. Oxford: Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/06/Insight-90-Transitioning-to-Net-Zero-CCUS-and-the-Role-of-Oil-and-Gas-Producing-Countries-.pdf

[6] Peszko et al, 2020. Diversification and Cooperation in a Decarbonizing World, World Bank Publications, The World Bank, number 34011.

compensate for the high upfront and operation costs.[7] Given the squeeze on governments' budgets in most oil and gas exporting countries, especially as they look to diversify their economies into new non-energy sectors, diverting public funding towards large scale CCS projects could have a high opportunity cost. Some revenue streams for captured CO2 could be generated through its use in enhanced oil recovery (EOR) or in some industrial applications. But these opportunities remain very limited in scope, and the vast proportion of the captured CO2 will have no intrinsic economic value.

- There is currently no business model available that could secure large-scale financing of CCS by the private sector. Without governments putting in place a supportive regulatory framework and incentives, the private sector will find it difficult to justify large-scale investment in CCS given the cost and risks of the technology. A commercial arrangement could be built by disaggregating the capture, transport and storage components of the CCS technology chain, allowing different market actors with different strength and risk appetites to collaborate on CCS. In this arrangement it will be necessary to manage the interdependency risk, and governments will need to accept the long-term liability for CO2 retention in the subsurface although the probability of leakage of CO2 from well selected and managed storage is very low.[8]

Given the dominance of national oil companies (NOCs) in oil and gas exporting countries and the vertically integrated structure of the energy industry in many of these countries, private sector involvement in CCS projects, at least at the early stages of deployment, is likely to be limited. The source of the emissions, the transportation/pipeline network, and the storage facilities are likely to fall within the government ownership structure.

If investment in such projects is key for the competitiveness of the strategic oil and gas sector in a net-zero emissions world, the real challenge for oil and gas exporting countries becomes how to incentivise deployment of CCS while limiting the adverse fiscal implications of CCS support schemes[9] on their economies. This is especially important at times when some regions and countries are considering the use of trade tools to capture an increasing portion of oil and gas rents in order to stimulate more active climate policy in oil and gas exporting countries.

From the perspective of a corporation, three categories are generally used to classify emissions associated with their activities:

- Scope 1 emissions: direct emissions from operations that are under the control of the organisation.
- Scope 2 emissions: indirect emissions from purchased energy consumed by the organisation.
- Scope 3 emissions: indirect emissions that occur outside the control of the supplying organisation (e.g. emissions by consumers of its product, such as oil and gas).

Applying the same classification to oil and gas exporting countries, some can be considered to be in a relatively good position to reduce their scope 1 and scope 2 emissions. For instance, Saudi Arabia has invested heavily in reducing methane emissions and reducing gas flaring through the establishment of

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[7] See for instance, Element Energy & Vivid Economics. 2018. CCS market mechanisms: Policy mechanisms to support the large-scale deployment of Carbon Capture and Storage (CCS). Krahé, M., W. Heidug, J. Ward, and R. Smale. 2013. 'From demonstration to deployment: An economic analysis of support policies for carbon capture and storage', Energy Policy 60: 753-763.

[8] The *IPPC Special Report on Carbon Dioxide Capture and Storage* published in 2005 states in section 5.7.3.5: For large scale operational CO2 storage projects, assuming that the sites are well-selected, designed, operated and appropriately monitored, the balance of available evidence suggests the following: 1. It is very likely that the fraction of stored CO2 retained is more than 99% over the first 100 years. 2. It is likely that the fraction of CO2 retained is more than 99% over the first 1000 years. See: https://www.ipcc.ch/report/carbon-dioxide-capture-and-storage. The financial implication of future leakage is difficult to predict and private operators would want to shift the long-term liability risk to the government before committing to a project.

[9] See Fattouh, B., W. Heidug and P. Zakkour. 2021. 'Transitioning to Net-Zero: CCUS and the Role of Oil and Gas Producing Countries', OIES Energy Insight 90, June. Oxford: Oxford Institute for Energy Studies.

the Master Gas System (MGS).[10] Also, many oil and gas exporting countries could benefit from low-cost renewable energy such as solar and wind, which could be integrated into their hydrocarbon infrastructure.[11] For instance, platform electrification using renewables could significantly reduce the scope 2 emissions of oil and gas production operations. The real challenge for oil and gas operators lies with reducing scope 3 emissions associated with the final consumption of their products. This challenge is different for different oil and gas producers and varies with the carbon intensity of their products.

