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King Abdullah Petroleum Studies and Research Center

Supply-Side Climate Policy for Crude Oil Producers:

Exploring Policy Pathways for Decarbonizing Fossil Fuels

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Key Points

This paper provides an overview of supply-side climate policies, considers options for fossil fuel producers to establish proactive and progressive approaches toward climate mitigation, and assesses factors and challenges that could influence their success. The following elements are considered in these regards:

Supply-side measures are the 'road less taken' by climate policymakers worldwide. Historically, climate policies have focused on demand-side measures that target fossil fuels users and the greenhouse gases they emit.

Efforts to mobilize supply-side policies have so far tended to focus on measures to curtail fossil fuel development and investment, with only limited attempts to engage fossil fuel suppliers in action to address the greenhouse gas emissions arising from the use of their products.

In light of the risks posed to the resource endowments of fossil fuel producers by comprehensive and sustained climate action, this paper explores potential new ways to incentivize fossil fuel suppliers to decarbonize their products, and thereby sustain the continued use of an essential portion of fossil fuels.

The measures reviewed herein center on establishing a value for sequestering carbon in geological reservoirs. Balancing the rates of carbon deposition and carbon extraction to and from the geosphere can achieve the net-zero carbon dioxide (CO_2) emissions goal of the Paris Agreement in the same way as cutting emissions. It can also complement efforts to curb emissions through carbon pricing.

Employing a wide range of policy tools — covering both supply- and demand-side measures — can mobilize the technical and financial resources of fossil fuel producers in taking meaningful action, thereby scaling up and enhancing climate ambition.

Executive Summary

This paper considers the potential for supply-side climate policy to increase climate action, with a focus on crude oil producers and exporting countries. To date, supply-side policies have not been widely used in efforts to tackle climate change, and the emerging dialogue on the topic tends to focus solely on measures that can curtail and ultimately end fossil fuel production. These strategies, in combination with comprehensive and sustained demand-side climate policy actions, pose a threat to the value of fossil fuel resource endowments held by countries and companies alike.

This paper takes an alternative look at the topic. We frame supply-side climate policies as an opportunity to establish pathways for decarbonizing fossil fuels, based on producers sequestering carbon at rates increasingly aligned to those at which they extract it from the geosphere. We refer to these as progressive and proactive supply-side policies, since they seek to transcend the traditional, polarized and binary, supply-side narrative where fossil fuels must either be phased out or runaway climate change will occur. In our view, targeted supply-side climate policy can instead allow for the continued use of an essential portion of decarbonized fossil fuels, help fossil fuel producers maintain the value of their natural resource endowments, catalyze the deployment of near-market, climate-critical technologies such as carbon capture and storage (CCS), and ultimately enhance climate action aligned with the net-zero emissions goal of the Paris Agreement.

The paper provides a rapid overview of supply-side policies, design features for progressive supply-side policies, and the opportunities and challenges involved in proceeding with their development. The focus is on possibilities for proactive and ambitious action by crude oil resources holders, primarily the countries of the Gulf region.

1 Introduction

Demand-side climate policies, such as carbon taxes, emissions taxes and emissions trading schemes, are the mainstream choice of policymakers worldwide in attempting to control atmospheric greenhouse gas (GHG) accumulations. Measures such as the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, and underlying national and regional policy actions such as the European Union's (EU's) emissions trading scheme, all focus on pricing GHG emissions arising from the consumption of fossil fuel (i.e., scope 1 emissions from fossil fuel users; Box 1). As a policy approach, it draws on the principle of polluter or emitter pays, and thus targets organizations and consumers that use fossil fuels.[1]

Supply-side climate policies, on the other hand, target actions on the production and supply of fossil fuels. Such measures can complement demand-side climate policies, and therefore increase efficiency and decrease the cost of climate regulation (Fæhn 2017). To date, supply-side climate policies have been 'the road less taken' by climate policymakers (Lazarus and van Asselt 2018), but interest in the potential of measures to curtail and end fossil fuel production and use is increasing. Only limited attention has been afforded to policies that seek to engage supply-side actors in proactive efforts to address the climate impacts of the fossil fuels they produce (i.e., an extended producer responsibility approach to address scope 3 emissions; Box 1). In our view, this misses an important and substantial opportunity to mobilize fossil fuel resource holders in contributing to ambitious climate action.

Box 1. Glossary of emissions terms

Various terms are applied to the GHG emissions associated with fossil fuel extraction, supply, transformation and use. These include:

Scope 1 emissions: direct emissions associated with supplying a given product or service to a consumer that are under the control of the supplying organization (e.g., emissions from fuels combusted by the organisation).

Scope 2 emissions: indirect emissions associated with supplying a given product or service to a consumer that are under the control of the supplying organization (e.g., emissions from bought-in heat or power used by the organisation).

Scope 3 emissions: indirect emissions associated with the use of a product by a consumer that occur outside the control of the supplying organization.

Embodied carbon: the carbon content embodied within a product. It can include only scope 1 and 2 emissions, scope 1, 2 and 3 emissions, or only scope 3 emissions.

Well-to-tank: emissions associated with the extraction, supply and transformation of crude oil up to the point of use (scope 1 and 2 emissions).

Well-to-wheel: emissions associated with the extraction, supply, transformation and use of crude oil products (scope 1, 2 and 3 emissions).

Tank-to-wheel: emissions associated with the use of crude oil derived products (scope 3 emissions).

1 Introduction

There are good reasons for the historical focus on demand-side policies: adopting a polluter pays principle is regarded as more equitable since it focuses on the widespread use of fossil fuels, rather than the small number of countries that extract and export more carbon than they emit to the atmosphere. On the other hand, supply-side policies have the potential to reduce the complexity of international climate action because they involve fewer actors. They can also offer a pathway to enhance climate ambition by complementing and supplementing demand-side measures.

The advent and widespread deployment of carbon dioxide (CO_2) capture and geological storage (CCS) technologies open up possibilities for changing the supply-side climate policy narrative. These technologies can put carbon back into the geosphere alongside technologies that take it out. Achieving equilibrium between rates of carbon extraction and carbon sequestration in the geosphere can deliver a net-zero emissions outcome, aligned with the Paris Agreement,[2] in the same way as focusing solely on curbing emission flows. Indeed, absent a comprehensive worldwide ban on the production and use of fossil fuels, storing carbon in non-atmospheric pools is a prerequisite for achieving net-zero emissions.

Framing the climate mitigation challenge in these terms could help move the supply-side climate policy dialogue away from a focus solely on ending fossil fuel production toward a more progressive approach focused on balancing carbon extraction and carbon sequestration. Moreover, mobilizing oil and gas producers to decarbonize oil (Box 2) also incentivizes firms with the financial resources, technical capabilities and know-how to establish geological carbon stores.

As such, progressive, proactive, supply-side policies can play a role in supporting ambitious climate action.

Box 2. Defining decarbonized fuels

A ‘decarbonized’ fossil fuel may be established either physically or virtually.

The fossil hydrocarbon fuel can be physically decarbonized though chemical engineering techniques (e.g., reforming) to separate the hydrogen and carbon fractions. The resulting hydrogen is used as a replacement for conventional fossil fuel energy carriers, and the carbon fraction may be geologically sequestered to avoid being emitted to the atmosphere. The resulting hydrogen produces no emissions upon combustion. The hydrogen can only be called a truly decarbonized fossil fuel if the carbon produced during reforming is geologically sequestered by the producer. The development of the approach is dependent on the widespread uptake of hydrogen (or ammonia) as a substitute for conventional fossil fuels.

