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A carbon takeback obligation for fossil fuels

Feasibility study phase 2, final report

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Content

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Policy Brief, Nederlands

Een Carbon Takeback Obligation voor de productie en import van aardgas vergroot de kans op halen klimaatdoelen

Na ontwikkeling van een CTBO voor aardgas zijn ook andere koolstofstromen en -voorraden aan te pakken

1. Inleiding

De afgelopen jaren blijkt in toenemende mate hoe groot de uitdaging van de energietransitie is. Met de oorlog in Oekraïne zijn er krachtige geopolitieke argumenten bijgekomen om de afhankelijkheid van fossiele brandstoffen versneld af te bouwen. Maar ondanks de spectaculaire groei van duurzame energie blijft het gebruik van fossiele energie op veel plaatsen nog stijgen, en nemen de emissies nog toe.

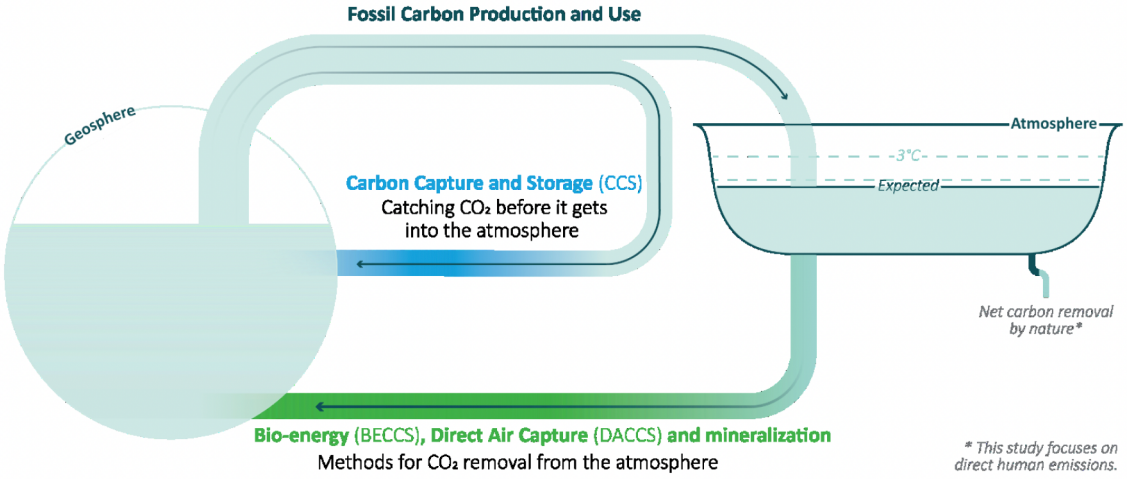
Tegen deze achtergrond is het niet onwaarschijnlijk dat vooral aardgas nog een lange tijd nodig zal zijn in Europa, hoeveel sneller de energietransitie ook gaat verlopen. Het is daarom belangrijk om niet alleen verhoogd in te zetten op vraagvermindering (energiebesparing, energie-efficiëntie) en CO_2-vrije energiebronnen (nog meer hernieuwbare energie, wellicht ook kernenergie), maar ook systematisch te gaan werken aan het verlagen van de uitstoot door de resterende benodigde fossiele energie: minder methaanemissies en meer CO_2-afvang en -opslag. Het emissiehandelssysteem ETS is tot nu toe niet zodanig stringent geweest dat ook afvang en opslag van CO_2 economisch rendabel werd. De eerste projecten worden nu gepland met subsidies, maar daar is veel discussie over: moet er wel publiek geld naar deze optie? En wordt zo niet indirect toch het fossiele systeem financieel gesteund? De overtuiging is breed dat het wenselijk is dat de subsidies zo snel mogelijk afgebouwd worden en worden vervangen door regelgeving die op langere termijn zekerheid geeft. En die de rekening bij de veroorzakers legt. De toenemende krapte aan ETS-rechten en bijbehorende prijsstijgingen biedt daarbij een deel van de oplossing, maar biedt waarschijnlijk nog onvoldoende zekerheid, en dekt ook maar een deel van het fossiele gebruik, namelijk in die sectoren die onder het ETS vallen. Aanvullend beleid is daarom nodig om tijdig, en met een grotere mate van zekerheid dan er nu is de netto CO_2-uitstoot van gebruik van fossiele energie naar nul te krijgen.

Dat kan door voorwaarden te stellen aan op de markt te brengen hoeveelheden aardgas, en voor te schrijven dat voor elke kubieke meter aardgas die op de markt wordt gebracht een passend percentage koolstof permanent wordt opgeslagen. Deze vorm van uitgebreide producentenverantwoordelijkheid noemen we Carbon Takeback Obligation (CTBO). Deze maatregel is tot nu vooral voor aardgas uitgewerkt, maar dezelfde principes kunnen ook op andere fossiele brandstoffen toegepast worden. Zie ook het rapport over de eerste fase dat hier is te vinden.

2. Invoering CTBO

De afgelopen twee jaar is onderzoek gedaan naar wat het instrument Carbon Takeback Obligation voor Nederland zou kunnen betekenen.

In de huidige situatie zorgt aan de geosfeer onttrokken aardgas (en andere koolwaterstoffen) voor een toename van het koolstofgehalte in de atmosfeer bij verbranding. Die toename kan worden gestopt door te eisen dat de koolstof van nieuw op de markt gebrachte voorraden koolwaterstoffen wordt teruggevoerd in de geosfeer in de vorm van permanente opslag[1]. Met name via CCS, Carbon Capture and Storage. Het contracteren van voldoende opslag kan als voorwaarde worden opgelegd voor inzet van fossiele brandstoffen zolang deze nog nodig zijn ook bij maximaal tempo in de energietransitie. De kosten hiervoor kunnen via een Carbon Takeback Obligation (CTBO) bij de veroorzaker worden gelegd – de bedrijven die fossiele brandstoffen op de markt brengen (en hun klanten). Dat is doelmatig en doeltreffend (de vervuiler betaalt) en zorgt daarnaast voor een verhoging van de prijs van fossiel waardoor het gebruik verder ontmoedigd wordt.



Figuur 1: Via een carbon takeback obligation kan worden geregeld dat koolstof uit de geosfeer na gebruik in de economie niet na afloop in de atmosfeer belandt, zodat nieuwe fossiele voorraden alleen maar ingezet kunnen worden als ze niet ten laste komen van het koolstofbudget.

Bij invoering van een CTBO zullen producenten en importeurs van aardgas verplicht worden om opslagcertificaten te kopen (en in te leveren) om zo aan hun Carbon Takeback-verplichting te voldoen. De bedrijven die CO_2 of koolstof permanent opslaan krijgen deze opslagcertificaten en kunnen deze verkopen. Hiermee ontstaat aanvullende financiering voor CCS-projecten. De

[1] In principe is elke techniek of activiteit waarmee koolstof permanent wordt opgeslagen toegestaan (bijvoorbeeld ook vaste koolstof, mineralisatie, biochar, langetermijnopslag in beton); de verwachting is wel dat het grootste deel van permanente opslag zal plaatsvinden door middel van geologische opslag van CO_2.

opslagcertificaten geven het recht op productie en import van aardgas. Verhandelbare opslagcertificaten zorgen voor efficiënte implementatie en marktwerking. Op die manier kan zeker gesteld worden dat, ongeacht hoeveel fossiele energie er nog nodig is, de netto impact op het klimaat tijdig naar nul kan worden teruggebracht. Uit het Parijse klimaatakkoord vloeit immers voort dat de Westerse wereld rond 2040 à 2050 netto klimaatneutraal opereert.

Na de introductie van een CTBO kan het percentage koolstof dat moet worden verwijderd en opgeslagen geleidelijk worden opgevoerd. Het is mogelijk in Nederland te beginnen en stap voor stap andere landen, bijvoorbeeld rondom de Noordzee, te betrekken en daarmee ook hogere CO_2-afvang- en -opslagpercentages te eisen. Op dit moment is er nog geen (=0%) compensatie van de fossiele koolstofproductie door CO_2-opslag. In 2050 moet dat 100% zijn om de (geologische) Net Zero doelstelling te kunnen halen waarbij de koolstofproductie en permanente opslag volledig in balans zullen zijn. Gegeven de discussies over de mondiale verdeling van het nog resterende carbon budget wordt er vaak op gewezen dat de westerse wereld eerder naar Net Zero zal moeten. Een CTBO biedt een 'regelknop' om dat ook daadwerkelijk te realiseren als daarvoor wordt gekozen.
Er zal onder streng mondiaal klimaatbeleid veel minder fossiele energie gebruikt worden, maar in de meeste scenario's is het niet nul in 2050 (dan wel in 2040 in de westerse wereld). In die scenario's wordt er gemiddeld 10 à 20% van de emissiereductie in 2050 bereikt met behulp van CCS en CDR (Carbon Dioxide Removal). Dat is een stevige opgave die net als andere transitiedoelen een planmatige aanpak vereist om tijdig gerealiseerd te kunnen worden.

3. Doelen en voordelen

Zekerheid over het tijdig terugdringen van emissies van het resterende fossiele energiegebruik is, gegeven het beperkte koolstofbudget, het hoofddoel van een CTBO.

Daarnaast biedt een CTBO nog de volgende voordelen:

- Voor het gebruik van aardgas wordt een meer realistische prijs betaald, inclusief de kosten voor reductie van de klimaatimpact in de vorm van opslagkosten. Als gevolg hiervan worden duurzame energiebronnen sneller concurrerend met aardgas.
- Het veiligstellen van klimaatoverwegingen in besluitvorming over fossiele energieproductie: door een CTBO op te nemen in vergunningen voor gasproductie in Nederland kan worden geborgd dat de klimaatdoelen niet in gevaar komen als sprake is van (additionele) binnenlandse gasproductie.
- Het vergroten van draagvlak voor (de financiering van) CCS-projecten door een faire verdeling van de kosten: op deze manier worden de vervuilers verantwoordelijk voor het opruimen van de vervuiling die bij gebruik van de producten ontstaat (de vervuiler betaalt), en zal er een duidelijke 'businesscase' komen voor permanente opslag van CO_2 die investeringszekerheid biedt.
- Wegbereiding van CDR-projecten (carbon removal: CO_2-verwijdering) die op termijn nodig zullen om
  1) eventuele overshoots in de CO_2-concentratie alsnog terug te dringen,
  2) eventuele onvolledige afvang- en opslag te compenseren, en/of

3) eventuele pieklastinzet van (vanwege korte bedrijfstijd unabated[2]) gascentrales te compenseren.

- Meer innovatie en samenwerking in de waardeketens om op zo'n slim mogelijke manier emissies te reduceren en koolstof uit de atmosfeer te houden en op termijn uit de atmosfeer te verwijderen door permanente opslag in de geosfeer.
- Een uitweg uit de thans onoplosbare internationale onderhandelingen over de verdeling van nog toegestane fossiele productie gegeven het beperkte koolstofbudget. Veel rapporten roepen op tot stoppen met productie van fossiele brandstoffen, maar de wereld is er tot nu niet in geslaagd een faire en geaccepteerde verdeelsleutel te vinden: wie mag nog wat produceren, op basis van welke criteria? Door in lijn met het Parijs-akkoord en het Glasgow-akkoord onderscheid te maken tussen '*unabated*' en '*abated*' (met of zonder CO_2-emissies) koolstofstromen is in elk geval een deel van die verdeelpuzzel te leggen: winning mag alleen als er sprake is van een concreet *abatement* plan.
- Het verminderen van de volatiliteit in de energiemarkten de komende decennia (bij internationale invoering): de onzekerheid over onder welke voorwaarden er nog productie van fossiele energie mogelijk is in verschillende landen draagt bij aan groeiende afhankelijkheid van landen zoals Rusland en Saoedi-Arabië, en aan toenemende geopolitieke risico's en prijsfluctuaties. Door strenge, maar duidelijke voorwaarden te stellen aan productie kan een CTBO bijdragen aan investeringszekerheid en minder groei in de afhankelijkheid van landen met de grootste reserves (Rusland, Midden-Oosten).