3. Limitations to Existing Carbon Pricing Schemes

Carbon pricing, i.e. putting a price on the CO2 emitted into the atmosphere, is the main market-based instrument in the policy toolbox to reduce CO2 emissions. It is an effective instrument, in the sense that it induces emission reduction at lowest macroeconomic cost while also raising revenues to support fiscal reform and climate reduction goals. Carbon pricing could be implemented either through a tax on carbon emissions or via an emission trading scheme (ETS), and both options are presently in use. Because of their attractive features, price-based policy instruments have played a key role in international climate treaties.

The Kyoto Protocol, which has now expired, introduced three market-based mechanisms. First, it introduced emission trading between Annex I Parties, i.e. countries that made quantitative commitments (listed in Annex B of the Kyoto Protocol). Countries that have emissions below their targets and so have emission allowances to spare could sell their excess capacity to countries that overshoot their target, thereby reducing overall compliance costs. Second, they could use project-based mechanisms such as Joint Implementation (JI; to claim credits for an emission reduction project in another Annex 1 country) or the Clean Development Mechanism (CDM) which allowed Annex 1 countries to offset their own emissions through investment in projects in developing countries that faced no emission caps under the Kyoto Protocol.

The Paris Agreement, through Article 6.2, allows for direct bilateral and multilateral arrangement and enables the use of 'internationally transferred mitigation outcomes' (ITMOs) to achieve emission reduction targets. Its Article 6.4 establishes a new market mechanism under UN auspices (sometimes referred to as the Sustainable Development Mechanism (SDM)) which is expected to replace the CDM.

While carbon pricing schemes can be effective and efficient in correcting the negative externality related to free atmospheric CO2 emission, the economic signal they provide is not sufficient to incentivise the type of large-scale investment needed for deploying CCS at scale. A point in case is that the European ETS has so far not been able to offer a sufficiently stable incentive to deliver any CCS project, even though CCS was introduced into the system around 2010. Zakkour and Heidug[12] argue that policies that offer incentives both for emitters and storers could prove to be more effective in commercializing CCS projects. Since CCS is a pre-commercial technology, private investors will find it hard to accept the financial and technical risks associated with investment in these types of technology without a sustained and stable flow of revenues. Public policies that aim at de-risking investment are required to promote the adoption and deployment of CCS at scale. These policies need to provide *technology-specific* support and not rely on technology-neutral carbon pricing to trigger investment in CCS. As far as policy design is concerned the situation is rather similar to that faced by low-carbon electricity generation. Feed-in tariffs and renewable portfolio standards have been among the instruments policy makers instituted to specifically increase the share of renewable energy in electricity markets even in

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[10] See Fattouh, B. 2021. 'Saudi Oil Policy: Continuity and Change in the Era of the Energy Transition', OIES Paper WPM 81, Oxford: Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/01/Saudi-Oil-Policy-Continuity-and-Change-in-the-Era-of-theEnergy-Transtion-WPM-81.pdf

[11] See Fattouh B., and A. Sen. 2021. 'Economic Diversification in Arab Oil-Exporting Countries in the Context of Peak Oil and the Energy Transition'. In When Can Oil Economies Be Deemed Sustainable? The Political Economy of the Middle East, edited by G. Luciani and T. Moerenhout. Singapore: Palgrave Macmillan. https://doi.org/10.1007/978-981-15-5728-6_5. 29

[12] Zakkour, P., and W. Heidug. 2019. 'A Mechanism for CCUS in the Post-Paris Era: Piloting Results-Based Finance and Supply Side Policy Under Article 6, KAPSARC Discussion Paper, April.

countries (e.g., Germany, UK) with operational emissions trading systems covering electricity generation.

4. Innovative Mechanisms

Many countries are aspiring to achieve carbon neutral economies over the coming decades and this provides an additional policy perspective for CCS. Carbon neutrality means that positive emissions in some sectors of the economy are offset by CO2 removals and the storage of CO2 in sinks. Terrestrial sinks (involving afforestation and reforestation) and geological sinks could provide capacity for this. The enhancement of carbon sinks therefore needs to be an important objective of policies driving the net-zero transition, which in turn requires effective incentives for the permanent geological storage of carbon complementing policies that are used for enhancing terrestrial sinks.