Alternatively, fossil fuels may be virtually decarbonized if the producer offsets, through the use of carbon sequestration, either all the life cycle GHG emissions associated with the fuel (well-to-wheel, or scope 1, 2 and 3 emissions), or just the carbon embodied in the fuel that is emitted upon its use (tank-to-wheel, or scope 3 emissions). A ‘low carbon’ fossil fuel may also be produced where at least a portion of the carbon embodied in the supplied fuel is offset. Similarly, a net-negative fuel could also conceivably be supplied where the amount of carbon sequestered exceeds the embodied carbon.

1.1 The opportunity of supply-side climate policy for fossil fuel exporters

For crude oil exporting regions, the incentive for action is particularly acute because of the strong linkage between exports and national economies. Actions taken by crude oil exporters to reduce or eliminate the climate-related impacts of the products they sell (e.g., through decarbonizing oil) can help maintain market access and preserve the value of their natural resource endowments. Furthermore, such measures can potentially help to retain a portion of resource rents that are currently collected by importers through demand-side climate policies. This income could be channeled into low-carbon technology endeavors that support economic diversification away from fossil fuel export dependence. They can also be more effective in tackling global CO_2 emissions.

Conversely, adopting local demand-side policies focused on reducing the national GHG emissions (scope 1 emissions) of crude oil exporters offers far fewer possibilities to control global CO_2 emissions, and provides less insulation against the risk of stranding natural resource assets. Rather, they may only offer value if there are significant structural changes to crude oil exporting economies that reduce their reliance on oil exports and increase domestic value added (i.e., using fossil fuels to manufacture export goods such as petrochemicals, metals, cement, among others). National economic strategies, such as Saudi Vision 2030, envisage economic developments of this type occurring over the coming years. However, in the near- to mid-term, oil exporting countries will most likely continue to rely on crude oil exports as a key source of national earnings.

In reflecting on opportunities for possible progressive supply-side policies, this paper reviews some options for establishing new types of policies that support enhanced climate action by producers and exporters of crude oil.

2 Supply-Side Climate Policy

2.1 Typology

Lazarus and van Asselt (2018), drawing upon a classification scheme set out in the Intergovernmental Panel on Climate Change's (IPCC's) Fifth Assessment Report (AR5; Somanathan et al. 2014), identify several variants of supply-side climate policies. These broadly mirror policies and measures applicable to demand-side climate action, including:

- Priced-based economic instruments that increase the relative costs of fossil fuel production or supply with an assumed demand-side response that lowers emissions.
- Quantity-based economic instruments that aim to incentivize or mandate the supply of alternative, low carbon and/or non-fossil fuels.
- Regulatory and voluntary approaches that seek to curtail and ultimately eliminate fossil fuel development, production, supply and/or investment, to compensate for forgone revenues associated with restricting fossil fuel development or production (Box 3), or to promote the decarbonization of fossil fuels (Box 2).
- Government-led programs that drive markets for low carbon goods and services.

A summary of the various supply- and demand-side climate policy approaches is set out below, according to the typology described (Table 1).

In many cases the divisions presented in Table 1 are somewhat arbitrary, and some types of instruments could be considered as either regulatory approaches or quantity-based instruments, depending on how

Table 1. Overview of supply- and demand-side climate policy approaches.

	Supply-side climate policies	Demand-side climate policies
Price-based instrument	• Carbon production (wellhead) tax • Carbon export tax • Producer taxes • Removal of fossil subsidies	• Carbon tax (embodied carbon in fuel) • Emissions tax • Carbon price border adjustments • Subsidies for low-carbon technologies
Quantity-based instrument	• Quotas for fossil fuel production rights (with trading) • Low-carbon portfolio standards (fuels)	• Emissions trading • Mandatory emissions offsetting • Low-carbon portfolio standards (electricity, products)
Regulatory/voluntary approaches	• Restricting fossil fuel development • Restricting fossil fuel exports (quotas) • Fossil fuel divestment • Mandatory/voluntary offsetting • Compensation for leaving assets in the ground	• Emissions performance standards • Low-carbon technology mandates • Building codes
Government-led programs	• Restricting the development of fossil fuel reserves on state-owned lands • Restricting government finance for fossil fuel projects	• Capital incentives • Public procurement • Low-carbon infrastructure expansion • Public finance (loans, grants, etc.)

Source: Adapted from Lazarus and van Asselt (2018).

they are implemented. For example, mandatory offsetting or sequestration could in practice also be established through a quantity-based tradable asset system, or compensation for leaving fuels in the ground could be financed by the generation of sellable offset credits under a market-based mechanism.

Furthermore, many of the measures described are similar for both demand- and supply-side approaches, with the differentiating factor being the placement of the obligation in respect to either the fossil fuel supplier or user. While these overlaps suggest that either demand- or supply-side policies can result in similar outcomes, modifying the placement of regulations can drive significant behavioral changes from different actors involved in the fossil fuel supply chain. Such a shift in emphasis could be used to create new ways of looking at the problem and new business models for delivering meaningful and ambitious climate action.

2.2 Current usage

Historically, the use of supply-side climate policies as set out above (Table 1) has been limited, although it has seen increased activity over the past few years.

Many jurisdictions around the world have introduced upstream carbon taxes on fossil fuels (e.g., in Europe, various states of the United States [U.S.], in Canadian provinces, and in Chile and Mexico. among others), while some are exploring the option (e.g., India, the Philippines). However, these taxes are applied at the point of supply or use of fossil fuels (including imports), rather than directly on producers. Therefore, they act as a demand-side rather than a supply-side measure. Few, if any, countries currently apply carbon taxes to fossil fuel production or exports. Europe, the U.S. and Canada have also implemented portfolio standards for fuel suppliers, with the objective of lowering the full chain (well-to-wheel) carbon intensity of liquid fuels supplied and used in the region, primarily by promoting biofuels (as discussed further below).

Measures focused on curtailing fossil fuel development and investment, mainly centering on coal, have also increased over recent years. Planned coal projects have been subject to grassroots activist efforts to prevent them from going ahead[3] and judicial rulings to stop their development on the grounds of climate change impacts.[4] Shareholder activism to withdraw funding from fossil fuel investments, such as 'fossil fuel divestment,' 'unburnable carbon' and 'keep it in the ground' campaigns, have also become increasingly mainstream over the past few years.

Greater financial disclosure of climate change impacts of investment activities — guided by initiatives such as the Bank of England's Task-Force on Climate-related Financial Disclosure (TCFD) and the mandatory reporting of climate investment exposure in France — also pose issues for underwriting and financing fossil fuel developments. This, in turn, is driving investor concerns about the risk of stranded assets in the fossil fuel sector. Most multilateral development banks, in particular the World Bank Group and its affiliates, have pledged to end funding for all forms of fossil fuel activity, except in exceptional circumstances. Many private banks have also made similar pledges, although the implementation has been quite patchy (e.g., see Bank Track).