Het is belangrijk te benadrukken dat een CTBO een complementair instrument is omdat het een zogenaamd 'supply-side' -sturing betreft. Samen met al bestaande 'demand-side'-sturing (zoals het Europese emissiehandelssysteem ETS, prestatienormen) kan zo voldoende stimulans ontstaan om de netto emissies van het resterende fossiele energiegebruik tijdig naar nul te reduceren.

4. Randvoorwaarden en onderzoeken

Belangrijke randvoorwaarden daarbij zijn dat dit niet leidt tot meer gebruik van fossiele energie (met andere woorden de verhoogde inzet op fossiele vraagvermindering blijft essentieel) en dat dit geen nadelige gevolgen heeft voor de concurrentiepositie van de Nederlandse industrie.

CTBO onderzoeken samen met brede groep belanghebbenden
De CTBO-onderzoeken zijn gedaan in samenspraak met een brede groep belanghebbenden: bedrijven, milieuorganisaties, wetenschappers en experts. Ook wordt er nauw samengewerkt met wetenschappers van Oxford University (prof Myles Allen et al.) die al meerdere wetenschappelijke artikelen over dit beleidsinstrument gepubliceerd hebben. Verschillende milieuorganisaties (Natuur & Milieu, Bellona, Clean Air Task Force, Zero Norway) staan positief tegenover het toepassen van het principe van producentenverantwoordelijkheid voor de productie en verkoop van aardgas.

[2] 'Abated' en 'unabated' is de internationale terminologie voor activiteiten *met* dan wel *zonder* CO_2-verwijdering en opslag. In internationale klimaatakkoorden zoals dat van Glasgow en in internationale studies wordt gesteld dat nieuwe *unabated* koolstofvoorraden in wezen niet meer gewonnen en gebruikt kunnen worden.

Economisch onderzoek van CE Delft laat zien dat de CTBO initieel voornamelijk als effect heeft dat subsidies voor CCS (SDE++) sneller afgebouwd kunnen worden. Op langere termijn zal een CTBO leiden tot conversie naar waterstof of elektriciteit met CO_2-opslag (zolang er nog fossiel gas nodig is) en tot de inzet van Carbon Removal (verwijdering van CO_2 uit de atmosfeer) voor de moeilijk te mitigeren emissies. Onderzoek van zowel Oxford University als van CE Delft geeft aan dat implementatie van een CTBO (bovenop kortetermijnbeleid om de vraag naar fossiele energie te verlagen) resulteert in een betaalbare, laagrisicoroute naar netto nul-emissies in 2050.

Juridisch onderzoek laat zien dat een CTBO op vergelijkbare wijze kan worden opgelegd als zogenaamde Uitgebreide Producenten Verantwoordelijkheid-regeling zoals die bestaan voor onder meer afval van producten (bv batterijen, verpakkingen, elektronica). Dit kan het best via een maatwerkregeling worden opgezet die ook door andere landen makkelijk gekopieerd kan worden, waardoor opslagcertificaten ook internationaal verhandeld kunnen worden.

5. Volgende stappen

Een CTBO kan een belangrijk additioneel instrument zijn om de emissies van nog resterend fossiele energiegebruik tijdig naar nul te brengen. Op basis daarvan stellen we daarom voor:

1. Onderzoek te starten naar de beste manier om nieuwe regelgeving toe te voegen voor een CTBO voor producenten en importeurs van fossiel gas, bij voorkeur in combinatie met een (vrijwillig) pilotproject.
2. Verder onderzoek te laten doen naar de interactie van een CTBO met andere regelgeving, en de effecten voor verschillende groepen in de samenleving (voortbouwend op het CE Delft-onderzoek).
3. In overleg te gaan met andere Noorzeelanden en de EU om de mogelijkheden van het vormen van een Noordzee-CTBO-regio te verkennen.
4. De klimaatwet uit te breiden met het doel om in 2050 100% van het resterende fossiele energiegebruik te compenseren door permanente CO_2-opslag, en de verplichting om voortgang te monitoren van dit percentage CO_2-opslag.[3]
5. De stakeholders, bijvoorbeeld zoals bijeengebracht in de brede CTBO-klankbordgroep, te blijven betrekken.
6. Een formele werkgroep op te richten die namens de producenten en de overheid de bovenstaande activiteiten gaat coördineren en de implementatie van CTBO gaat voorbereiden.

Met de constatering dat CTBO een wenselijk en toepasbaar nieuw beleidsinstrument kan vormen om de benodigde beperking van CO_2-emissies te realiseren, zal bepaald moeten worden hoe dit kan worden ingevoerd. Het invoeren van nieuw beleid is aan de overheid, maar daarvoor is nadere afstemming met verschillende sectoren nodig. Idealiter maken we een 'beleidsroutekaart' die in beeld brengt wat de benodigde stappen richting invoering van een CTBO zijn, met daarbij de rollen die de verschillende betrokken partijen hierbij kunnen spelen.

[3] Verder zou overwogen moeten worden om een grens te stellen aan de maximale hoeveelheid CO_2-opslag die door Carbon Removal geleverd mag worden. Veel landen stellen zo'n grens omdat in principe vermijden van emissies voorrang moet hebben boven achteraf weer verwijderen uit de atmosfeer.

6. Meer weten?

Nadere informatie over CTBO:
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Policy Brief, English

A Carbon Takeback Obligation on the production and import of natural gas makes achieving climate targets more likely

After the development of a CTBO for natural gas, other carbon flows can also be tackled

1 Introduction

Recent years have shown just how difficult the energy transition will be. The war in Ukraine, meanwhile, has added a powerful geopolitical argument to rapidly reduce dependence on fossil fuels. However, despite the rapid growth in renewable energy use, fossil fuel use, as well as global emissions, are still rising.

Given this context, it's not an unlikely scenario that fossil fuels, and especially natural gas, will still be needed in Europe for a long time, however quickly the energy transition takes place. It is important, therefore, to not only focus climate policy on demand reduction measures (such as energy saving, energy efficiency) and on CO_2-free energy sources (more renewables, perhaps nuclear), but to also think systematically on how the emissions from continuing fossil energy use can be reduced (less methane emissions, more CO_2 capture and storage). The ETS emission trading system has so far not been stringent enough to make the capture and storage of CO_2 economically viable. The first CCS projects are now being planned with the help of subsidies, but this has not been without controversy, raising questions such as: is this how public money should be spent? And isn't this an indirect way of financially supporting the fossil energy system? There is broad consensus that subsidies should be phased out as soon as possible, and be replaced by a regulatory regime that gives long term certainty. And that perpetrators are footing the bill.

ETS allowances are increasingly in short supply, and the price increases in ETS certificates as result are a part of the solution, but this still isn't likely to offer enough certainty. Furthermore, the ETS only covers part of fossil fuel use, namely in the sectors that fall under the ETS. Additional policy instruments are therefore needed to be certain that CO_2 emissions from fossil energy use will be brought down to net zero in time.

This can be done by imposing conditions on the quantity of natural gas that can be brought onto the market, and by prescribing that, for every cubic metre of natural gas brought onto the market, an appropriate percentage of carbon is permanently stored. This is a type of producer responsibility called the Carbon Takeback Obligation (CTBO). This policy instrument has been investigated mainly in its application to natural gas, but the same principles can also be applied to other fossil fuels. See also the report on the first phase of the project, which can be found here.

2 Implementing a CTBO

In the past two years, significant research has been done about what the CTBO could mean for the Netherlands. As things stand, natural gas is extracted from the geosphere and increases the carbon content in the atmosphere when it is burned. This increase in atmospheric carbon can be stopped by requiring that the carbon contained in new hydrocarbons brought onto the market is put back into the geosphere and permanently stored there[4]. This can be done primarily with the use of CCS (Carbon Capture and Storage). Continuing the use of fossil fuels can be made conditional on having contracted sufficient carbon storage whilst they are still being used, all while undertaking the energy transition as fast as possible.

The CTBO ensures that the costs of this are paid by the entity causing emissions - the companies that bring fossil fuels onto the market. This is efficient and effective (the polluter pays), and furthermore means that fossil fuel prices will rise, discouraging their use. With the introduction of a CTBO, producers and importers of natural gas will be obliged to buy (and surrender) carbon storage certificates in order to comply with the Carbon Takeback Obligation. The companies that can permanently store CO_2 receive these storage certificates and can sell them. This provides additional financing for CCS projects.

Storage certificates give a company the right to produce and import natural gas. Making storage certificates tradable (and thus creating a market), ensures this will be implemented efficiently. In this way it can be guaranteed that, regardless of how much fossil energy will still be needed, the net impact on the climate can be brought down to zero in good time. After all, it follows from the Paris agreement that the western world should be operating at climate neutrality between 2040 and 2050.

After the introduction of a CTBO, the fraction of carbon that must be removed and stored can be gradually increased. It's feasible to first implement this in the Netherlands, and then, as other countries become involved (such as those around the North Sea), to demand higher capture and storage percentages over time.

At the moment, there is no compensation for CO_2 fossil fuel carbon production through CO_2 storage (=0%). In 2050, this percentage must rise to 100% to achieve the Net Zero target. Given the discussions around a fair distribution of the global carbon budget, it's often pointed out that the West has to reach Net Zero even sooner. The CTBO offers a 'control lever' to actually achieve this if countries chose to do so.

Ambitious global climate policy would mean that fossil energy will be drastically curtailed, but in most scenarios it is not zero in 2050 (or 2040, in the western case). In these ambitious climate scenarios, roughly 10-20% of emission reductions are achieved with CCS and CDR (Carbon Dioxide Removal). This is a substantial challenge that, just like other energy transition goals, requires a planned approach to be realised in time.

[4] Any technology or activity that results in permanent carbon storage is in principle allowed (e.g. also carbon black storage, mineralization, biochar, long-term storage in concrete); the expectation is that the majority of permanent storage will take place though through storage of CO_2.

3 Goals and advantages

The goal of the CTBO is to provide certainty that the emissions from remaining fossil fuel use will be reduced in time, given the limited carbon budget.

In addition, a CTBO offers the following benefits:

- A more realistic price will be paid for natural gas, as the costs to the climate will be included in the form of storage costs. As a result, renewables will be able to compete with natural gas more quickly.
- A guarantee that climate considerations will be taken into account in decision making around (increasing) fossil fuel production: by making new permits for gas production in the Netherlands contingent on carbon storage (aka introducing a CTBO), it can be ensured that climate targets are not jeopardised if there is a decision to increase domestic gas production.
- Increased support for (the financing of) CCS projects through a fair distribution of costs: with a CTBO, polluters become responsible for cleaning up the pollution caused by the use of their products (the "polluter pays" principle), and there will be a compelling 'business case' for permanent CO_2 storage that offers investor certainty.
- Preparing the way for CDR (carbon removal) projects, that will be needed in the long term to
    - (1) Reduce potential overshoots in CO_2 concentration
    - (2) Compensate for any potential leakages in capture and storage and/or
    - (3) Compensate for any use of gas-fired power stations at leak load times (that are unabated due to short operating times).
- The CTBO will lead to more innovation and collaboration throughout the supply chain to find the smartest route of keeping carbon out of the atmosphere, and eventually removing it from the atmosphere through permanent storage in the geosphere.
- A way out of the so far irresolvable international negotiations about who will still be allowed to produce fossil fuels, given the remaining carbon budget. A multitude of reports call for the end of fossil fuel production, but, so far, the world has not succeeded in finding a fair and acceptable allocation formula: who can still produce what, and based on what criteria? By making a distinction between 'unabated' (with CO_2 emissions) and 'abated' (without CO_2 emissions) fossil fuel carbon flows - in line with the Paris and Glasgow agreements - at least part of the puzzle is solved: extraction is only permitted if there is a concrete carbon abatement plan in place.
- If implemented internationally, the CTBO can reduce the volatility of the energy markets in the coming decades: the uncertainty around the conditions under which fossil fuel production is still possible in different countries is contributing to an increasing dependence on countries like Russia and Saudi Arabia, increasing geopolitical risks and price fluctuations. By implementing strict but clear conditions for production, a CTBO can contribute to investor certainty and reduced dependency on countries with the largest reserves (Russia, the Middle East).