There have been some proposals to enhance this objective. For instance, the Low Carbon Technology Partnerships initiative (LCTPi) proposes the creation of a Zero Emission Credit (ZEC) awarded for each tonne of CO2 stored in the geosphere by a storage operator.[13] ZECs would be purchased by a Zero Emission Credit Development Fund (ZDF) formed by like-minded investors to drive early demand and to ensure that price signals are generated in the early stages of the mechanism. In the long term, as the market matures, ZECs would transition to an emitter obligation scheme, that is ZECs could be traded or surrendered against governments' obligations or commitments to reduce emissions.[14]

An alternative proposal which only at first glance looks similar to the ZEC approach has been put forward by Zakkour and Heidug.[15] There the policy focus is on the storer of CO2 and not the emitter as is the case for the ZEC scheme. For each tonne of CO2 that is submitted to permanent storage the storer is awarded a Carbon Storage Unit (CSU). A CSU provides a monitored, verified, transferable record of the addition of a tonne CO2 to a carbon sink.[16] Zakkour and Heidug[17] propose the creation of a CCS club of countries with interest in CCS to pool resources to establish a fund for purchasing CSUs. This is similar to the role of the ZDF for ZECs. It is important that CSUs only quantify the amount of CO2 stored and not an emission reduction, and hence cannot be counted towards emission reduction targets. Thus, CSUs could provide an additional layer of financing for CCS but would not undermine the environmental integrity of emission reduction based policies by double-counting.[18] The authors recognise that in existing multilateral framework carbon pricing policies that involve trading emission allowances (such as in the EU-ETS) or certified emission reductions (as in the CDM) are well established and thus integrating CSUs into existing frameworks will not be straightforward. However, Article 6 of the Paris Agreement provides flexibility and its decentralised approach offers the possibility of establishing a dedicated international funding instrument for CCS that is based on the CSU approach. In the parlance of the Paris Agreement, CSUs could be generated as part of a country's 'Nationally Determined Contribution' (NDC) and they could be traded as ITMOs.

5. Supply Side Policies Open Avenues for Producers

Another major limitation of existing carbon pricing policies is their tendency to focus on the emissions at the consumers end without giving a role to oil and gas producers to address the climate change challenge. This is sub-optimal since the subsurface competencies, skills, and assets required to enable CCS are all in the hands of oil and gas producers and could be used effectively for climate action. To

[13] World Business Council for Sustainable Development 2015. 'Innovative Solution to Accelerate CCS', November.
[14] World Business Council for Sustainable Development 2015. 'Innovative Solution to Accelerate CCS', November.
[15] Zakkour, P., and W. Heidug. 2019. 'A Mechanism for CCUS in the Post-Paris Era: Piloting Results-Based Finance and Supply Side Policy Under Article 6, KAPSARC Discussion Paper, April.
[16] An internationally agreed minimum standard for this is set out in vol. 2, ch. 5 of the *2006 IPCC guidelines for national greenhouse gas inventories*. Prepared by the National Greenhouse Gas Inventories Programme [Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds).] Published: IGES, Japan. https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html
[17] Zakkour, P., and W. Heidug. 2019. 'A Mechanism for CCUS in the Post-Paris Era: Piloting Results-Based Finance and Supply Side Policy Under Article 6, KAPSARC Discussion Paper, April.
[18] As noted by Zakkour and Heidug, 'the absence of an explicit emissions reduction value in a CSU means that the unit generated has relevance to supply sides policies pertaining to the management and accounting of carbon stocks'.

constructively engage oil and gas producers on CCS requires innovative supply side policies complementing the present focus of climate policy on the demand side.

Unfortunately, current supply-side policy is not yet able to fulfil this purpose. The toolbox of supply-side instruments is so far rather limited, and some instruments do not recognise the political economy realities.[19] Advocates of some supply side approaches remain dismissive of CCS. This toolbox includes instruments like leaving fossil fuel in the ground, and various forms of carbon storage obligations. Such supply side policy instruments have been under-researched so far with proposals tending to focus on the environmental effectiveness of an instrument but disregarding the important issues of economic efficiency and economic cost as well as a just and inclusive energy transition.[20] Recent work by Peszko et al.[21] which uses macroeconomic simulations explores some mutually beneficial policy options for cooperation between oil and gas exporters and importers on climate issues. This is achieved through a variety of scenarios that are couched in terms of supply and demand carbon tax and trade policies. While the scenarios do not explicitly consider CCS, they provide a perspective for international cooperation that is relevant for CCS deployment.