Shareholder activists are also pushing for the oil and gas industry to take greater responsibility for the emissions arising from the use of its products. In an open letter to the Financial Times in May 2018, sixty of the world's largest institutional investors called on the sector to be “more transparent and take responsibility for all of its emissions” (Mooney et al. 2018). Activist groups such as the Climate Action 100+ group[5] (CA100+) and Follow This have been successful in forcing enhanced corporate pledges on climate action by several publicly listed oil and gas companies, including Shell, BP and Equinor. Many groups call for the oil and gas industry to take greater responsibility for scope 3 emissions and to align their business goals with those of the Paris Agreement (see, for example, Follow This [2019]). Recent moves by some firms, such as BP and Total, suggest that changes are afoot in the sector at the time of writing (BP 2020; Table 2).

Response measures, financial support for economic diversification, compensation for forgone revenues and ‘just transition’ are high on the agenda of fossil fuel producing and exporting countries within the UNFCCC process. All of these activities aim to soften the potential economic and social impacts of a low-carbon transition for those countries, regions and sectors highly dependent on fossil fuel production. The Paris Agreement states that mitigation co-benefits resulting from Parties’ adaptation actions and/or economic diversification plans can contribute to mitigation outcomes. A supply-side policy response can be a pledge to transition away from economic dependence on fossil fuel extraction in return for compensation for the potential economic and social impacts. Sentiments such as these have been pledged in a number of countries’ nationally determined contributions (NDCs) under the Paris Agreement, including Algeria, Bahrain, Iran, Qatar, Saudi Arabia, South Africa and the United Arab Emirates. However, to date, only one (unsuccessful) attempt has been made to implement the compensation concept in practice (Box 3).

Box 3. Compensation for ‘leaving it in the ground’

In 2007, Ecuador attempted to implement a policy based on receiving compensation for leaving fossil fuels in the ground. Ecuador’s Yasuní National Park is underlain by approximately 920 million barrels of crude oil in the Ishpingo-Tiputini-Tambococha (ITT) reserves. The Yasuní ITT Initiative was launched by the government in 2007 to prevent the development of the ITT — and thus avoid the production of 410 million tonnes of embodied CO_2 — in return for US$ 3.6 billion compensation from international donors (about half of the forgone expected revenues).

The initiative received some high-level backing, and several governments made pledges, including Germany, Italy, Spain and Chile. However, a lead proponent — Germany — withdrew its support in 2010, citing concerns about whether it would be setting a precedent for other governments and noting a preference to pursue active policies for active countries, rather than paying them to do nothing. By mid-2013 only around US$300 million had been pledged by various donors.

Following a review by President Raphael Correa, the initiative was abandoned in August 2013. Exploratory drilling began in the ITT fields in 2016.

Much of the scholarly literature on supply-side climate policy tends to offer only blunt options to drive a rapid retreat from fossil fuels. Piggot et al. (2018), for example, in reviewing options for UNFCCC Parties to address supply-side climate policies under the Paris Agreement, were dismissive of the potential of CCS and instead summarized the following options.

"Nations could embed supply-side strategies in their NDCs [nationally determined contributions] in various ways. Alongside their emissions reduction targets, countries could include targets for a fossil fuel production phase-down (e.g., production reduction targets). In addition, they could include commitments to constrain investment in fossil fuel supply, such as by pledging to remove subsidies to fossil fuel producers (van Asselt and Kulovesi, 2017). Alongside existing descriptions of mitigation activities, Parties could include measures such as moratoria on new fossil fuel infrastructure or taxes on fossil fuel exports. Countries could also discuss policy measures to ensure a just transition for extractive-industry workers, such as job-retraining programmes." (Rosemberg 2017, 1991)

A consequence of this singular focus is that choices and outcomes are framed in binary terms: either fossil fuels will be phased out, or runaway climate change will occur because fossil fuel suppliers will be driven away from mainstream climate action. Such binary terms ignore the potentially large opportunity to put the technical and financial resources of fossil fuel producers to work in finding new ways of delivering ambitious and meaningful climate action. Presently these actors are widely viewed as 'part of the problem' and are mainly forced to react to emerging demand-side climate policies rather than being proactively engaged in finding solutions.

Measures that seek to promote the supply of decarbonized fossil fuels seem to warrant a place within the supply-side policy debate. Such measures could be highly effective in supporting both the temperature limitation goals and longer-term net-zero emissions objective of the Paris Agreement. Achieving net-zero emissions will require recalcitrant emissions sources with limited non-fossil alternatives, such as load-following electricity, heavy goods transportation and aviation (Davis et al. 2018) to be offset by sequestration activities in order to maintain the net-zero balance. This indicates a need in all cases for the advent and widespread deployment of carbon sequestration technologies, including commercially viable, low-cost, CCS, direct air capture (DAC), CO_2 utilization and nature-based solutions. It also suggests a need for new methods by which to create value for depositing carbon into planetary carbon stocks other than the atmosphere, to complement measures that price CO_2 emissions.

Based on this backdrop, the following sections consider options for 'smarter' supply-side policies and measures that could promote fossil fuel producing companies and countries to decarbonize their fossil fuels and drive enhanced investments into sequestration technologies.

2.3 Policies That Support Decarbonized Fuels

2.3.1 Production (wellhead) or export-based carbon taxes

Taxes on fossil fuel production (e.g., wellhead or mine-mouth taxes) or exports based on carbon content are price-based economic instruments that can raise the price of fossil fuels and, therefore, elicit a demand response with resultant emission reductions.

Presently no fossil fuel production anywhere in the world is subject to taxes or royalties tied to the fuel's carbon content.

Many importers, on the other hand, impose taxes on fossil fuel supply at the point of sale, as outlined previously. This suggests that there is scope for producers to recover at least part of that rent and use it locally to support low-carbon technology deployment and economic diversification goals (Peszko, van der Mensbrugghe and Golub 2020). For example, revenues could be cycled directly into CCS schemes to decarbonize fossil fuel supply.

2.3.2 Low-carbon portfolio (fuel) standards

Low-carbon portfolio standards are quantity-based economic instruments that set target emission rates for the well-to-wheel GHG emissions of a portfolio of fuels. These fuels are supplied by organizations into a specific market, and the portfolio standards cover domestic and imported alternative fuels, crude oil and refined products.

The policy approach can be used to reduce emissions and promote low carbon technology deployment across the liquid fuel supply chain in ways that transcend national borders. Several fossil fuel producing and importing countries and regions around the world employ these types of policy instruments, usually referred to as 'renewable' or 'low-carbon' fuel standards (LCFS). They include:

- The U.S. (at a federal level under the Renewable Fuel Standard);
- The EU (formerly under the Renewable Energy Directive I and the Fuel Quality Directive, and now transitioning into the Renewable Energy Directive II);
- The U.S. states of California, Oregon and Washington (e.g., the California Low Carbon Fuel Standard; the Oregon Clean Fuel Standard); and,
- The Canadian Province of British Columbia (the BC Renewable and Low Carbon Fuel Requirement).

In practice, these policies usually involve setting a standard for either an increasing portion of 'renewable' fuels or a decreasing average GHG or carbon intensity of fuels in the supply portfolio. The first type of policy mechanism uses a percentage supply target for a list of approved fuel pathways; the second uses a 'lifecycle' or well-to-wheel GHG emissions intensity target for all fuels supplied, measured in kilograms of CO_2 equivalent ($kgCO_2e$) per megajoule (MJ) of fuel supplied. In either system, the target portfolio rate is usually associated with achieving an implicit or explicit GHG reduction against a fossil fuel comparator baseline or benchmark.