The CTBO is an instrument that is complementary to the ETS (emissions trading system). It is increasingly discussed that the ETS aims to drive large scale emission reductions, but does nothing to prevent new fossil fuel production. As a result, the social license to

operate for new extraction projects is limited, while the use of fossil fuel continues to increase, even with ambitious energy transition policy in place. This means businesses are being increasingly held to account by society and through legal proceedings on so-called scope 3 emissions. A CTBO addresses these emissions.

4 Boundary conditions

Important pre-conditions of the CTBO include that it should not lead to the use of more fossil fuel energy (in other words, ramping up efforts to decrease demand remain essential), and that it doesn't negatively impact the competitiveness of Dutch industry. The CTBO studies that were performed were done in collaboration with a wide range of stakeholders: companies, environmental organisations, scientists and experts. There is also close cooperation with scientists from Oxford University (Prof. Myles Allen et al.), who have already published multiple scientific articles on the policy instrument. International environmental organisations such as Bellona, Clean Air Task Force and Zero (Norway) are also positive about a CTBO.

It is important to emphasise that the CTBO is complementary to other climate policies as it is a so-called 'supply side' policy. It would work along-side existing demand-side policies (such as the European emission trading scheme ETS, or performance standards) to give the necessary incentives to reduce emissions from remaining fossil fuel production in time.

Economic research from CE Delft shows that the initial effect of the CTBO is mainly that subsidies for CCS (SDE++) can be phased out more quickly. On a longer term time horizon, the CTBO will lead to the conversion to hydrogen or (whilst fossil gas is still needed) electricity with CO_2 storage, and to the development of Carbon Removal (removal of CO_2 from the atmosphere) for hard to abate emissions. Research from both Oxford University and CE Delft indicates that the implementation of a CTBO (on top of quick acting policies to reduce fossil fuel demand) is an affordable, low-risk route to get to net-zero emissions by 2050.

Legal research indicates that a CTBO can be implemented in a similar way to so-called Extended Producer Responsibility regulation. This producer responsibility legislation is already in place for certain products which cause waste (e.g. batteries, packaging, electronics). The CTBO could best be using a customisable regulatory scheme that can be easily copied by other countries, so storage certificates can also be traded internationally.

5 Next steps

The CTBO could be an key additional instrument to reduce the emissions from the residual use of fossil fuel energy down to zero in time. We therefore propose the following:

1. To research about the best way of implementing a CTBO for producers and importers of natural gas under Dutch law, possibly in the form of an initial (voluntary) pilot project.

2. To carry out further research on the interaction of the CTBO with other regulations, and the effects it would have for different societal groups (building on the CE Delft research piece).
3. To discuss and closely cooperate with other North Sea countries and the EU to explore the possibility of forming a CTBO North Sea region.
4. To expand the Climate Act with a target to compensate 100% of remaining fossil energy use by 2050 with permanent CO_2 storage, and with an obligation to monitor the progress of this storage by reporting the percentage of CO_2 being stored.
5. To continue to involve stakeholders, such as those brought together by the CTBO sounding board group.

Having determined that the CTBO could be an attractive and applicable new policy instrument to achieve the desired reduction of CO_2 emissions, it will be necessary to think about how this will be implemented. It is up to the government to implement new policy, but this requires coordination and harmonisation between various sectors. Ideally, we would create a 'policy road map', which would outline the necessary steps towards the introduction of a CTBO, including the roles that different involved parties can play.

1. Introduction

1.1 CTBO in a nutshell

Worldwide, there is a range of policy instruments to implement the Paris and Glasgow agreements, trying to achieve the climate goal of limiting global warming to 2 degrees, and preferably to 1.5 degrees C. Most of them aim at *emissions,* that is the demand side in the energy system. Since a few years, the debate has come-up whether we need some additional instruments aiming at *inputs,* the influx of fossil fuels in the energy (and feedstocks) system. That is the supply side in the system. The well-known climate scientist Myles Allen, Oxford University, developed the idea of a carbon storage obligation as a mechanism to guarantee that geological carbon stocks that enter the economy in the form of hydrocarbons like oil and gas, will not end up in the atmosphere contributing to global warming, but need to be taken back to the geosphere in the form of carbon capture and storage and/or mineralisation.

> *The Carbon Takeback Obligation (CTBO is based on a simple scientific principle: If flow out (of the geopspher) (=production) is matched by flow in (storage), then there can be no net accumulation in the atmosphere. In other words, if carbon in fossil fuels supplied to a market is balanced by carbon taken out and stored, then none remains to accumulate in the atmosphere and cause global warming.*

A CTBO would make producers of fossil fuels and feedstocks responsible for making sure that sufficient storage is taking place. The required 'stored fraction' would be small first, but would increase to 1 (or 100%) in the year a country aims to become Net Zero. Compliance with the CTBO-regulations is demonstrated by purchasing and handing in (to the regulator) sufficient Carbon Storage Units or CSUs (evidence of safe and permanent carbon storage). CSUs can be traded, similarly to many other environmental attributes that can be traded, like emission allowances or manure allowances. The CTBO policy provides an assurance to all stakeholders that the net emissions caused by fossil energy use will reach Net Zero on time. For more details see Chapter 2.3 and Appendix B.

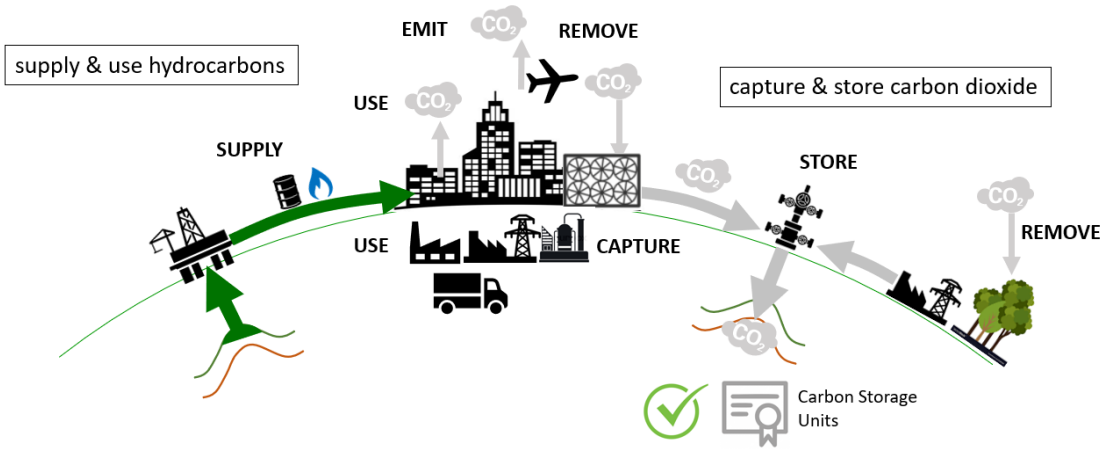

Figure 2: Principles of a carbon take back system

1.2 Global Context

The war in Ukraine is causing a fundamental change to the national and global gas markets. It has become clear that energy security requires diversification of energy sources, and avoidance of overdependence on certain countries like Russia. Unfortunately, it is exactly those countries (Russia, many OPEC countries) with autocratic leaders that are the owners of the largest proven reserves with the lowest production costs. This means that *not* investing in fossil energy elsewhere will make the whole world more and more dependent on these large resource holders, as production and consumption of fossil energy declines over the coming decades. In a world where all countries work together and trust each other fully, this would not be a problem, and the increasing dependence on large resource holders would be the optimum solution from an economic perspective. However, it is clear that we do not live in that world, and that it would be naïve to think that this could change in the coming years. Therefore, there will be new investments needed and actually done in fossil energy infrastructure in non-OPEC-plus countries.[5]

Solving dependency issues creates another problem, however. From the IPCC WG3 report:

> The continued installation of unabated fossil fuel[55] infrastructure will 'lock-in' GHG emissions. (*high confidence*)
>
> FOOTNOTE 55 says: In this context, 'unabated fossil fuels' refers to fossil fuels produced and used without interventions that substantially reduce the amount of GHG emitted throughout the life-cycle; for example, capturing 90% or more from power plants, or 50-80% of fugitive methane emissions from energy supply.

The challenge therefore is clear: all decisions that are made the coming months and years on new fossil energy contracts and projects have to include concrete requirements and plans to lower the carbon footprint of using that fossil energy. If we manage to do that, then the changes in the global energy markets will not only lead to inreased energy security, but also to the lowering of emissions from remaining fossil energy use.

This changed global context means that it has become very urgent now to implement policies and regulations that will make sure that there are no more investments in *unabated* fossil energy. This is one of the main objectives of a Carbon Takeback Obligation. Instead of a more gradual implementation and scaling up (as proposed in the roadmap of our first report), we now think it is essential that governments get serious about including strict 'abatement' requirements in all decisions that concern fossil energy production, supply and use. Our report has been revised to reflect this sense if urgency, and is therefore a combination of a more traditional feasibility study (see below) and a call for action.

We realize that it takes time to implement new policies and regulations, especially at the international level. However, there is no reason *not* to apply CTBO principles already in new production permits, bilateral agreements, LNG contracts, etc. Concrete targets for reducing methane intensity and safely stored fractions (CO_2 storage) can be included now and be

[5] In this report we focus on how to reduce the carbon footprint of the fossil energy that is still needed and used. This effort should be *in addition* to efforts to reduce demand for fossil energy by scaling up renewable energy, nuclear energy and increasing efficiency of energy use.

integrated in- and superseded by economy-wide CTBO regulations at a later date. The goal should be to *not* lock-in more unabated fossil energy production and infrastructure.

1.3 Conclusions of the first report

The first CTBO report was published in January 2021. On the basis of four stakeholder sessions, and many more separate discussions, we agreed on a set of shared objectives and boundary conditions for the implementation of a CTBO for fossil gas in the Netherlands:

Key objectives of a CTBO (2021 study):

1. A mechanism to ensure that the emissions from any remaining fossil carbon use are net zero by 2050
2. A simple and transparent mechanism to ensure that new decisions that involve fossil carbon (new production, use, investments) include the necessary conditions to be Paris-compliant
3. A mechanism that will provide a sustainable and broadly supported business model for CCS or other permanent removal. For broad support a clear and simple narrative is required.

Important boundary conditions:

- A CTBO should not slow down the transition (lock-in fossil energy, delay renewables)
- A CTBO should not make NL less attractive for investments
- General boundary conditions: fair, transparent, no perverse incentives, low leakage risk, cost effective, no/few legal barriers, public support, low admin costs, etc.

Next, these objectives and boundary conditions were used to discuss some of the more detailed design choices that have to be made when designing a CTBO policy. More details on this can be found in the original report.

The study included a more qualitative assessment of the impact a CTBO could have on different stakeholder groups. In the proposed Roadmap, it was suggested to start with a trial phase in the Netherlands (for fossil gas), but to scale-up quickly to North Sea or EU level.

1.4 Objectives of this study

This second CTBO study was intended to be a feasibility study. This means that possible showstoppers have to be identified, mitigated and evaluated.