Based on the scenarios analysed, Peszko et al. argue for the establishment of a carbon wellhead tax agreement whereby oil that is taxed on its carbon content in an oil exporting country is exempt from CO2 taxation in the importing countries. Details of the sharing of tax revenue would need to negotiated bilateral or internationally. This arrangement allows exporters to retain a share of the tax revenue that otherwise would be collected by the importer (discussed in further detail below).

A similar logic reciprocity could be applied to cooperation on CCS between exporters and importers so that in exchange for decarbonising oil ‘upstream’ through CCS, the ‘decarbonised’ oil would be exempt from climate regulations in oil-consuming countries. The arrangement could be implemented by allowing CSUs generated by the oil exporter to qualify as offsets under local policies (e.g. low-carbon fuel standards) applied in several oil importing countries. Other arrangements are also possible. Article 6 of the Paris Agreement provides an opportunity to design the modalities supporting this type of cooperation that could produce win-win situations for oil exporters and importers.

Burden Sharing and Trade Policies

Such schemes, while essential to improving the resilience of the oil and gas sector, don’t necessarily address the burden sharing problem. Shifting the burden to producers alone will disincentivise them from pursuing large scale CCS projects. Therefore, it is important to focus on mechanisms that allow these costs to be shared with importers/users. For instance, part of the CSUs generated could be sold to end consumers/importers using these fuels. This could be done through bilateral agreements or clubs. For instance, country A exporting a certain volume of oil and gas to country B can generate enough CSUs to cover the volumes exported and sell all or part of these CSUs alongside the physical cargoes of oil and gas. This allows the cost to be shared between the two parties. Alternatively, a group of countries could agree to establish a fund to bid for CSUs which could be used to offset emissions associated with their fossil fuel imports. This could be implemented under the umbrella of the type of novel cooperative mechanisms envisaged by the Paris Agreement.

In a world where some countries/regions are considering applying carbon border adjustment measures (CBAM), supply side policies will increasingly become more important. So far, no CBAM policy has been implemented, but the European Union (EU) is gradually introducing CBAM from 2023 as ‘a climate measure that should prevent the risk of carbon leakage and support the EU's increased ambition on

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[19] See for instance, Lazarus, M., and H.van Asselt. 2018. ‘Fossil fuel supply and climate policy: exploring the road less taken’ *Climatic Change* 150: 1-13.

[20] Allen, MR., DJ. Frame, and CF. Mason. 2009. ‘The case for mandatory sequestration?’ Nature Geoscience 2: 813-814. Kuijper, M. (2019). Carbon take back obligation. Presentation to CCUS developments in the North Sea region workshop, 26 June 2019, CO_2 Capture Transport and Storage in The Netherlands (CATO).

[21] Peszko, Grzegorz; van der Mensbrugghe, Dominique; Golub, Alexander. 2020. Diversification and Cooperation Strategies in a Decarbonizing World. Policy Research Working Paper; No. 9315. World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/34056

climate mitigation, while ensuring World Trade Organization (WTO) compatibility'[22]. The CBAM has the effect of equalising the price of carbon between domestic products and imports. The CBAM will initially apply to imports of cement, iron and steel aluminium, fertilisers and electricity, key sectors which oil and gas exporting countries are diversifying into and in which they have established competitive advantage. While oil, oil products and gas imports have been excluded for now, the EU's direction of travel is clear, and it is seemingly a matter of time before these sectors are included under CBAM.

Applying carbon taxes to imports from oil and gas exporting countries has the effect of extracting part of the rents from these countries that could be used to diversify their economies and/or be invested in technologies that reduce CO2 emissions. Franks, Edenhofer, and Lessmann show that since the ownership of fossil fuel resources gives rise to scarcity rents, from an importing country perspective, a carbon tax is more advantageous than a capital tax since it allows importing governments to capture part of that rent.[23] The authors recognise that this could cause resistance from the resource owners and incentivize them to accelerate the extraction of resources with adverse environmental impacts (known as the green paradox, a term coined by Sinn[24]). However, in contrast to Sinn, Franks, Edenhofer, and Lessmann find that under a realistic set of assumptions, the carbon tax will not give rise to a green paradox and instead the resource owners will react by reducing the rate of extraction and therefore carbon taxes have beneficial environmental implications. Some of these revenues could be channelled back to exporting countries to incentivise them to cooperate, adapt their economies, and invest in emissions reduction technologies. Presently there is no such commitment from importers applying the carbon tax.[25]

Applying such taxes is nothing new as importing countries, especially in Europe, and Japan, have always taxed fossil fuels heavily. Although this was not motivated necessarily by environmental but by budgetary reasons, the underlying motivation makes no difference in terms of importing countries capturing part of the rent.