Implementation involves assigning a credit or tag to approved renewable/low carbon fuels per unit supplied, for example, a renewable identification number (RIN) per MJ or volume of approved fuel. Obligated entities (suppliers) must surrender these credits or tags to the regulator in proportion to their emissions intensity target to demonstrate compliance. Entities with surpluses and deficits can trade credits — either with or without the associated physical fuel product — to help meet their obligations.

Schemes vary in the way targets are established and must be met, which affects scheme designs and their implementation. Consequently, there are subtle differences in the way fossil fuels are considered within each scheme; in particular, the way the benchmark intensity of the fossil fuel comparator is incorporated. This affects the schemes' potential to promote low-carbon or decarbonized fossil fuels.

Portfolio standards that set a target only for increasing the volume of biofuels in the transport fuel portfolio do not provide a basis upon which to promote decarbonized fossil fuels (e.g., the U.S. Federal Renewable Fuel Standard). This is because they focus solely on increasing the share of biofuels in the transport sector energy mix.

On the other hand, schemes using a GHG or carbon intensity target potentially offer greater latitude because the approach is, in theory, technology-neutral rather than specific in defining eligible fuel types (e.g., the California Low-Carbon Fuel Standard and the EU Fuel Quality Directive). However, this is not how they are being implemented in practice. Presently all schemes focus only on promoting the use of biofuels, electricity, hydrogen and other gaseous and waste-derived fuels (including CO_2) as substitutes for petroleum-based products (Box 4). The one exception is the treatment of DAC under the California Low Carbon Fuel Standard, which does offer a pathway to directly using geological sequestration as an offset against a fuel's entire well-to-wheel emissions (Box 4).

Box 4. Treatment of fossil fuels and CCS in low-carbon fuel standards

Both the California low-carbon fuel standard (C-LCFS) and the EU's Fuel Quality Directive (FQD) apply a GHG or carbon intensity standard as the metric for setting targets for fuel supply portfolios.

The C-LCFS aims to reduce the carbon intensity (CI) of fuels supplied to the California transport sector by at least 10% from 2007 to 2020. Suppliers must calculate the CI of all fuels supplied and compare their results against annual CI benchmarks. Exceeding the CI benchmark creates deficits, which must be offset through the purchase of credits from suppliers falling below the CI benchmark. Crude oils from all sources are given an average CI for upstream emissions (scope 1 emissions from extraction), which is then added to the refining and end-use emissions to arrive at the life cycle (well-to-wheel) emissions. Because the CI is calculated on an average crude oil, differential upstream GHG performance for different crude oils is not counted within the scheme.

The introduction of a CCS module under the C-LCFS in 2018 now means that emission reductions achieved through CCS at fuel extraction sites and at refineries can be awarded 'credits' under the C-LCFS (respectively, under the Innovative Crude and Refinery Investment Credit provisions). The C-LCFS covers only scope 1 emissions in the production and refining of the fuel products used in California. Since these emission sources are insufficient to offset the entire well-to-wheel emissions of the fuel product (i.e., including scope 3 emissions), the scheme cannot presently incorporate a virtual low-carbon or decarbonized fossil fuel as defined herein (Box 2). Hydrogen with CCS can be counted.

Notably, DAC projects capturing and geologically storing more than 100,000 tonnes of CO_2 (tCO_2) per year, located anywhere in the world, are able to generate credits under the scheme. DAC projects can thus count such activities as direct offsets against a fuel suppliers' well-to-wheel portfolio emissions.

The EU's FQD adopts a similar system to that of the C-LCFS, where upstream emission reductions, including from CCS, may be incorporated into the fossil fuel comparator benchmark. As it is currently set out, the FQD allows the emission reductions arising from the use of CCS within the crude oil production system to be deducted and counted toward the fuel supplier's portfolio GHG-intensity target . However, similar to the C-LCFS, this cannot currently extend into offsetting scope 3 emissions and promoting virtual decarbonized fuels, as described in Box 2. Moreover, the FQD will end in 2020 and will be replaced by the EU's revised RED II Directive. Under RED II, the fossil fuel comparator benchmark is fixed at 94 $kgCO_2e/MJ$, meaning that innovations in fossil fuel supply will no longer be counted in the scheme. This therefore prevents the introduction of a virtual low-carbon or decarbonized fossil fuel within the system, as currently set out in EU law.

2.3.3 Voluntary offsetting

Companies and countries involved in fossil fuel production may consider the introduction of a voluntary pledge to increase the supply of decarbonized or low-carbon fuels as a way to promote enhanced GHG-removal activities, including nature-based solutions and geosequestration.

Presently, most oil and gas companies — and the alliance of companies under the Oil and Gas Climate Initiative (OGCI) — have formulated pledges to reduce their methane emissions and other internal operational emissions (i.e., scope 1 emissions). Pledges to address their scope 3 emissions have been more variable, and many companies are seemingly still considering their accountability in these respects.

In light of increasing pressure from shareholders, as outlined in section 2, there is an emerging movement toward more progressive positions and the adoption of targets for, and investments in, offsetting that are more closely aligned to emissions from product end use (covering well-to-wheel and/or tank-to-wheel emissions). The current positions of several major oil and gas companies are summarized below (Table 2).

Nearly all of the oil and gas industry's corporate offsetting actions to date are mainly linked to the use of nature-based carbon sinks (Table 2). So far, actions on geosequestration have been largely restricted to joint demonstration projects with government or enhanced oil recovery (EOR). For example, Shell's Quest project was undertaken in conjunction with financial support from the Canadian Federal Government and the Government of Alberta. Both the Clean Gas Project and the Northern Lights project are, to an extent, contingent on governmental support from the United Kingdom and Norway, respectively. There is a likelihood that as supply-side climate action pressure grows, there will be an increasing need to move toward more direct linkages between CCS and the offsetting of fossil carbon emissions, particularly scope 3 emissions.

No fossil fuel producing or exporting country has yet proposed a voluntary pledge to offset emissions from its produced volumes in its NDC under the Paris Agreement.

Table 2. Examples of corporate positions on emissions and offsetting.