The main scope items as agreed with the steering group were:

- Regulatory showstopper check (by Penrose) to evaluate if Dutch 'Extended Producer Responsibility' (in Dutch: Uitgebreide Producentenverantwoordelijkheid UPV) regulations can be applied directly also to fossil gas sales on the Dutch market.
- An economic impact assessment (by CE Delft) of implementing a CTBO, split into 2 parts:

  - Implementation of a CTBO in NL for fossil gas (between now and 2030): assessment of the economic impact for different stakeholder groups.
  - Implementation of a CTBO for all fossil energy in EU (up to 2050): economic modelling (MERGE model) to evaluate main impacts and differences with scenario's without CTBO-policies.
- Continued stakeholder engagement, especially at international level. Although a CTBO at lower percentages can be implemented at a national level, it is important that more countries join when the takeback percentage increases to significant levels (to maintain a level playing field for NL companies and to increase the climate impact).
- An update of the Roadmap; next steps.

Due to the changed reality (see comments above on the impact of the war in Ukraine), the latter action has been replaced by a more urgent call for action (instead of the more gradual roadmap).

To raise the profile of the CTBO as a supply-side instrument, we have also engaged with many groups and organisations, and also with the media, both nationally and internationally, and have held workshops at several conferences including COP-26 in Glasgow. More info can be found on the UK website www.carbontakeback.org.

1.5 Structure of the report

The structure of the report is fairly simple.

The First chapter is called Policy Brief and is a seperately readable piece that serves as an introductory chapter, and as a summary for policy makers. The Policy Brief in Dutch but will made available in English as well.

In Chapter 2 we give an update on the main CTBO developments and the results of feasibility studies. In Chapter 3 we summarize the main conclusions and recommendations.

We have tried to keep the main text of the report as concise as possible. More detailed background information and the full Penrose Law (legal) and CE Delft (economic) reports can be found in appendices.

2. Developments and study results

2.1 Objectives and Boundary Conditions

We did a quick review of whether or not the current developments warrant an update of the agreed objectives and boundary conditions for Carbon Takeback regulations.

In general, the conclusion is that no update is needed.
The second objective (to ensure that new decisions on fossil energy projects or contracts include conditions to ensure that emission reduction commitments will be met) has become especially important and urgent in the light of expected decisions and changes over the coming years. No new *unabated* fossil energy projects should be approved, according to the recent IPCC working group 3 report.
Although CTBO policies and regulations cannot be implemented overnight, there is no reason why agreements with industry on additional domestic production, new production permits, new LNG contracts, etc, cannot include specific requirements on methane emissions during production and overall CO_2 emissions, due to the use of the product (e.g. a 10% reduction target for 2030 can easiliy be converted to a 10% 'takeback' percentage in a few years when more formal CTBO policies are implemented).

The concern for a fossil energy 'lock-in' is increasing, as countries are looking at ways to reduce dependence from Russia by increasing domestic production and building new LNG infrastructure in more democratic countries. Considering that in 2021 the IEA concluded that in a Net Zero scenario 'no new projects' were needed, and that even LNG projects already under construction should be cancelled (!), it is understandable that people are very concerned (from a climate perspective) with all the new plans for projects and production. Studies show that a large % of proven reserves will have to stay in the ground to meet Paris commitments. Most studies calculate *what* stays in the ground and *where,* based on production costs. The lowest cost producers continue to produce the longest and most. These are typically the OPEC-plus countries.

There are important reasons though why countries deviate from this economically determined 'optimum' distribution:

- Energy security (geopolitics): dependence on imports carries certain risks as the world has found out (many times already). That's why countries with large domestic resources, even if these are maybe a bit higher cost, will always prefer to continue (some) domestic production (for example USA, Canada).
- Economic reasons: even if a country produces oil at twice the production costs as for example Saudi Arabia, they can still generate a lot of income from domestic oil production if the market prices are significantly higher than the production costs (as is currently the case in most countries).
- Climate reasons: strict conditions for production and use (eg methane regulations and CTBO) are more easily included for domestic production than for imports from Russia or the Middle-East. Also the climate footprint of resources may depend on the resource and geological field characteristics (like CO_2 content, viscosity, purity, depth, etc.) and the state of production technology (leakages and spills, illegal activities etc.).
- Fairness and social justice: there are several African countries that would like to develop their fossil gas resources, but are told by 'the west' that there is no room in the carbon budget for new projects and therefore financing of these projects is

becoming more and more difficult. To them, it seems unfair that instead countries that already produced a lot of oil and gas will be allowed to supply the remaining fossil energy that the world still needs this century.

In our first report we argued that when discussing 'lock-in', it is very important to distinguish between supply-side and demand-side lock-ins. Demand-side lock-ins should be avoided as much as possible: customers should be able to switch to electricity or hydrogen (or sustainable heat sources) as soon as possible. On the supply-side, however, we will need fossil energy for several more decades. *On the supply-side we propose to change the focus from 'no new projects' to 'no new* unabated *projects'.*
Every properly abated fossil energy project in Europe, North America, Africa, etc, means less import from unabated production from Russia and other countries. This will lead to more oil and gas reserves unused in OPEC+ countries and less unused reserves in countries that only allow 'abated' fossil energy production and use. Because CTBO requirements apply to anyone selling oil or gas products in a certain country or region, this will also apply to imported oil and gas from other countries. This will avoid unfair competition from low-cost producers that do not implement CTBO-like policies to reduce fossil energy emissions.
Ultimately, demand needs to be brought down by scaling up renewables, nuclear and energy efficiency. The energy demand that cannot yet be met with clean energy supply will be met with fossil energy. The objective should be that more and more of this fossil energy will be subject to CTBO-like requirements, so that the net footprint of this fossil energy use will come down, the costs of CO_2 removal are properly included in the product cost, and the energy transition will be accelerated.

2.2 Policy Developments and Interfaces

Many scenario studies have shown that the current policies will not reduce emissions rapidly enough to meet the targets that countries have set themselves[6]. That is of course one of the reasons that we are proposing a new, additional policy instrument. In the first report we explain in quite some detail the differences between supply- and demand-side policies and which 'policy gap' we are aiming to fill with the CTBO (see chapters 2.3, 2.4 and Appendix F in the first report).

A quick recap.

The goal of net zero emissions requires policies, regulations and plans (including targets) in three areas:

- *Reduce* fossil energy use by scaling up renewables, nuclear, efficiency, behavior changes, etc. Many countries have plans and policies for this. (1)
- *Clean up* remaining fossil energy use: reducing methane emissions and reducing net CO_2 emissions (2). Government plans are scarce.

[6] Heleen L. van Soest – Mind the Gap. Applying Integrated Assessment Models to Inform International and National Climate Policy on Bridging the Emissions Gap. PhD thesis, https://dspace.library.uu.nl/handle/1874/416583

- Carbon *removal* from the atmosphere: develop technologies, regulations, accounting rules, so that companies can take responsibility and compensate for any remaining, difficult to avoid, emissions. (3) Here too, government plans are scarce.

For each of these areas, governments will have to set targets, develop regulations, ensure that incentives are in place, monitor, report, etc. Policies can target either the supply- or the demand-side, or both. We argue that in view of the very rapid emission reductions required, governments should incentivize (through regulations and/or subsidies) both the supplier/producer and the user/consumer. This is happening already for renewable electricity and hydrogen, and this should also be done for cleaning up fossil energy use. On the demand-side, taxes and ETS are already in place, but *on the supply-side* (the producers of oil and gas) *there is no direct incentive to take responsibility for the emissions caused by the use of the product*. This is the purpose of the CTBO.

A question that often comes up is how a CTBO interacts or overlaps with other policy proposals.

First, it should be noted that in a technical-instrumental sense, there is no direct interaction, since the leverage points for measures are very different: emissions in the case of demand-side regulations (emissions from cars, from industries, from households etc.), versus fossil carbon flows in case of a supply-side instrument like the CTBO. It regulates the *market entry:* batches of fossil fuels are *only* allowed on the market if it is *guaranteed beforehand* that the CO_2 they produce in the use phase are *never emitted* into the atmosphere, but instead are stored in geological formations. In that sense, there is no interference: the leverage points do *not* overlap, they are different and complimentary.

Nevertheless, as some instruments like emission allowances are tradeable, and we aim at also making CSUs (Carbon Storage Units) tradable, the brain may be tricked to think that there is overlap. As said, technically there is not, and CSU *can not be used* to comply with ETS incentives. But there may be *market* interference or market coupling, as we know from other markets, e.g. price fluctuations on the market for grains may influence the rice market or any other staple food market. As becomes clear as an outcome of the Ukraine crisis as well. So indeed, CSU prices may affect ETS prices and vice versa. And other market-based pricing mechanisms, like SDE++ subsidies, that are based on market prices (contract for difference) after all.

But these pricing interactions should *not* be mistaken for technical-instrumental interference or overlap.

The work done by CE Delft (see section 2.5) gives some insights into the interaction with SDE++ and the ETS. In Appendix A we have done an extensive assessment of the EU Fit-for-55 package's relevance for the CTBO. Every policy proposal has advantages and disadvantages that need careful assessment, mitigation and management. *In general though, the CTBO remains the only supply-side policy proposal that aims at regulating climate impacting emissions as close as possible to the wellhead.* This makes it a unique policy with unique added value and characteristics that cannot easily be replaced by other policies. For coal, there is an argument to be made to exclude this, and to focus instead on a rapid phase-out (at least for Europe; but worldwide, this would be needed as well, as IPCC and IEA mention). For oil, fuel quality directives that would allow CCS/CDR projects to meet the standard (like the California FQD) would be a possible alternative for a CTBO for the oil produced for fuels. Oil used as feedstock for chemicals and plastics is a more difficult challenge altogether. Our initial focus will therefore continue to be on implementing the

CTBO for fossil gas production, import and use.

2.3 How would a CTBO work in practice?

Based on a more detailed look at the Dutch gas market we propose the following set-up for implementing a CTBO (see Appendix B for more detail):

- An obligation is placed on a producer to demonstrate that an increasing percentage of the carbon taken out of the ground is stored permanently somewhere.
- The producer can meet this obligation by generating or purchasing sufficient Carbon Storage Units (CSUs)
- CSUs are awarded for each ton of carbon (or CO_2) permanently stored
- Only fossil gas that meets CTBO standards can be sold on the Dutch market
  This can be compared to e.g. the requirement that only wood from sustainably managed forests can be used or sold on a market. We propose to introduce CTBO certificates for fossil gas that meets the CTBO-obligation standards.
- Producers or importers that want to sell on the Dutch market can purchase CSUs and exchange their CSUs for CTBO-certificates for their gas. The number of CTBO certificates that they get for 1 CSU will gradually decline as the CTBO percentage increases to 100%.
- All the fossil gas sold on the (in our case: Dutch) Market has to have CTBO-certificates. These can be checked and traced and retired similarly to the system altready in place for green gas certificates. It is the expectation that a carbon storage surcharge will be included in the price of gas to (re)cover the additional cost of purchasing CSUs.

Technically it is not necessary to have both CSUs and CTBO-certificates for fossil gas. However, we think adding the CTBO-certificates has some further advantages:

- It will raise customer awareness that the producers and suppliers of their gas are working to progressively lower the net impact of fossil gas use. For that reason the CTBO-gas will have an increasingly higher price than unabated gas.
- It may help with international trading between countries that both have CTBOs in place (but possibly with different net zero dates; eg African countries may have a later Net Zero date than EU countries). Fossil gas with a valid CTBO-certificate can be sold on the market in any country that is a member of the CTBO club.
- Over time countries like the EU should aim to only import CTBO-certified gas, and countries that still export a lot (like Norway) should only export to countries that have CTBO regulations in place and therefore prefer to purchase CTBO-gas.