An extreme variant of CBAM is the application of what is referred to as Nordhaus[26] taxes where countries apply carbon taxes on imports from non-cooperative countries on climate change action irrespective of the carbon content of their exports. This gives importing countries some leverage and could be used to induce a change in behaviour in countries not cooperating on climate change action[27]. However, such a tax will be highly discriminatory especially given that it is applied to exporting countries irrespective of their level of development and thus will be resisted and could be subject to legal challenges under the WTO. It also undermines key principles such as just and inclusive transition, the common but differentiated responsibility, and the current multilateral framework based on cooperation.

Recognising these challenges, Parry, Black and Roaf[28] from the International Monetary Fund (IMF) have proposed the implementation of an international carbon price floor which will have three main components. First, mechanisms could be negotiated within a smaller number of countries (for instance a group of large emitters) which makes it easier to reach agreements. Second, countries would commit

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[22] See European Commission, Cross Border Adjustment Mechanism: Questions and Answers. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661

[23] Franks, M. and O. Edenhofer, and K. Lessmann, 2015. 'Why Finance Ministers Favor Carbon Taxes, Even If They Do Not Take Climate Change into Account'. Available at SSRN: https://ssrn.com/abstract=2599482 or http://dx.doi.org/10.2139/ssrn.2599482

[24] Sinn, H. 2015. 'The Green Paradox: A Supply-Side View of the Climate Problem'. CESifo Working Paper Series No. 5385, Available at SSRN: https://ssrn.com/abstract=2621998

[25] Peszko, van der Mensbrugghe, and Golub (2020) find that cooperation by fossil fuel developing countries could reduce by $5.5 trillion the losses experienced by other high-income countries and only one-eighth of these savings could be used to provide the necessary incentives for the most vulnerable FFDCs to participate.

[26] Nordhaus, William. 2015. 'Climate Clubs: Overcoming Free-Riding in International Climate Policy.' *American Economic Review* 105 (4): 1339–70.

[27] Peszko, van der Mensbrugghe, and Golub (2020) find that cooperation by fossil fuel developing countries could reduce by $5.5 trillion the losses experienced by other high-income countries and only one-eighth of these savings could be used to provide the necessary incentives for the most vulnerable FFDCs to participate.

[28] Parry, I. S. Black, and J. Roaf, 2021. 'Proposal for an International Carbon Price Floor Among Large Emitters', IMF Staff Climate Notes.

to imposing a minimum carbon price floor. Third, different countries/regions could impose different price floors to help address equity issues.[29]

Indeed, under the different variants of CBAM, oil and gas producers may have the incentive themselves to introduce carbon pricing to counteract the carbon tax.[30] Under certain conditions, such a tax enables producers to reduce the revenues leaking to importing countries imposing a carbon tax and thus retain part of the revenues. For instance, an oil and gas exporter can introduce carbon taxes or new regulations that require a certain fraction of embodied carbon/CO2 to be captured and stored in carbon sinks. This would result in the creation of CSUs that could be surrendered against oil and gas countries' exports to importing countries or sold to countries introducing CBAM. As discussed above, Pezko et al (2021) recommend the use of wellhead taxes which allow the creation of mechanisms to share the carbon tax revenues between exporters and importers and which can be combined with existing carbon pricing mechanisms and bilateral or multilateral initiatives aimed at helping producers in their adaptation process.

Cooperative schemes based on revenue sharing require the harmonization of regulations and taxes and reaching agreements to address the distribution issue. They also require putting in place a robust system of measurement, reporting and verification. The Paris Agreement offers a flexible framework for such agreements. Strand (2021)[31] shows that without a tax rebatement under CBAM, exporters of energy intensive products don't achieve any direct benefit from a carbon tax and thus will not impose any such tax. Instead, if rebating is allowed, exporting countries may have the incentive to impose their own carbon tax. Importers imposing CBAM could go one step further and return all tax revenues raised to incentivize higher carbon tax regimes in exporting countries.