Company	Corporate position	Offsetting activities
Shell	• Reduce the 'net carbon footprint' (NCF) of the energy products it sells by 65% in 2050, based on the full lifecycle (well-to-wheel) emissions • Interim NCF target of around 30% by 2035 • Set specific NCF targets each year on a rolling basis for shorter-term periods (three or five years), covering the period 2020 to 2050 • Establish, by 2020, a link between energy transition goals and long-term staff remuneration	• US$300 million into natural ecosystems between 2019-2022 to address CO_2 emissions from customers using its products • 'Shell Go+' and 'Carbon Neutral' V-Power petrol and diesel products in the UK and Netherlands (customers automatically contribute to an offset for the fuel's well-to-wheel emissions via nature-based investments) • Roll out the scheme to other countries
Equinor	• Reduce the net carbon intensity, from initial production to final consumption, of energy produced by at least 50% by 2050 • Address own emissions through the emitter pays principle	• Invest in forest protection to meet offsetting pledge
BP	• Net-zero emissions by 2050 or sooner for all operations, and a 50% reduction in intensity in traded products	• Net-zero strategy and near-term plans to be unveiled in September 2020 • Target Neutral program for BP customers • Various forestry investments under Target Neutral
Occidental	• 'Carbon Neutral Aspiration' to reduce and offset total carbon impact, including products (scopes 1-3) • No specific timeframe as yet	• CCUS core part of carbon-neutral pledge • Oxy Low Carbon Ventures LLC focused on CCS for enhanced oil recovery (EOR) use. Investing in CCS/DAC tech
Repsol	• Aims to achieve net-zero emissions by 2050	• If necessary, offset emissions through reforestation and other natural climate sinks to achieve zero net emissions
ENI	• Obtain by 2050 an 80% reduction in net scope 1, 2 and 3 emissions, with reference to the entire lifecycle of the energy products sold and a 55% reduction in emission intensity compared with 2018 • Net-zero carbon footprint by 2030 for scope 1 and 2 emissions from upstream activities • Net-zero carbon footprint for scope 1 and 2 emissions from the Eni group by 2040	• Purchase offsets from forestry, capturing more than 20 $MtCO_2e$ to achieve 'net-zero.' Projects in the DRC, Indonesia, Mexico and Ghana • Two REDD (Reducing Emissions from Deforestation and forest Degradation) initiatives in Ecuador and Ghana
Total	• Net-zero across Total's worldwide operations by 2050 or sooner (scope 1 and 2) • Net-zero across all its production and energy products used by its customers in Europe by 2050 or sooner (scope 1, 2 and 3) • 60% or more reduction in the average carbon intensity of energy products used worldwide by Total customers by 2050 (less than 27.5 gCO_2/MJ), with intermediate steps of 15% by 2030 and 35% by 2040 (scope 1, 2 and 3)	• Various ongoing sequestration initiatives
ExxonMobil	• Expand natural gas supply • Create lightweight plastics • Develop high-efficiency fuels and lubricants	• Not mentioned

Sources: Corporate websites of Shell, BP, Equinor, ENI, Reposl, Total and ExxonMobil (accessed July 2019 and July 2020).

2.3.4 Mandatory offsetting

Rather than employing an LCFS (Section 2.3.2), or relying on voluntary offsetting by exporters and suppliers (Section 2.3.3), countries may impose mandatory requirements for fuel suppliers to offset scope 3 emissions associated with their products. Switzerland takes such an approach to decarbonizing liquid fuel use in the country, albeit linked to more general emissions reduction offsets rather than sequestration per se (Box 5).

Box 5. Mandatory offsetting road transport emissions under the Swiss CO_2 Act

Under the 2011 revision of the Swiss CO_2 Act, since January 2013 all fossil fuel producers and importers have been required to compensate for at least 10% of the CO_2 emissions caused by road traffic by 2020. The target has been raised incrementally over the period, from 2%, to 5% and then 8% for the period 2014 to 2019.

Compensation is achieved by the use of offsets supplied by emissions reduction projects, implemented either directly by fuel suppliers or by them acquiring offset attestations from third party project developers. Only domestic projects validated by the Swiss administrative office may provide relevant attestations. Presently the scheme explicitly excludes CCS projects from generating offsets/attestations, and it therefore cannot promote the types of decarbonized fuels described herein.

2.3.5 Mandatory sequestration

On the supply side, fossil fuel producing and exporting countries could mandate producers to use CCS or other technologies to offset some or all of the carbon embodied in produced and/or exported volumes. The sequestered adequate fraction extracted (SAFE-carbon) concept proposed by Myles Allen and colleagues (Allen et al. 2009; Box 6) outlines the basis of such an approach. Alternatively, a more generalized mandate for CCS deployment could be established based on different types of outcomes (Section 2.4.2).

For fossil fuel producing countries, the most rational and practical pathway to operationalize a mandatory sequestration approach would be to create laws that enact a country-level voluntary pledge within, for example, an NDC to offset all or part of the scope 3 emissions associated with national fossil fuel production (Section 2.3.3). Such a law as described would, in practice, pass on a government's voluntary pledge as an obligation on fossil fuel producers in the country. Alternatively, CCS deployment could be mandated by a fossil fuel producing country through a fixed national target without necessarily linking it to a voluntary pledge (Section 2.4.2).

On the demand side, fossil fuel importers could also impose a requirement for offsetting, via CCS, a certain proportion of the carbon content of imported fuels. For example, calls have been made in the Netherlands for a carbon take-back obligation for fossil fuel suppliers, following similar principles to that of SAFE-carbon (Box 6; Kuijper 2019). Such approaches could potentially be fulfilled either through a low-carbon portfolio standard approach or a mandate as in Switzerland (Box 5). In either case, the rules applicable in the existing schemes would need to be modified to accommodate decarbonized fuels.

An alternative option is to establish a similar approach through collaborative bilateral arrangements between exporters and importers. An example would be Japan's national Hydrogen Strategy and its cooperation plans with Australia, Brunei, Norway and Saudi Arabia (Box 7).

Box 6. The sequestered adequate fraction extracted (SAFE-carbon) concept (after Allen et al. [2009])

Allen and colleagues, in considering atmospheric carbon budgets in 2009, proposed a novel but straightforward concept for mandatory sequestration, which they termed the 'sequestered adequate fraction extracted' (SAFE). Their idea involves placing a global mandate on all fossil fuel producers to sequester an amount of carbon corresponding to the amount of carbon they extract from the geosphere. The adequate fraction is recalculated over time according to cumulative emissions. As the remaining atmospheric carbon budget is taken up by CO_2 emissions, the adequate fraction eventually reaches 100%, meaning a sustained balance is maintained thereafter between carbon extraction and carbon sequestration.

A useful insight from the work of Allen and his colleagues is that a net-zero emissions outcome can be equally framed as a carbon stock or an extraction management challenge as much as an emissions control and removals — or carbon flow management — problem. Allen et al. suggest that such a reframing may be more palatable than focusing on reducing carbon emissions, with the attendant implications of restricted energy consumption and constrained economic development.

Box 7. Japan's Hydrogen Strategy

Japan is exploring the potential to convert various fossil fuels, including Saudi Arabian crude oil, Australian coal and Norwegian and Bruneian natural gas, into hydrogen for export to Japan. While Japan's Hydrogen Strategy could potentially operate without CCS and still decarbonize Japan's energy mix (see Box 9), it clearly foresees a key role in using CCS to decarbonize the complete hydrogen production cycle (Ministry of Economy, Trade and Industry 2017).

The draft Saudi-Japan collaboration roadmap, for example, outlines the need for CCS in decarbonizing hydrogen imports (Nagashima 2018). The collaboration therefore will require Saudi Arabia and others to use CCS to sequester the carbon fraction arising from any future manufacture and supply of hydrogen to Japan.

2.3.6 Technology mechanism

A technology-specific mechanism could be used as a quantity-based economic instrument to establish a direct incentive to deploy CCS under a market-based framework.

Generally, technology mechanisms are built around a portfolio standard like an LCFS, but are specific to one single technology group. An example of such a mechanism is a renewable energy portfolio standard, where electricity producers are mandated to supply a specific and increasing proportion of electricity from renewable sources (wind, solar, etc.). The system works by attaching a 'credit' to generated renewable power (e.g., a renewable energy certificate or REC attached to each megawatthour), which can be traded between

Box 8. Piloting storage credits and supply-side policy under the Paris Agreement (after Zakkour and Heidug [2019])

A paper published by KAPSARC in April 2019 proposed that a storage crediting mechanism could be introduced by a group of Parties to the Paris Agreement with mutual interests in decarbonizing fossil fuels using CCS. Article 6.1 of the Paris Agreement provides latitude for Parties with common interests to participate in voluntary cooperation. Article 6.2 provides the basis for establishing mechanisms through which cooperative actions could flow. The paper proposed that a club of countries with interests in CCS could develop a storage crediting system under Article 6.2.