2.4 Use of EPR Regulations (Penrose report)

After concluding the first study and report, discussions were held with experts to better understand the legal and regulatory challenges of implementing a CTBO in the Netherlands, before other countries may be ready to join.

This presents the usual challenge of how to avoid 'level playing field' problems with foreign competitors and/or imported products. It quickly became clear that border taxes are not an option at country level anymore in the EU. This is only possible at EU level. Nevertheless, it was important to make sure that if a Carbon Takeback Obligation would be placed on

domestic producers only, this would not disadvantage them compared to importers of fossil gas in the Netherlands.

Extended Producer Responsibility schemes (in NL: Uitgebreide Producenten Verantwoordelijkheid, UPV) deal with that issue all the time: anyone selling a certain product on the Dutch market is held responsible for the collection, recycling and/or safe waste disposal of the waste created by the product. This requirement is independent of whether the product is produced in the Netherlands or whether it is produced elsewhere and imported and sold in the Netherlands. In EPR regulations the term 'producer' therefore applies to producers and also to importers of a product. This seemed very appropriate also for the CTBO as this would require importers to also purchase CSUs in order to be allowed to sell fossil gas on the dutch market.

Penrose Law was asked to carry out a legal and regulatory review of Dutch EPR regulations to assess if it is indeed possible to use the same regulations as are used for example for batteries, electronic goods, car tyres, etc. Their report can be found in Appendix C.

The legal research has led to the following conclusions:

- A mandatory scheme based on EPR-principles is feasible but would require additional legislation and/or regulations
- A mandatory system with a generally-binding EPR-agreement is not feasible within the current Dutch legal framework because of the explicit exclusion of CO_2 as waste under EPR.
- A voluntary system is conceivable but would not provide a level playing field

The main reason for this showstopper is that explicit exceptions have been made in the EMA (Environmental Management Act, Wet Milieubeheer) with regard to (the emission, capture and storage of) CO_2.

The advantage of using the EMA-EPR legislation would be that this could be done relatively quickly if the sector agreed and requested this. The disadvantage of using the EMA-EPR regulations is that the Dutch EPR regulations are fairly unique and would be difficult to copy by other countries. It is therefore recommended that, if it is decided to develop additional legislation and/or regulations for the CTBO in NL that this is done in close co-operation with the EU and other countries (like UK and Norway) that are interested in CTBO regulations. The Penrose report offers some suggestions and options on how this could be set up.

2.5 Economic Impact Analysis CE Delft

CE Delft has done a quantitative assessment of the estimates made in the first CTBO report on economic impacts for different stakeholder groups.

Their study is split into two parts:

1. Period up to 2030:

A fossil gas CTBO is implemented in NL; in this period the CCS infrastructure and volumes stored will be limited, and therefore it is assumed that the CSU-price will be fixed[7] (roughly at the level of the transport and storage costs; 40 €/t) and that the takeback percentage will be determined by the amount of CO_2 actually stored (due to a combination of ETS price, CSU-price and SDE++).

The main conclusions for this phase are:

- additional costs for customers is limited to around 1 cent per m3 gas
- this additional cost could reduce gas demand by roughly 1%, leading to some reduced income for suppliers (sales) and government (taxes)
- the CTBO effectively takes over the role of the SDE++ (for gas projects) in providing additional (to ETS) financing for CCS projects
- this creates room (under the SDE++ ceiling for CCS projects) for some additional CCS projects on emissions from oil processing (+/- 2 Mt/y extra in 2030)
- The CTBO percentage is around 15% by 2030; this percentage is not very sensitive to the CSU-price.

2. *Period up to 2050:*
A CTBO is implemented by the EU; the CTBO percentage is ramped up to 100% in 2050; CSUs are traded on a market (similar to ETS and emission allowances). The purpose of this analysis is to investigate how the energy system as described by models and scenario's, is impacted when a supply-side policy like a CTBO is added. This is not an easy question as most models work best with only supply or demand side policies. Therefore the results should be regarded as a first indication, and further work has been identified to define how the CTBO can best be included in economic models.

The main conclusions for this phase are:

- Compared to a scenario in which net zero is reached with a limited amount of CCS (capped) there is likely to be more carbon storage, both for fossil energy and for CO_2 emissions from biomass use.
- Overall costs of reaching net zero are reduced; lower energy and ETS prices
- *Not* modelled yet is the addition of a CTBO to scenario's in which net zero is *not* reached in time. For example, the 'stated policies scenario' or the scenario based on current national pledges. Both these scenario's lead to longer-term use of fossil gas, and it would be interesting to see the impact of adding a CTBO on these scenario's.

[7] The ultimate goal of an open market where the CSU-price is determined by supply and demand (and the increasing CTBO percentage) can only be realized when there is enough liquidity in the market (more mature CCS infrastructure, more countries joined).

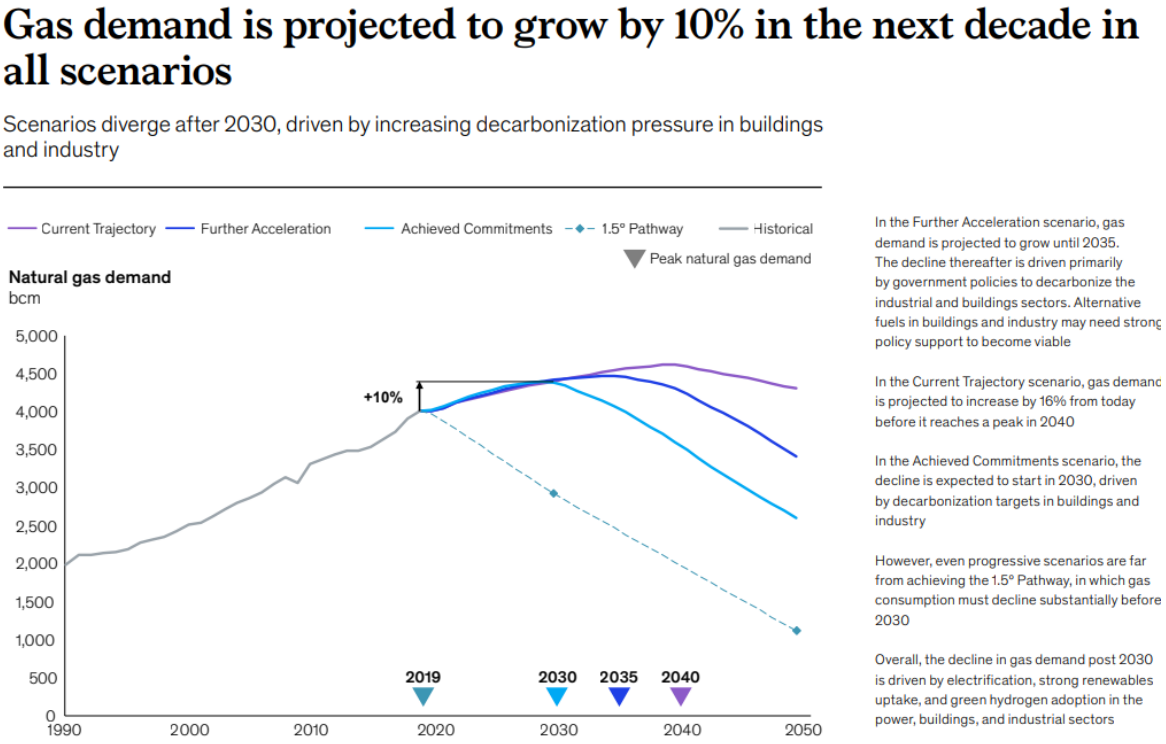

Figure 3: Projected increases in gas demand are driving the need for instruments that help decarbonizing fossil fuels.

2.6 Stakeholders

Significant amount of time was spent on engaging more stakeholders and organisations, with two objectives: to get more people familiar with and interested in the CTBO and to understand their perspectives, and secondly, to start growing an international network of supporters for the CTBO-principles. Ultimately, a CTBO is most effective when implemented in as many countries as possible. To grow awareness there have also been several media-items on the CTBO idea, both in the Netherlands and internationally.

The main developments in stakeholder perspectives over the last year have been as follows:

- NGOs: environmental NGOs have continued to become more interested and/or supportive of the CTBO concept. The hard targets for net emissions and the way the CTBO forces the polluter to pay for cleaning up, are the main advantages of a CTBO for ngo's. Fossil energy 'lock-in' remains the main concern (as addressed in the first report).
- Producing companies: the pressure to take action on scope 3 emissions continues to increase and demonstrating that projects and activities are 'Paris-compliant' has become more and more important. The CTBO provides a strong narrative that can deliver both on energy security and timely emission reductions, and also reduce the uncertainties that currently hamper investments (both in fossil energy and CCS)

ElementNL (formerly NOGEPA) has therefore included CTBO as a potentially interesting policy instrument in their recently published action plan. [8]

- CO_2 infra (transport and storage companies): the certainty of a growing demand for CSUs provides these companies with a much more robust and longer-term business model than most alternative options for financing their activities. It is expected that a CTBO policy will create interest in transport- and storage activities from new companies as well as from oil- and gas-producing companies that will become dependent on having access to affordable CSUs.
- Emitting companies: the CTBO means that there will be companies actively looking for CO_2 that they can store; this is a big change from the current situation where emitters have to find companies that are willing to do the transport and storage as a contractor. On the other hand, the price of fossil gas will go up gradually due to the carbon storage surcharge, which can be a risk for companies operating on an international market.
- Governments: the renewed awareness of the importance of energy security has led to new interest in domestic production of fossil gas. At the same time new exploration and production permits are increasingly getting challenged in courts and the political support for new oil and gas production is also declining in most European countries. A CTBO for fossil gas production and use could help with both (defence in court cases, political support). The Dutch minister for Climate and Energy has recently agreed to include the CTBO in the discussions with the gas producers about possible increases of fossil gas production from the North Sea.

Below is a list of the main organisations that have been engaged over the last couple of years. In Appendix C the most commonly asked questions about a CTBO have been answered.

NGOs:
Bellona, Clean Air Task Force, Natuur & Milieu, Milieudefensie, Zero Norway

Branche organisations and companies:
SPE, IEA, IOGP, IPIECA, NOIA (North Sea operators association), OGCI, CCSa, NEP (Negative Emissions Platform), Carbon Gap, ECF (European Climate Foundation), ExxonMobil, Gasterra

Governments:
UK Net Zero APPG, Norway (via Zero), Denmark (Danish Energy Agency), Netherlands (MP's, min EZK, Climate Envoy), COP-26 event on CTBO

Scientific community:
Oxford Net Zero (prof Myles Allen and others) are the main drivers of the CTBO policy in the UK and internationally. Also very active on this is prof Stuart Haszeldine of the university of Edinburgh. Information is available via www.carbontakeback.org .

In Appendix E some of the most frequently expressed concerns are listed and responded to.

[8] https://www.elementnl.nl/actieagenda/verminderen-emissies-hele-keten

Other linked initiatives that are worth mentioning:

- Sustainable Markets Initiative (together with BP) have made a video and slidepack: https://www.sustainable-markets.org/taskforces/ccus-taskforce/
- Geological Net Zero: https://www.researchgate.net/publication/358248129_Geological_Net_Zero_Geological_Carbon_Neutrality_-How_could_we_get_there
- PACE (Producer Accountability for Carbon Emissions): North-American non-profit organisation set up to promote producer responsibility policies for fossil carbon production. Website currently under construction. https://pacemissions.org/
- KAPSARC (Saudi Arabia) research papers: https://www.kapsarc.org/file-download.php?i=28368
- OGCI report: https://www.ogci.com/study-on-carbon-storage-units-and-obligations-under-article-6-of-the-paris-agreement

3. Conclusions and recommendations

General:
The latest IPCC working group 3 report ("no more unabated fossil energy projects") and the need to stop using Russian gas, have made the introduction of regulations to 'abate' the emissions from fossil gas use more urgent. CTBO-like policies and/or performance standard should therefore be investigated, progressed and implemented with high priority.