Another advantage of introducing carbon taxes or carbon pricing under CBAM is that it allows oil and gas exporting countries to identify the most cost-efficient way to capture and store CO2 and focus on the low-hanging sources of CO2 emissions first, minimising the revenue leakage to importers. It can also allow some time to leverage the high degree of integration in their energy sector. For instance, emissions from energy intensive industries such as steel and aluminium could be captured and stored and/or used in EOR, in the process, generating CSUs which could be offset against the exports of steel and aluminium products. Given that the CBAM will not be applied equally across all products and may be applied in stages according to the export product (for instance, products such as aluminium and steel could be subject to CBAM earlier than exports of crude oil and natural gas), this gives oil and gas exporters more flexibility.

Conclusions

CCS has mostly been approached from a project developer's perspective (such as an international oil or gas company's perspective) and putting in place frameworks that spread risks and costs and enable the deployment of CCS in specific geographical contexts. For oil and gas producers, the perspective is much wider and technology-based energy modelling has only limited relevance for the deployment of CCS in fossil-dependent economies. In oil and gas exporting countries, CCS relates to the future of oil

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[30] An alternative is for producers to increase the price of the fossil fuel through some form of collusion to counteract the tax. For instance, Dullieux, Ragot, and Schubert (2011) argue that in response to a carbon tax, OPEC can increase the oil price and capture the rent. However, oil consuming countries can behave as a coalition and coordinate their policies and implement a high carbon tax pushing OPEC to lower price to limit the decrease in oil demand. See, Dullieux, Rémy, Lionel Ragot, and Katheline Schubert. 2011. "Carbon Tax and OPEC's Rents under a Ceiling Constraint." *Scandinavian Journal of Economics* 113 (4): 798–824. Böhringer, Rosendahl and Schneider (2018) also find that OPEC has the incentive to increase the price in response to climate policy to retain the resource rents. The authors examine the implications of OPEC's strategic responses under various dimensions including the size of the climate coalition and the size of the oil cartel and subsidies for oil consumption within OPEC. See, Böhringer, C., K. E. Rosendahl, and J. Schneider. 2018. "Unilateral Emission Pricing and OPEC's Behaviour." *Strategic Behavior and the Environment* 7 (3–4): 225–80.

[31] Strand, J. (2021) 'Incentivizing Carbon Taxation in Low-Income Countries: Tax Rebating versus Carbon Crediting', World Bank, Policy Research Working Paper 9698.

and gas and the key role these sectors play in their economies and welfare and shaping their political economies. It relates to maintaining and establishing key sources of competitive advantage. Rather than just compete on low cost alone, oil and gas exporters could also compete on emissions reductions. CCS could play a key role in such a strategy. This requires that oil and gas exporters take a leading role in scaling up CCS and geological storage and developing successful regulatory and business models. Such a strategy could result in lower returns when compared to the current one of exporting unabated oil and gas given the costs associated with CCS, but it may prove essential to maintain the competitiveness of the oil and gas sector in a world transitioning to net-zero.

However, a low-emissions strategy centred around CCS accompanied by changes in the trade system associated with carbon pricing could have macroeconomic consequences beyond project economics. While CCS is a technology that oil and gas exporters could develop, the cost of adjustment could be too high, which could undermine their economic stability. To enable investments in CCS and minimise the adverse impact on their economies and public finances, oil and gas exporters should also take a leading role in developing burden sharing mechanisms that generate new sources of revenues for CCS projects and/or allow for the costs to be shared both across the supply chain and between fossil fuel exporters and importers. These could be developed within existing frameworks such as the Paris Agreement. This is especially true in times when some of the current proposals such as keeping reserves underground or restricting investment in the oil and gas sector and/or trade policies such as CBAM (or extreme versions of CBAM) are being considered. These policies will reduce the income of oil and gas producing countries, placing pressure on funds available for economic diversification aligned with a just energy transition.

Herein lies the importance of developing frameworks and mechanisms that give value to permanently storing CO2 away from the atmosphere in enhanced sinks and integrate these into the Paris Agreement. This requires harmonization of policies and strong cooperation either through multilateral or bilateral agreements or clubs of like-minded countries. Such cooperative frameworks are key to deploying large scale CCS and to enabling oil and gas exporters on their path towards low emissions strategies to ensure an inclusive and just transition.