The paper notes that, because of the current focus of climate policy on demand-side measures and emissions flow-based accounting, in the first instance the system would be best operated in isolation from current climate policy systems to avoid double counting emission reductions (Box 9). It proposes to therefore initially implement the approach through a results-based finance (RBF) framework. This would require the club of cooperating countries, in the first instance, to pool their financial resources in a fund that is used to offtake and cancel storage credits from operational CCS projects. This would also have the added benefit of providing a complementary and supplementary layer of financing to demand-side carbon pricing policies, without the risk of double counting the emissions reduction. Additional layers of finance as described would provide much-needed finance for CCS in its early deployment stage, which could drive down costs for its longer-term roll-out. It would also create a price signal for CO_2 storers, and thereby unlock opportunities for commercial transactions of physical CO_2 between CO_2 emitters, shippers and storers.

Over the medium-term, experiences from RBF could be reviewed, and decisions made in respect of transitioning the RBF approach into a systematic means of creating demand for storage credits. This could be based on using either:

- Stock-based, supply-side, policies and measures based on embodied carbon; or,
- Flow-based, demand-side, policies and measures based on carbon emissions (e.g., carbon pricing instruments)

There may also be the option of using both measures, depending on how accounting and MRV were to be applied in future to avoid double counting.

electricity producers to collectively meet their obligations. A similar system could be implemented for CCS, either as a supply- or demand-side policy instrument.

In a supply-side approach, oil producers could be mandated to store an increasing portion of the carbon they produce, similar to the SAFE-carbon proposal (Box 6), albeit built around a flexible quota system. Storage certificates — representing a verified tonne of CO_2 securely stored or sequestered in a geological reservoir — could provide a basis for producers to trade so as to meet their targets. Such a storage crediting system could be introduced on a regional basis by a group of countries with common interests, such as the countries of the Gulf region. Alternatively, it could be introduced through a multilateral or global system using mechanisms under Article 6 of the Paris Agreement. Such a proposal was recently made by researchers at KAPSARC (Zakkour and Heidug 2019; Box 8).

Zakkour and Heidug's proposal could provide a coherent strategy for supporting CCS deployment by fossil fuel producers over the near term. A key factor at this stage is whether the yet-to-be-agreed rules on Article 6 of the Paris Agreement will leave sufficient latitude for a storage crediting system to be developed in the future. Expectations are that the Article 6 rules will be finalized at the postponed 2020 UN Climate Change Conference (COP 26), due to take place in the United Kingdom in late-2021.

2.4 Design aspects of progressive supply-side climate policy

The previous section outlined how different supply-side climate policy approaches could be used to promote and deploy CCS and decarbonize fossil fuels. It should be noted, however, that not all of the proposed options are mutually exclusive, as noted when describing the potential link, above, between a country's voluntary pledge and a local or regional mandate placed on operators. Indeed, most of the policies described previously could be mixed and matched. A wellhead carbon tax could be linked with a storage mandate to provide ring-fenced capital to recycle back to operators to invest in CCS, a storage crediting approach could be linked to a low carbon fuel standard, and so on. Consequently, some careful thought will be needed regarding the most appropriate mix for fossil fuel exporting regions.

Mindful of these similarities, the following sections set out some strategic, technical and economic factors to consider for policy design associated with going beyond reducing a company or country's own emissions (scope 1 and 2 emissions) and extending into customer emissions occurring outside the control of the fuel supplier (i.e., scope 3 emissions) under an extended producer responsibility framework.

2.4.1 Strategic factors

For crude oil exporting countries, climate action presents strategic choices for maintaining the value of regional resource endowments, export earnings and market access for products. Assuming a desire to sustain current levels of production irrespective of the point of end use, two possible outcomes can be envisaged under scenarios of comprehensive and sustained climate action globally. In the near future, fossil fuel exporters could be required to either:

- Find volumes of CO_2 to sequester in order to decarbonize crude oil supplies and maintain market access; or

- Undertake greater domestic value additions of fossil fuel resources to compensate for falling international demand, and use CCS to manufacture decarbonized energy-intensive products for export (e.g., petrochemicals, steel, cement, etc.).

Taking into account both near-term ambitions of crude oil producers in maintaining market access for exports, and longer-term regional ambitions for economic development into more value-added activities, near-term policy choices need to offer value both now and in the future. This suggests a short-term focus on considering supply-side policy approaches, but also longer-term flexibility in order to offer similar pathways for decarbonized energy-intensive value-added products at some future point, as economic circumstances and priorities change.

Irrespective of the choice of policy instrument, or combinations thereof, the actual amount of CCS needed under both scenarios would likely remain broadly consistent over time, since the amount of carbon in produced fuels would remain broadly constant. Consequently, the tonnes of CO_2 emissions captured, avoided or stored — and their associated costs — could ultimately be similar under either policy scenario: either CCS is needed to offset scope 3 emissions from fuel exports, or CCS is needed to reduce scope 1 emissions from local value-added activities. It is therefore only the point in the value chain where the reduction is counted — either on the supply- or demand-side — that makes a difference to how different types of products may be decarbonized. A deep understanding of the full implications of these subtle allocation and accounting aspects is needed to help fully inform strategies and choices.

2.4.2 Technical factors

In designing an offset pledge, both countries and companies need to carefully consider what portion of the total embodied carbon in their products they would seek to offset in the first instance. As noted previously, a low carbon fuel can be differentiated from a decarbonized fuel on the basis of having part or all of its carbon content offset (Box 2). Shell and Equinor, for example, both limit their pledges to around 50-65% of the energy intensity of their entire portfolio fuel products (Table 2).

Using a country- or sector-specific approach can also limit the level of offsetting/sequestration required in early phase piloting. This would mean only a portion of production or supply, rather than the entire portfolio, would need to be offset. For example, Shell has so far limited its offsetting activities to drivers in the Netherlands and the United Kingdom, with plans for a wider roll-out in the future (Table 2). Alternatively, sector-specific actions could focus on, for example, jet fuel supply, perhaps in cooperation with the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) program.[6]

A mandatory sequestration target could also be formulated in ways indirectly linked to produced carbon. For example, establishing one demonstration or large-scale CCS project, a fixed fund dedicated to CCS projects, or a target for a mass of CO_2 to be stored by a fixed point in time. However, such approaches would not necessarily align pledges or policies with long-term climate mitigation goals of the Paris Agreement.

2.4.3 Economic factors

Economic factors are a major consideration in the design of any supply-side policy, particularly those developed by producers and exporters. For example, any production or export tax would need to consider the following:

- The level of taxation that might be applied
- The ability to pass costs to importers
- The willingness and capacity of the fossil fuel exporting government to hypothecate revenues
- The design of schemes through which to recycle revenues (disbursement method, eligible technologies and activities, etc.)

A detailed review of these issues is beyond the scope of this paper, but they would need to be worked through on a case-by-case basis, taking account of local circumstances and priorities.