Legal/regulations:
Specific regulations should be developed that can easily be adopted and implemented in a wide range of countries. It is possible and recommended to base the regulations on the same principles and structures as used for other 'producer responsibility' regulations that are already proven and operational.

Economic impact:
A safe trial phase with limited impact can be set up in the Netherlands based on a fixed CSU price and a cost pass-through to customers.
A CTBO is predicted to become relatively more important over time as the takeback percentage increases and there is no 'easy' CO_2 to capture anymore at large (ETS) point sources. This will lead to a more rapid increase of the CSU price and fossil gas price. Increased use of CCS leads to lower energy and ETS-prices, and to a lower cost of reaching net zero. Compared to a net zero scenario with very little CCS adding a CTBO will by definition lead to more fossil energy use (and also biomass and CCS).

For further conclusions and recommendations: see the Policy Brief, included in this report (in Dutch and in English).

Appendices

Margriet Kuijper Consultancy

Royal HaskoningDHV
Enhancing Society Together

De Gemeynt

Appendix A: CTBO Policy fit

CTBO policy: how does it fit in, is it still needed (Fitfor55), and what are the main alternatives?

Introduction

Climate policies are constantly developing, and therefore it is important to evaluate from time to time whether a CTBO would still add value to already existing and proposed policies, and how a CTBO compares with newly proposed policies. The most recent addition to climate policies in the EU is the Fit-for-55 package of proposals. And specifically, the extension of the ETS to buildings (heating) and road transport. In this note we therefore address the following questions:

A: Climate policy framework: where does a CTBO fit in?

B: What would the impact be of an ETS for buildings and road transport? Is a CTBO still needed?

C: What are the main alternative policies for a CTBO, and how do these compare?

Three key questions

A: Climate policy framework: where does a CTBO fit in?

It is generally considered good practice not to have too much overlap in policies. Nevertheless, this does happen quite often as goals are added to the goal of emission reduction (eg efficiency targets, or renewable energy targets). In the first CTBO report we address this issue (climate policy framework) in quite some detail (see 1.2, 2.3, 3.3, 4.4 and Attachment F). The table below is from Attachment F:

	SUPPLY (producer)	DEMAND (user)
Renewable Energy Efficiency	RE directive (%) Subsidies RE Fuel Quality directive Upstream tax fossil energy FF production bans	Energy/carbon pricing Subsidies (PV, insolation, EV) Performance standards (buildings, equipment)
Clean-up fossil energy use (CCS)	CTBO	Carbon pricing Subsidies
Remove/store carbon	CTBO	Carbon pricing Emission standards

In theory, with a timely start improving energy efficiency and replacing fossil fuels with renewable energy would have been all that is needed. However, we did not start on time, time is running out and emissions are not declining, and therefore it is now also necessary to clean-up fossil energy use while we still need it to meet energy demand. This means reducing the greenhouse gas emissions per unit of energy produced, for example by minimising methane emissions and capturing and storing CO_2. But even that may not be enough, and it now seems likely that carbon removal (from the atmosphere) will also be required.

Because of the *unprecedented rapid emission reduction requirements* it will be important to implement complementary policies both on the '*supply'* and '*demand'* side. This will encourage cooperation in the value chains and avoid 'chicken-or-egg' delays: e.g. users waiting to shift to electricity until there is enough renewable electricity and producers waiting to produce more renewable electricity until they're sure there is a market; same with hydrogen production and customers; same with CO_2 capture and transport and storage infrastructure.

A well-balanced and comprehensive climate policy framework has specific policies (regulations, incentives, pricing, etc) for each of the 6 boxes in the table above.

The Carbon Takeback Obligation is unique in addressing the supply side of the fossil energy value chain. Indirectly it also provides an incentive for energy efficiency and renewable energy (by increasing fossil energy prices) and for the storage of carbon removed from the atmosphere. At the moment there is a large disconnect between decision making on new oil and gas production and the targets that are being set for emission reductions.[9] A CTBO will make fossil energy production dependent on progress with carbon storage, thereby directly linking production and sales of fossil fuels with the emission reduction targets. Ultimately net zero in 2050 means that either fossil energy use has to be ended by 2050 or remaining fossil energy use has to be made carbon neutral by capturing and storing emissions and/or by offsetting any remaining emissions. *In other words: remaining fossil carbon production has to be fully balanced by permanent carbon storage.*

The CTBO percentage (or Safely Stored Fraction) has to be 100%. Actively monitoring and mandating a gradually increasing percentage will greatly increase the probability of actually reaching 100% by 2050. Without (something like) a CTBO the most likely alternative is that fossil energy use will remain 'unabated' and emissions will continue to be dumped in the atmosphere until we don't need fossil energy anymore.

In the 2021 NL CTBO study it was decided to focus on natural gas in first instance; at the moment there are no requirements for natural gas producers or suppliers to do anything about the emissions caused by the use of their product. *There is therefore clearly a gap in the policy framework for the supply-side for natural gas.*

B: What would the impact be of an ETS for buildings and road transport? Is a CTBO still needed?

In the Fit-for-55 package there is a proposal to set up a separate ETS for transport and buildings. This would start in 2026 (or 2028) and a linear reduction of 5.15% (or 5.43%) would be mandated to ensure net zero is reached before 2050. The emission allowances have to be bought 'upstream' by the companies that bring the fuels to the market.

Where does this policy fit in the climate policy framework? It clearly is a 'supply-side' policy as the suppliers of the fuels have to purchase emission allowances. The question is what these suppliers can do to reduce the number of emission allowances they need by >5% per year, year on year.

Remember that all these fuels are used by small and dispersed users (cars and buildings). Therefore, carbon capture and storage is not really an option. The best way to achieve reductions is by efficiency improvements (cars with better fuel efficiency, home insulation) and by switching to renewable energy sources (blending in biofuels, low-carbon gases, renewable electricity, EV's, etc).

[9] https://energymonitor.ai/finance/risk-management/exclusive-natural-gas-data-reveals-trillions-of-dollars-of-upcoming-gas-projects

Therefore, this policy predominantly falls in the top line of our policy framework (see A). Decarbonised fossil fuels (eg hydrogen, methanol, produced with CO_2 storage) could make a small contribution if and where allowed (eg by blending in hydrogen into the gas network, or adding methanol to gasoline).

From the above it is clear that many of the actions required to reduce demand for fossil fuels in transport and buildings is OUTSIDE the influence of the companies selling the fuels (eg promoting switching to EV's or insolation of homes or switching to heat-pumps). Complementary policies on the 'demand-side' (see policy framework) are therefore essential to avoid energy/fuel shortages in case of insufficient emission allowances. Emission reductions will predominantly be a result of these demand-side policies, and not of the supply-side ETS. As such, this new ETS is mainly a revenue raising policy. Considering the political risk of backlash (gilet jaune etc) this may not be worth it. These dynamics are explained in detail in the book 'Making Climate Policy Work'.[10]

What does this mean for the proposed CTBO for natural gas sales in the Netherlands?

We think that a CTBO for natural gas will still be important for the following reasons:

- Natural gas is used by many different users in the Netherlands. Gas use in buildings is only one of the many uses for natural gas. A CTBO would cover ALL natural gas sales in the Netherlands: by ETS companies (heavy industry and power plants), by non-ETS industry and smaller businesses, by farmers, by greenhouses, and by buildings (users).
- A CTBO is an obligation for suppliers to collect and permanently store an increasing % of the CO_2 emissions caused by their product; the polluter is paying to clean-up, and that will cause an increase of the product price. Carbon pricing schemes (ETS, taxes) also make the polluter pay, but they pay to (be allowed to) pollute. In both cases it is the hope that the resulting higher prices will make the customer switch to more sustainable alternatives.
- A CTBO mandates responsible companies (producers, suppliers) to invest in CO_2 transport and storage infrastructure so that they can be sure that they can comply with their CTBO, and so that NL can be sure that 100% takeback is reached on time (2050). In addition to infrastructure this will require timely investments in carbon removal technologies like DACS and BiCRS.

Furthermore, not all objectives of a CTBO can be achieved with the FF55 proposals. See below.

C: What are the main alternative policies for a CTBO, and how do these compare?

C1: Introduction

Questions often asked about the CTBO are how it is different from carbon pricing and other proposed or existing policies to reduce fossil energy emissions. To answer this in more detail it is good to first discuss the objectives of a CTBO-policy. In the 2020 study in the Netherlands we started with an in-depth discussion on *why* different stakeholders thought a CTBO could be useful. In the end, the group agreed on the following 3 objectives:

1) *A mechanism to ensure that the emissions from any remaining fossil carbon use are net zero by 2050;*

[10] https://politybooks.com/bookdetail/?isbn=9781509541799

There is a real concern that as demand for energy continues to increase we will continue to use unabated fossil energy and emissions will not reduce sufficiently; mandating a steadily increasing Takeback Obligation would greatly improve the chances that we do not have net emissions from fossil energy use anymore by 2050.

2) *A simple and transparent mechanism to ensure that new decisions that involve fossil carbon (new production, use, investments) include the necessary conditions to be Paris-compliant;*
In most of the world (and until recently in all of the world) decisions about more fossil energy production, plants, etc, are made without any regard for the remaining carbon budget. That does not make sense anymore, and is increasingly getting challenged in courts. A CTBO for new production (as condition in the production permit) would ensure that emissions as a result of the production and use would reduce over time and be net zero by 2050.

3) *A mechanism that will provide a sustainable and broadly supported business model for CCS or other permanent removal.*
The first CCS projects in Europe that are being planned at the moment all depend on subsidies. Although this is understandable for first projects it is essential that subsidies are replaced asap by long-term regulations that ensure that companies continue to capture and store more and more of the remaining fossil energy use, also after subsidies end. The cost of waste disposal should be borne by the beneficiaries of the fossil energy value chain (producers, users, governments) and reflected in the product price. For companies interested in investing in (parts of) the CCS value chain a CTBO will provide the longer-term policy certainty that is needed for large projects and investments.

We also discussed important boundary conditions such as 'no lock-in of fossil energy use' and 'level playing field for companies'. Please check out our report (chapter 3) for more details.

So how does CTBO compare to some alternative policies?

First comment to make is that, as we have explained above, we think that CTBO is *not* an *alternative* to many policies, but a policy instrument that should be used *in addition* to other policy instruments. So, when answering the question we will assume CTBO is added to policies already in place. For each alternative we will discuss:

a) How the alternative scores against the agreed objectives for the CTBO
b) The main pros and cons of the alternative compared to a CTBO

C2: Carbon pricing 'demand-side'

The question on how the CTBO differs from carbon pricing under ETS (or carbon taxes) comes up often. We see ETS and CTBO as complimentary policies that together will ensure a stable business case for investing in CCS and decarbonised fossil energy projects (blue H2, ammonia, gas power).

a) Comparison against CTBO objectives

- Net zero by 2050: Although technically the ETS cannot deal with 'negative emissions' at the moment, there is no reason that the ETS could not be adjusted so that net zero emissions by 2050 can be reached. For carbon taxes this is more difficult, but in theory also possible if taxes are increased enough. However, ETS only covers a limited % of total

fossil energy use and emissions. A CTBO would cover all fossil gas (and possibly oil later on) that is produced and used.
- New decisions on fossil energy production to include Paris-compliant conditions: that is not possible with a carbon pricing system for emissions.
- A broadly supported business model for CCS: carbon pricing of emissions (ETS or tax) can provide a good business model for CCS for large point sources. However, it can take quite a bit of time before ETS-prices are high (and certain) enough to support CCS projects, and ETS is less effective after most of the large point sources have been captured (or eliminated) and there still are a lot of emissions from smaller sources. CTBO can help in the early stages (as transport and storage costs are effectively shared by all users) and in the later stages when smaller remaining users need to be decarbonised (by switching to electricity or hydrogen e.g.).

b) Main pro's & con's emission pricing vs CTBO

- Concluding we would say that the main 'pro' of *not* adding a CTBO is that emissions trading and carbon pricing are policies with established track records and therefore known and easier to extend and make more ambitious.
- The main 'cons' of only carbon pricing on emissions is that it's very difficult to cover all emission sources (see ETS eg) and it does nothing to make the producers/suppliers of the fossil carbon (co-)responsible for the emissions of their product and thereby putting a 'brake' on fossil energy production (if not enough carbon is stored then production will be restricted).