Cost pass-through presents a particular challenge in the absence of universal application of supply-side policies across the sector. The willingness of fossil fuel importers to pay a premium for decarbonized fuels is likely to be heavily influenced by the accounting rules applied to such products, as this determines how emissions from their use will be recorded (Box 9). Further policy developments are needed to fully support the approach, as discussed further below.

2.4.4 Conditionality

Taking into account the economic factors described above, the impacts could be limited by introducing conditionality into any proactive supply-side pledge or policy. A pledge or policy could therefore be predicated on other factors being in place such as:

- Linking the offsetting pledge to the level of action being taken by other producers and suppliers.
- Linking the pledge to continued unfettered access to markets (e.g., limiting demand-side actions).
- Linking the level of decarbonization or offsetting to the remaining atmospheric carbon budget or the recorded rate of temperature increase, mindful of the long-term objectives of the Paris Agreement (see also the ‘SAFE-carbon’ concept in Box 6).

In terms of the final bullet point, linking a voluntary pledge to Paris Agreement targets could align corporate strategies with the demands of shareholder groups such as CA100+, and bring companies in line with the Science-Based Target initiative.[7] Coordinated action could also take place at the sectoral level, for example through the OGCI.

3 Opportunities and Challenges For Decarbonized Fossil Fuel Policy

Lazarus and van Asselt (2018) suggest that supply-side policies offer the potential to "widen the mitigation cost curve" by allowing greater emission reductions at the same or lower cost than demand-side policies. This view suggests that the main challenge facing policymakers is simply one of scale or coverage, rather than the carbon price level itself. We tend to agree with the sentiments of Lazarus and colleagues insomuch as complementary supply-side policies can widen the number of actors contributing — rather than only reacting — to climate policy actions (i.e., fossil fuel producers). However, we also consider that progressive supply-side policies provide a means of blending mitigation policies to leverage supplementary climate finance, rather than solely using demand-side measures.

A recognized shortcoming of carbon pricing policies is their limited ability to promote and deploy emergent, near-market, low-carbon technologies like CCS. Novel technologies will have early-phase deployment risks and costs that exceed the compensation on offer through emissions pricing, even though they may be critical for meeting long-term climate mitigation goals. These long-run future benefits are not visible in carbon pricing policies, which tend to clear at a price equivalent to short-run marginal abatement costs. The Carbon Pricing Leadership Coalition — a cross-sectoral group that is promoting the expansion of carbon pricing policies around the world — notes this limitation when it states that:

"Carbon pricing by itself may not be sufficient to induce change at the pace and on the scale required for the Paris target to be met, and may need to be complemented by other well-designed policies tackling various market and government failures, as well as other imperfections" (Carbon Pricing Leadership Coalition 2017, 3).

Similarly, the International Energy Agency also suggests that:

"Without targeted support, it is unlikely that the current momentum in [CCS] project deployment will be maintained, with progress likely to stall by 2020. This will substantially inhibit the availability of CCS to contribute to medium and long-term climate targets." (IEA 2016, 46)

There is generally broad agreement that a series of interacting policy instruments is often needed to correct such market failures and drive the deployment of technologies like CCS (Krahé et al. 2013), and also that the choice of the instrument is often jurisdiction specific.

So far, only the Norwegian CO_2 Tax — a highly-focused sectoral carbon pricing scheme applied to Norway's offshore oil and gas industry — has offered a sufficiently high and stable emissions price signal to promote the deployment of two captive CCS projects by Equinor, namely Sleipner and Snøhvit. The narrow scope of the tax means that it functions as a supply-side climate policy. Similarly, the carbon pricing policies in Alberta, Canada were modified to offer a double credit alongside government grants to support the development of Shell's captive Quest project. The EU's GHG emissions trading scheme, which applies only to CO_2 emitters, has so far failed to deliver any CCS projects in its 15 years of operation.

Deploying integrated CCS projects involving multiple entities across the capture, transport and storage chain has largely proved all but impossible, except in situations where there is also an incentive for CO_2 storers, as is the case with CO_2-enhanced oil recovery (EOR) projects in the U.S. and Canada. Indications are that, although all components of the CCS chain are technically mature, the business models and policy approaches of the chain are not.

Extraordinary innovations in, and cost reductions of, renewable energies over the past 10 years have been delivered through a combination of explicit supply-side technology support measures in the electricity sector (e.g., feed-in tariffs and obligations), often coupled with the implicit price signals created by carbon pricing in some jurisdictions. These experiences suggest that supply-side policy measures in the fossil fuel supply sector, coupled with demand-side policies on emitters, could offer a way of increasing deployment, driving down costs through technology learning effects, and ultimately supporting the longer-term widespread roll-outs of CCS technologies to deepen global climate ambition.

Creating value for sequestering carbon alongside pricing carbon emissions also enhances the flexibility for developing and deploying CCS. Typically, CCS is seen as a single chain of activities from capture to transport to storage, with all the value created at the point of capture. The carbon emissions price must then be passed down the CCS chain from the capture entity in order to compensate the shippers and storers of CO_2. This has hampered the development of business models for CCS outside of captive situations and EOR. The introduction of new types of instruments that value storage independently of CO_2 capture offers opportunities to establish business models that are not confined to this single-chain linear project architecture. Rather, CO_2 storers can be incentivized to find sequestration opportunities linked to a set of policy drivers that are independent of those applicable to emitters. This indicates possibilities for driving the CCS business model in new directions, with structures that promote efficiency in deployment, and, ultimately, the scaling-up of ambition.

Creating a market that supports commercial transactions of physical CO_2 between capturers, shippers and storers will also be key to unlocking the potential of CCS without the need for excessive government intervention. In addition, prospects for CO_2 removal technologies, such as DAC, would be enhanced by supply-side policies that establish incentives for action independent of CO_2 emissions sources. Distributional issues associated with storage capacity could be overcome by using DAC in crude oil exporting regions as a means to offset the scope 3 emissions from fuels supplied to regions that are constrained in their available geologic storage capacity. Policymakers in California are clearly thinking along these lines, where DAC deployed anywhere in the world can be used to offset well-to-wheel emissions of the fuels sold in the state (Box 4).

The advantages described notwithstanding, accounting rules pose a challenge for supply-side climate policy approaches. The pervasiveness of demand-side policy means that the accompanying measurement, reporting and verification (MRV) and GHG accounting rules are also based on measuring emission flows. National GHG inventories submitted by Parties to the UNFCCC and Paris Agreement are compiled on an annualized basis, according to the level of emissions and removals occurring within each country's territory. Stock- or extraction-based GHG accounting is only implemented in the forestry and land use sectors. Consequently, as noted by Piggot et al. (2018), the current system rewards actions taken domestically, but is unable to recognize actions that reduce emissions outside of national boundaries, bioenergy excepted. This has ramifications for the way decarbonized fuels might be effectively rewarded and counted within the UNFCCC framework (Box 9).

Box 9. GHG accounting and the MRV of decarbonized fuels

When a decarbonized fuel is supplied to a user, emissions from its combustion may or may not be 'zero-rated' depending on applicable GHG accounting and measurement, reporting and verification (MRV) rules (i.e., respectively recorded, or not recorded, as an emission in the relevant GHG emissions inventory).

In the case of hydrogen, its combustion does not create CO_2 emissions and, therefore, the country, organisation, sector or project activity using hydrogen may record zero emissions in the relevant GHG emissions inventory. However, unless the separated carbon fraction is geologically sequestered at source, there is no net global emissions reduction. In cases where there is a transboundary movement of the hydrogen, the accounting rules of the UNFCCC's global climate regime (IPCC 2006) allow the importing country to benefit at the expense of the producing/exporting country. The importer will be able to zero-rate the emissions while the producer will be required to report emissions from production in its national GHG inventory. As such, the importing country will have simply shifted its fossil fuel emissions outside its jurisdictional control and reporting boundary. A system of tagging and tracking the CO_2 fraction, such as storage credits, may therefore be needed in order to call hydrogen a truly decarbonized fuel.

In the case of a virtually decarbonized fuel, zero-rating of product emissions is dependent on a few factors.

First, implementation relies on establishing a system that can be used to 'tag' the decarbonized fuel product, based on recording and verifying deposits of carbon to the geosphere (or biosphere); for example, a storage crediting system (as described in Box 8).

Secondly, regardless of its implementation, the emissions reduction effect must not be double counted. Double counting can occur when the stored CO_2 is credited and used to create a virtually decarbonized fuel, and the emissions reduction effect of capturing and storing the same CO_2 is counted as an emissions reduction or avoided emissions by the entity or country where the CCS activity occurs. Counting and claiming the effect twice compromises the environmental integrity of either or both the supply- or demand-side measures.

The current emissions accounting and MRV rules mean that the global climate policy architecture is not fully geared up to credit nations for supply-side actions. The use of stock-, extraction- or production-based accounting systems would help to address this gap by ensuring actions by producers can be recognized accordingly, similar to the current rules for bioenergy (Box 10). Concepts such as SAFE (Box 6) and storage crediting (Box 8) are predicated on the evolution of carbon stock-based accounts that can monitor and reward climate actions relating to the management of carbon in the geosphere, at least over the longer term. In the near term, double counting remains a challenge. Recognizing the need to address this limitation, Piggot et al. (2018) proposed that parallel or “shadow” extraction-based carbon accounts could be created, alongside emissions-based accounts, as a means of supporting the early adoption of supply-side climate policy frameworks.

The overriding consequence of these arrangements is that supply-side approaches will no doubt require some time to mature in order to build confidence and provide certainty over how double counting will be avoided. As suggested in our previous research (Zakkour and Heidug 2019), the bottom-up architecture of the Paris Agreement does offer some latitude to move toward supply-side climate policy in parallel with demand-side measures. A piloting phase that blends both approaches could offer near-term benefits for enhanced climate action, while also offering opportunities to gain experience and identify the means to scale up (Box 8).

Box 10. Stock-based accounting and zero-rating emissions from fuel use

A useful analogue for framing supply-side and stock-based accounting issues are the IPCC guidelines (e.g., IPCC, 2006) and their application to bioenergy resources (IPCC Guidelines are mandated for use by UNFCCC Parties when compiling their national GHG inventories as reported to the UNFCCC). The IPCC Guidelines apply a carbon stock accounting approach to land use, land-use change, and forestry (LULUCF) accounts, meaning that changes in land carbon stocks due to harvesting and biomass growth are measured respectively as either a net emission by a source or a net removal by a sink. As a result, a country’s LULUCF account is reported either as an emissions source or sink, depending on the balance between the two activities. This arrangement means that the LULUCF account must assume that biomass is instantaneously oxidized to CO_2 upon harvesting (i.e., is an emission) — harvested wood products aside — so, consequently, downstream CO_2 emissions arising from the combustion of produced biogenic fuels must be zero-rated in the energy sector account to avoid double counting.

A similar approach would be necessary to fully integrate supply-side policies for promoting decarbonized fuels as described herein. This would mean that net-carbon stock changes in the geosphere resulting from extraction (production) and deposition (sequestration) activities are measured and regulated, allowing the emissions resulting from the use of the produced fuel to be zero-rated.

4 Conclusions

Oil-producing companies, and, in particular, oil-producing countries, face the risk of diminishing market shares for their products as carbon constraints are increasingly applied by oil-consuming countries. CCS is a technology that can mitigate this risk by allowing for the continued use of fossil fuels in some essential applications while significantly reducing their associated emissions.

The large-scale deployment of CCS is contingent on a policy framework that enables and supports the development of business models for its use in a carbon-constrained world. While both demand- and supply-side climate policy instruments could drive CCS deployment, the latter provide a more attractive option for fossil fuel exporting countries in the near term because of their significant co-benefits, such as:

- Supporting their ambitions to diversify and de-carbonize their economies.
- The increasing flexibility to allocate emissions reduction from CCS to decarbonized oil or value-added products, which can optimize the value of CCS. This flexibility is essential to accommodate the changing nature of these economies.
- The potential to generate new industrial activities and new sources of revenue driven by climate action.

Presently, the small number of supply-side policies implemented by crude oil importing regions, such as LCFS and the Swiss CO_2 Law, do not include provisions to incentivize decarbonized fuels as described herein, except for DAC in California. This seems like a missed opportunity to drive deeper climate ambition. Further efforts to raise awareness of the possibilities for decarbonized fuels could help to encourage the introduction of more progressive supply-side climate policies within these frameworks.

With the important provisions of Article 6 of the Paris Agreement still under negotiation, a window of opportunity exists through which to open up and establish a wider debate on progressive supply-side climate policy frameworks involving decarbonized fossil fuels using CCS. Action could be built around the alignment of interests between oil-producing countries and key international and national oil companies, such as members of the OGCI. The establishment of an international tradable certificate mechanism for CCS based on carbon storage could provide a catalyst for action. The alternative would be for a continued focus on supply-side actions that increasingly question the legitimacy of fossil fuels in a carbon-constrained world.

As noted throughout, many of the concepts for supply-side policy and decarbonized fossil fuels discussed herein need time to further mature. This paper provides some early building blocks upon which to further consider the choices and challenges.

Endnotes

[1] Demand-side policies and measures may also apply to scope 1 emissions from fuel producers and suppliers at various stages of the fuel cycle (e.g., during extraction, transportation and/or refining).

[2] Article 4.1 refers to achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century. This goal is often referred to as 'net-zero emissions' or 'carbon neutrality.'

[3] For example, the 2018 protest in the Hambach Forest against RWE's lignite mine expansion.

[4] The February 2019 ruling on Gloucester Energy's Rocky Hill coal mine project in New South Wales, Australia.

[5] The Climate Action 100+ is a collection of more than 320 institutional investors that are seeking to drive changes in 161 "focus companies" through investor engagement and the active promotion of climate-related shareholder resolutions. Its strategy consists of three elements: implementing a strong governance framework that includes board accountability and oversight of climate risks; taking action to reduce GHG emissions across the value chain consistent with the Paris Agreement's goal; providing enhanced corporate disclosure in line with the TCFD on climate related risks.

[6] The ICAO is presently considering options for using 'low-carbon fuels' under CORSIA.

[7] Scheme operated by the Climate Disclosure Project, World Resources Institute and the Worldwide Fund for Nature (WWF) https://sciencebasedtargets.org/.

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Notes

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About the Project

This study is part of a project examining opportunities for Saudi Arabia to apply Carbon Capture, Utilization and Storage technologies (CCUS) in an increasingly carbon-constrained world and the role that CCUS could play in the Saudi economy. The project assesses policy options and analyzes related regulatory and commercial issues affecting the development and deployment of CCUS.

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