C3: Carbon pricing supply-side (see also the discussion on FF55 above)

Instead of pricing the carbon at the point of emissions it can also be done further 'upstream' for example at the point of extraction (oil/gas producer) or at the point of sale (fuel supplier). As there are millions of emission points and less than 100 companies producing most of our oil and gas, there clearly is a point to be made to have 'supply-side' regulations (instead of emission pricing). Similar to a producer CTBO, a wellhead carbon tax would increase the costs of producers leading to higher product prices which should encourage consumers to consider and switch to cleaner alternatives.

a) Comparison against CTBO objectives

- Net zero by 2050: an upstream carbon tax is unlikely to deliver that (taxes tend not to be high enough and politically sensitive).
- New decisions on fossil energy production to include Paris-compliant conditions: no direct impact on these decisions; no guarantee of 'no new unabated fossil energy'.
- A broadly supported business model for CCS: does not result in a broadly supported business case for CCS

b) Main pros and cons supply-side carbon pricing vs CTBO

- pros: government revenues
- cons: does not help cleaning up fossil energy use, double taxing, further carbon entanglement of governments (dependence on revenues from fossil energy production and use).

C4: Production bans, phase-outs, non-proliferation treaties

There are many studies and scenario's that show that there is far more production possible (reserves) and being planned (production gap report) than that we can safely accommodate within

the remaining carbon budget. As a result the call for simply stopping new production and a 'managed decline' or 'winding down' of existing production is getting louder and louder. Some countries (mainly the ones with limited/no fossil energy reserves) have already committed to end fossil energy production. It is highly unlikely however that countries with large fossil energy reserves will join these kind of coalitions. They intend to keep producing as long as there is demand. Having said that, these initiatives do have psychological impact by further delegitimizing fossil energy production. See: https://www.weforum.org/agenda/2021/08/this-is-why-we-need-a-fossil-fuel-treaty/ and https://beyondoilandgasalliance.com/

C5: A few other advantages of CTBO policy:

- A CTBO is all about 'stock management': carbon taken out of geological reservoirs has to be compensated for by storing carbon in permanent storage locations. By demanding storage to be permanent (outside of the short term carbon cycle) it will indirectly also become very difficult to offset fossil emissions with carbon removal by planting trees. This is essential if we want to stop transferring fossil carbon to the short term carbon cycle.
- Fossil energy producers are made (co-)responsible for the waste of their product; no other policy exists or is currently proposed that does that.
- This will also encourage timely search for and development of CO_2 storage capacity. At the moment this is becoming a growing concern, especially in regions where exploration is needed before a CO_2 storage site can be developed.
- Carbon removal responsibility for difficult to mitigate emissions: a CTBO minimises the risk that costs for carbon removal to offset these emissions will be left to society; producer and user will need to pay for removal (to offset emissions) and permanent storage (to meet their CTB obligation)
  Carbon removal to compensate for historical emissions and overshoot: it is not unlikely that society will be using quite a bit of fossil energy still by 2050 (with CCS and remaining emissions compensated by removals with permanent storage). Eg in the IEA net zero scenario fossil gas use in 2050 is around 45% of current use. A CTBO policy could easily be used in that case to incentivize carbon removal simply by increasing the takeback percentage to above 100%. This will further discourage fossil energy use while contributing to removal of historic emissions (overshoot).

There are very few policies at this moment that assign formal responsibilities for the waste management of their products to fossil energy producers. Producers are held to be 'morally responsible' (see all the protest, divestment movement, court cases) even though their 'formal responsibility' for the waste of their products is very limited in most of the world. Hence the long discussions about scope 3 reporting over the last decades. Fortunately, this is changing, and companies are more and more accepting (some) responsibility for scope 3 emissions. This is the right time therefore to formalise this with a CTBO. These companies have the expertise and assets to carry our these projects, and some are already getting involved voluntarily. However, to keep the playing field level, and to make sure we progress rapidly enough it is important to make this mandatory in as many countries as quickly as possible.

Appendix B: CTBO: How it could work

B1: Takeback percentage: numerator and denominator

At the heart of the CTBO policy is the takeback percentage. Also called the 'stored fraction'.

The simplicity of the formula is part of its appeal:

CTBO%= carbon stored/ carbon produced (x100%)

Numerator = how much CO_2 is safely and permanently stored; usually expressed in tons of CO_2

Denominator = how much carbon has been produced (or imported); usually this is also expressed in tons of CO_2 by calculating how much CO_2 would be emitted if all the produced/imported carbon were to be burned.

Many countries have by now set a date by which they want to be Net Zero. For the Netherlands this is 2050. This means that the target has to be a CTB% of 100 by 2050. At the moment we are at zero.

In several papers it has been suggested that to have a chance of reaching 100% by 2050 the CTB% has to be around 10 in 2030 and around 40 or 50% in 2040. Note that total gas production/sales will start to decrease faster in the 2030's and toward 2050. Therefore annual storage volumes will actually level off after 2035 or so, as the 'denominator' gets smaller and smaller. The CTB% therefore will increase if more CO_2 is stored but also when less fossil carbon is produced (sold).

The question is often asked: why not 30 or 40% in 2030 as target? There are two main reasons for that: first of all, this would require scaling up too rapidly with associated cost and delivery risks, but equally important: this would force companies to do CCS where there are other options thereby creating an unnecessary lock-in. Remember that most of the 50-60% emission reductions targeted for 2030 will be coming from a switch to renewable energy sources, efficiency improvements and closing in of coal-fired power plants. A target of 10% is consistent with CCS volumes being discussed as part of the climate agreement.

We will start (section 2) by describing roughly how a CTBO commitment based on EPR-principles (Extended Producer Responsibility) could work in NL.

In section 3 we will discuss variations on this basic CTBO% formula by looking at specific cases in practice. For example, what if some of the stored CO_2 comes from carbon in oil or biomass?

B2. How does a CTBO work in practice under an UPV-agreement?

This section describes the proposed process for implementing a CTBO for fossil gas based on EPR-type regulations. It is important to keep in mind that the CTBO is proposed to be implemented in phases. In the first phase it is very similar to other EPR-schemes (or as similar as possible) in that producers/importers will be required to ensure that a certain percentage of the waste is collected and safely disposed of. The costs of collecting (transport) and disposing (storage) the waste is recovered by adding a carbon storage surcharge to the gas price. Over time (as the CCS infrastructure grows, more and more projects become operational, and other countries implement CTBO regulations) it is the intention to transition to a full market mechanism for determining the

price of Carbon Storage Units. See pg 64, 65 in the first CTBO-report. At that point CSU's could become very cheap (e.g. when ETS prices are high and driving the demand for CCS) or become very expensive (eg when there are no more easy to capture large point sources of CO_2). Ultimately, the CSU-price will have to include carbon storage from DACS and/or BiCRS (Biomass Carbon Removal and Storage) if continued production of fossil gas is still needed (to meet energy demand). In the end these increasing CSU-prices will lead to a much higher Carbon Storage Surcharge (see page 50 of first CTBO report).

For now, we are focussing on the first phase: implementation based on EPR-principles.

Fossil gas is traded many times before it goes to an end-user. Therefore, it is proposed to check compliance with the CTBO-regulations when and where the gas is sold on the Dutch market. The physical point where this happens is:

1) At the flange where delivery to large-scale users takes place
2) At the flange where delivery to a regional distribution network takes place

Companies selling/delivering fossil gas beyond this point will have to demonstrate they are in compliance with agreed 'takeback' targets. The group of companies to which this applies will be called 'the collective' under the EPR-principles. The Collective can choose to work together to collect and dispose of the required amounts of CO_2, but they can also allow companies to generate their own CSUs and sell them to customers. This needs further definition by the companies in the Collective.

For now we are proposing to organise this as follows:

- When the Collective or a company stores a certain amount of CO_2 (from fossil gas use) they will receive the corresponding number of CSUs.
- CSUs can be exchanged for CTBO-gas certificates (similar to existing scheme for green gas/Vertogas). See conversion table below.
- Only gas with CTBO-certificates is allowed to be sold on the Dutch market (past 'the flanges').
- When more countries join in (CTBO-regulations) NL can allow gas with CTBO-certificates from other countries also.
- Note that CTBO-gas will have exactly the same emissions as non-CTBO gas. There is no direct advantage for the customer other than knowing that fossil gas use in NL on average will be gradually becoming less carbon intensive. Emission reductions can only be claimed by the company where the CO_2 emissions are captured (for storage).

Conversion table: how many CTBO-certificates will be issued for 1 CSU (1000 kg CO_2)?

CTBO %	Number of CTBO-certificates (m3 fossil gas)
5	11.111
10	5556
50	1111
100	556 (=1000/1.8)

Assumption: burning 1 m^3 of gas will result in 1.8 kg of CO_2 emissions (note that this may need refining to distinguish hi- and lo-cal gas).

As CCS projects take time to develop it was proposed (in the CTBO-report) to start the implementation of the CTBO in a 'pilot-phase' in which basically whatever amount of CO_2 from fossil gas is stored, that will determine the CTBO% and therefore how many CSU's each producer/importer will need to purchase. In the pilot-phase the main objective is to get the system working, accounting etc set up, and all stakeholders familiar with the changes and the process. For this phase it was proposed that the CSU-costs would be based on transport (including compression near the coast) and storage costs. This phase could last from 2024 to 2026 for example. [11]

From 2027 onwards the required CTBO percentage could be increased by 2% per year to reach around 10% by 2030 (details to be worked out; the goal needs to be realistic but also challenging). In this phase the CSU costs will start to interact with the ETS-price, and depend on whether enough CO_2 is offered for storage based on ETS price. If that is not the case then the Collective would have to think about ways in which they could get more CO_2 for storage. This could mean paying for the CO_2 to take to storage (from a large ETS-source) or finding customers for blue hydrogen or ammonia. As mentioned before, if ETS -prices keep surging then CSUs could also become cheaper than the costs of transport and storage. The CTBO will ensure that whatever the ETS price is and whether or not there are any large point sources left to be captured, the 'takeback' percentage will continue to increase to 100% by the Net Zero year.

Who is in the Collective?

Basically any company/entity selling fossil gas 'past the flanges' is part of the Collective. This includes gas producers (NOGEPA companies) and other gas trading/importing companies that sell to the Dutch market.

B3: Variations on the base case

In this section a couple of likely or possible variations on the base case will be discussed. These are optional and will need a joint decision by the relevant stakeholders for each variation.

The base case is:
Denominator: all fossil gas sold on the Dutch market (carbon content converted to CO_2 emissions)
Numerator: all CO_2 captured from fossil gas origin that is permanently stored.

Variation 1: CO_2 captured and stored from oil or coal origin

It is likely that some of the CO_2 in NL that will be stored through the Porthos project is from oil (refineries) originally. Coal and oil users do not pay a 'carbon storage surcharge', and the carbon for coal and oil production sold on the Dutch market is not included in the base case denominator. Therefore it would not be fair nor correct to issue CSUs for the stored CO_2 from oil and coal. The objective of a CTBO for fossil gas is to make sure that there will be net zero emissions from fossil gas use in a certain year (when the CTBO is 100%). If some of the stored CO_2 comes from oil, then that would mean that the emissions from fossil gas use are still net positive when the CTBO reaches 100%. Therefore it is recommended <u>not</u> to award CSUs to stored CO_2 from oil (or coal).

The best way to include CO_2 from oil would be to also apply the CTBO to all oil production and imports to the Dutch market. At the moment this is considered for a later stage (as the

[11] In the CE Delft report it is assumed (for simplicity sake) that the fixed price for CSUs continues until 2030.

implementation for gas is more straightforward, and has a higher priority).
An alternative that may be worth to consider and evaluate in more detail would be an opt-in for oil (or coal) installations: a refinery could then choose to opt-in and participate under the CTBO agreement. There probably would have to be three conditions for an opt-in:

a) ALL the CO_2-emissions (from oil or coal) from that installation need to be included (added to the denominator); not just the captured CO_2. Captured/stored CO_2 can then be added to the numerator.
b) As user of fossil carbon, the refinery would have to pay a carbon storage surcharge for all the fossil carbon converted into emissions (the amount of carbon added to the denominator).
c) The owner of the refinery would become part of the Collective (as producer/supplier of the fossil carbon in the oil), and would therefore have to purchase CSU's to meet increasing CTBO percentages.
   Advantages for the refinery would be reduced transport and storage costs for any captured CO_2 and reputational advantages due to having made a firm commitment to become net zero in a certain year.

Variation 2: CO_2 from bio-origin (e.g. waste power plant or biomethane production/use) is stored

In this case (see Chapter 2 CTBO report 2021) the stored CO_2 does qualify for CSUs and can be added to the numerator. As no fossil carbon was taken out of the ground for this CO_2 there is no need to add anything to the denominator. Carbon is moved from the bio/atmosphere to the geosphere. Bio- CO_2 is therefore likely to become more popular (and valuable) when a CTBO is implemented.

Variation 3: the Collective builds a DAC-plant near the CO_2 compressor stations and stores the CO_2

This is very similar to the bio- CO_2 case: the CO_2 is taken out of the air and therefore the stored CO_2 qualifies for CSUs and nothing needs to be added to the denominator (fossil carbon produced). Note that the 'carbon credit' for taking carbon out of the air is a separate attribute that can still be sold (once the regulations for this are sorted) with the gas to customers who need to keep burning gas but want to do it in a net zero manner. See Chapter 2.5 of the 2021 CTBO report on how the accounting could work for this.

Variation 4: fossil gas is converted to blue hydrogen, blue ammonia, electricity (with CO_2 storage)

If the company doing this conversion purchases the fossil gas on the market then it falls under the base case. If the conversion is done by a producer of fossil gas then both the produced fossil gas (denominator) and the stored CO_2 (numerator) should be counted as part of the CTBO-commitment. When the CTBO% is still low, the producer can sell CSUs they do not need to other producers.

Appendix C: Questions and Answers (based on stakeholder feedback)

1. CTBO is not needed; we have ETS

ETS can indeed be very effective for large concentrated (high CO_2%) point sources that are relatively close to potential CO_2 transport and storage infrastructure. But that only covers maybe 30% of fossil gas use and emissions. A CTBO will force further actions to reduce also the net emissions of the other 70% of fossil gas that is more dispersed. Technologies like blue hydrogen, ammonia, electricity (all with CCS) and carbon sourcing from Direct Air Capture and biomass processing will all be incentivized by a CTBO and help to ensure that Net Zero is reached on time, also for the more difficult 70%.

Furthermore, ETS is uncertain and this has meant that in practice governments have been offering so-called 'contract for difference' subsidies to encourage companies to invest. These subsidies for fossil energy users are not broadly supported and should therefore be restricted to the start-up phase for CCS projects in a country. After that a CTBO can take over that role (CfD) to provide investors with the certainty needed to invest in CCS.

More info:
Oxford University research[12] shows how carbon pricing and a CTBO for producers together lead to cost-effective climate policy. Initially carbon pricing is needed to reduce fossil energy use and emissions; CTBO ensures that after that fossil energy use will become more and more 'decarbonised' (Eg by conversion into hydrogen, ammonia, electricity) and/or timely development of CDR technologies needed to offset hard-to-abate emissions.
Appendix E and Chapter 4.7 in the 2021 CTBO report describe the interaction with ETS in more detail. NB CTBO covers ALL fossil energy production and use, not just what falls under ETS.
Appendix A of this report explains the role of a CTBO in a comprehensive climate policy framework. Including the possible interaction or overlap with Fit-for-55 proposals.

2. Will take too long to implement new regulations

We have seen with Covid that when something is really urgent government can take action more quickly. In our opinion it does not have to take that long for leading countries (eg North Sea countries) to develop regulations and to start a test-phase for CTBO-implementation. At the same time pressure can be increased on other large fossil gas producing countries and companies to join the CTBO-club. Because of the ETS and the already planned subsidies for the first CCS projects this will not cause significant delays or problems. Remember that the CTBO is aimed at providing mid- and long-term policy certainty for emission reductions and investments in CCS. Nevertheless, it is necessary to start implementation asap as this will give companies the time they need to change their business models and ways of working so that they can continue to meet energy needs with a lower carbon footprint also after the initial phase where ETS takes care of the easy to capture CO_2 at large point sources.

[12] Peer-reviewed papers by Prof Allen et al, Oxford. See eg:
https://carbontakeback.org/2021/10/28/an-affordable-backstop-climate-policy/

3. Too complicated

Extraction-based accounting (as is needed for CTBO) is extremely simple and easy compared to emission-based accounting. Hundred companies produce around 80% of the fossil energy in the world. There are millions (if not billions) of emission points in the world. For a proper functioning CTBO production volumes need to be measured (which can be done fairly accurately, and is already available in most countries) and permanently stored carbon volumes (or weights) need to be measured. In EU (and some other countries also) regulations are already in place to make sure this is done (CCS directive, ETS regulations).

As explained in the intro: if all producers (producing countries) commit to storing as much carbon as they produce by the Net Zero year then *indirectly* the world will have achieved net zero emissions from remaining fossil energy use.

If nothing else, more formal extraction-based accounting (both production and storage) should be a useful cross-check on emission-based accounting results (emissions and carbon removals).

4. Risk of double counting emission (reduction)

Carbon Storage Units (CSUs) do not have a role in emission accounting and therefore cannot be used to claim emission reductions. CSUs only have a value for gas producers and importers as they need them to be allowed to produce or import gas and sell it on the Dutch market. The CTBO-gas (see section 2.3 and Appendix B of this report) cannot be sold as 'lower-emission' gas. The only customers that can claim emission reductions are the customers that capture the CO_2 that is being stored. The CTBO leads to a parallel, complementary accounting system that forces producers to *also* contribute to increasing the stored fraction of remaining fossil energy use. Fossil energy producers can and should report this stored fraction for all their production and fossil energy sales. Recently Neptune Energy announced that by 2030 they aim to store more CO_2 than what is generated by their production and customers emissions. If ALL fossil energy producers would make that commitment then the net emissions of fossil energy production and use would be zero by 2030. This is why the CTBO should be mandatory.

5. Monopoly risk for CO_2 transport and storage infra

There are many opinions at the moment on how CO_2 transport and storage infrastructure should be regulated. The CTBO is neutral on that subject. We think different countries may choose different ways of organising this. For a good functioning CSU market it is recommended that so-called 3rd party access to transport and storage services is guaranteed. The companies carrying out the transport and storage can be publicly owned, privately owned, a public-private partnership, or first publicly owned and transitioning to private ownership later on. Interesting lessons learned can be found in the way other waste infrastructure has been set up and evolved in the past (water, sewage, other waste). Whatever governance framework is selected, the storage companies will be generating CSUs which will be needed by producers and importers of fossil gas.

6. Greenwashing risk

See also question 4. Companies committing to an increasing stored fraction *should* get credit

for this commitment. It is one of the best ways fossil energy producers can contribute to lowering the net footprint of the use of their products (on average). They have a responsibility to make sure net extraction of fossil carbon goes down to net zero on time. They should *not* use this to claim that the gas they sell has lower emissions than 'normal' gas. Nevertheless, with a mandatory CTBO scheme it is indirectly inevitable that as the CTBO% gets closer to 100 the scope 3 emissions will effectively go to zero also. So what claims can producers and importers/suppliers of fossil gas (that is produced under a CTBO) make?
> they can claim that they only sell 'CTBO-compliant' gas; for customers this means paying a bit more in the knowledge that an increasing percentage of carbon will be permanently stored, and that if they want to keep using gas and emitting CO_2 it will becoming quite expensive in the end.
> they can claim they will reach 'geological net zero' by a certain year (and report progress towards that goal): this means that they will store as much carbon as they produce.
> and it seems reasonable to allow them to report reduced scope 3 emissions based on the average CTBO% (assuming the CTBO is mandatory in a country): eg for a CTBO% of 20 the average scope 3 emissions in a country will be 20% lower than in countries without CTBO regulations. That way the scope 3 emissions will slowly decline as the CTBO% goes up.
The precise accounting rules and regulations need to still be developed and agreed, should a CTBO be implemented.

7. Climate risk due to time-lag between production and storage

Some people think a 'carbon takeback' obligation means that a company actually has to go collect the CO_2 from the gas that they sold. This would not be efficient or cost-effective. The CTBO applies to a whole sector and therefore they can work together to make sure that enough CO_2 is captured and stored each year. Very similar to how companies work together for EPR (Extended Producer Responsibility) regulations to set up a joint company that collects the waste of all producers, and they all share in the cost (proportional to how much product they have sold). Each year producers/importers have to purchase enough CSU's for their production/sales that year. As a result storage will by definition take place more or less in the same year as the corresponding production. There is no time-lag.

8. Will a CBAM be needed to avoid carbon leakage (energy intensive companies moving elsewhere)?

A CTBO is implemented for all sales of a fossil energy product in a country. Producers *and* importers need to comply. As a result, there is a level playing field for the companies selling these products, whether domestically produced or imported. Both need to purchase and hand-in CSUs to be allowed to sell their gas on the (Dutch) market.

For large energy-intensive industries that sell their products on the international market the increase in price caused by a CTBO could be a problem. The CE Delft report shows that even at a 'takeback' of 15% the gas price will only increase 1 cent per m3 and therefore this leakage impact is expected to be limited still. And for industries that can capture their CO_2 the CTBO will effectively pay for part of the total CCS costs, so there also is an advantage for energy-intensive industries that use a lot of fossil gas. Ultimately though (as for all market-based policies) it is important that the CTBO is implemented as many countries as possible (with the focus on the countries that produce and export most fossil gas). CBAM can then be used to tax imports from countries without CTBO and carbon pricing (in a similar way as is produced now

for carbon taxes).

9. Would this make producers legally liable for the emissions of their products?

The question about legal liability for scope 3 emissions is an important one and one that is increasingly contested in court cases. We do not aim to influence this by introduction of a CTBO.

From a purely technical and legal perspective the CTBO is a *storage* requirement; the carbon being stored can be the produced carbon ('taken back') or can be carbon taken out of the atmosphere. The carbon can be stored as CO_2, but also as black carbon or in carbon minerals (through mineralisation). As such, there is no direct legal responsibility implied nor needed for the emissions caused by use of the products.
Nevertheless, as capturing CO_2 at large point sources is the easiest and cheapest way to capture carbon for permanent storage, producers will clearly become more interested in helping customers scale up carbon capture projects. And the *indirect* result of storing as much carbon as is being produced, is that net emissions will go down to zero also.

10. How does this impact or change corporate emission accounting and progress vs targets for oil and gas companies?

See question 6 (Greenwashing).