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Quantifying and Deploying Responsible Negative Emissions in Climate Resilient Pathways

Assessment of the potential for an NETP "capacity market"

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Executive Summary

The aim of the NEGEM Task 2.5 is to identifying policy instruments and commercialisation pathways appropriate to different classes of NETPs. Earlier NEGEM studies showed that mechanisms to support technological negative emissions technologies and practices (NETPs), which include Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS), were found to be particularly lacking, especially within Europe (Deliverable 2.1). In addition, the development of the carbon capture and storage (CCS) value chain – especially of capture, transport, and storage infrastructure and capacity -- is critical to the scale-up and commercialisation of these NETPs. To address these shortfalls, this deliverable is dedicated to the discussion of policy mechanisms and commercialisation pathways appropriate for BECCS and DACCS within the EU. The Article 18 of the European Commission's Net Zero Industry Act (NZIA) was recognized as a novel type of mandate mechanism that may prove valuable in increasing demand for technological NETPs. Thus, in this deliverable we focus on studying the "Policy Pathways for the Commercialisation of Technological NETPs in the Net Zero Industry Act".

The obligation under Article 18 of the European Commission's Net Zero Industry Act (NZIA) requires, for the first time, oil and gas producers in the European Union (EU) to contribute towards CO2 storage injection capacity pro rata, on the basis of their rate of oil and gas extraction within Europe. Here, we examine this regulatory policy and explore the potential mandate-based policy pathways it may give rise to for the commercialisation and scale-up of the two technological, or "engineered" NETPs: BECCS and DACCS.

Our analysis constitutes the first in-depth academic analysis of the Article 18 mechanism regarding its properties as a regulation, obligation, or mandate on fossil fuel extraction within the EU. We term the policy an Injection Capacity Obligation (ICO). The ICO is novel in several respects: it is the first climate-focussed obligation placed on a wide group of fossil fuel producers to reach legislative agreement anywhere globally, it introduces penalties on these entities for infringement of their obligations (again first-of-its-kind for a wide group of fossil fuel companies), and its focus is specifically on developing geological CO2 storage injection capacity to complement existing European policies for market growth in CO2 capture capacity (as opposed, for example, policy which directly supports the CO2 capture or sequestration activities).

The ICO is comparable but distinct to other kinds of proposed mandate mechanisms, such as a Carbon Takeback Obligation (CTBO). Comparing these two mechanisms, we find that the ICO varies on several key characteristics, including the obligation subject, mandated activity, obligated entities, contribution calculation, compliance mechanism, strategic use, purpose, and principle. A CTBO is a long-term supply-side mitigation policy requiring extractors and importers of fossil fuels to recapture and store a progressively increasing fraction of the CO2 generated by their activities and products, eventually reaching 100% by the net-zero date. It is a "backstop" policy in so far as the obligation ensures net emissions are reached by the net zero date in case other measures to reduce and remove CO2 prove insufficient, and is grounded in the principle of extended producer responsibility. In contrast, the ICO is a temporary – or what we term, "band-aid" -- obligation that is intended to provide a fast and temporary way of correcting market failure in the development of the carbon capture and storage (CCS) value chain in the Union by addressing the bottleneck in CO2 injection capacity. It applies to producers of oil and gas within the EU, and is, we argue, primarily grounded in the ability to pay principle, which stipulates that the burden of climate mitigation and action should fall on those who are most able to meet that burden, as opposed to those

who caused the issue (polluter pays principle), those who produce the products causing an end-of-life issue (extended producer responsibility), or benefited from it (beneficiary pays principle).

We conclude by identifying three separate pathways the Article 18 legislation may give rise to which may facilitate the scale-up of BECCS and DACCS. We label these the A18 Pathway, the Extended ICO Pathway, and the CTBO pathway, respectively.

Our analysis draws on and adds to the work of our previous Deliverable 2.1 (Hickey and Allen, 2021), which was tasked with performing a quantitative survey of current and proposed commercialisation mechanisms aimed at encouraging negative emissions in Europe as well as globally. We aim to develop the main body of this deliverable, in collaboration with other NEGEM partners, for submission as a peer-reviewed publication.

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Introduction

Negative emissions technologies and practices (NETPs) – alternatively known as carbon dioxide removal (CDR) technologies – are essential for meeting the objectives of the Paris Agreement of limiting global warming to 2°C, and pursuing efforts to limit warming to 1.5°C (Hickey et. al, 2023). Within Europe, the European Commission 2020 impact assessment estimates that total negative emissions must reach approximately 0.5 GTCO2/year by 2050 in order to ensure the EU's climate neutrality goals are met (COM(2020) 562 final; COM(2021) 800 final). NETPs will assist in mitigating the residual emissions from hard-to-abate sectors such as aviation, agriculture, and industry, as well as compensate for any temporary carbon budget overshoot (Fuss et. al., 2018). BECCS and DACCS are anticipated to be the primary NETPs options for removing CO2 on a global scale (Hickey and Allen, 2021). These removal technologies will be supplemented by smaller but crucial implementations of land-based and ocean-based NETPs, which include ecosystems restoration, afforestation, reforestation, improved forest management, enhancing soil carbon sequestration, biochar, enhanced weathering, ocean alkalinisation and ocean fertilisation (Hickey and Allen, 2021).

In order to support our net zero targets, NETPs must be effectively scaled so that they are able to meet required demand. Effective scaling of these technologies will require ``mechanisms", or "instruments" – collective terms used to refer to policies, incentives, regulation, standards and commercialisation mechanisms. Deliverable 2.1 (Hickey and Allen, 2021) was tasked with performing a quantitative survey of current and proposed commercialisation mechanisms aimed at encouraging negative emissions in Europe as well as globally. A key finding of their study was that mechanisms generally fall short of adequately incentivising carbon removal, particularly for hard-to-abate sectors. Mechanisms to support technological NETPs, which include BECCS and DACCS, were found to be particularly lacking, especially within Europe. To address this shortfall, this deliverable is dedicated to the discussion of policy mechanisms and commercialisation pathways appropriate for BECCS and DACCS within the EU.

In addition to the implementation of mechanisms that support the scale-up of BECCS and DACCS, the development of the carbon capture and storage (CCS) value chain – especially of capture, transport, and storage infrastructure and capacity -- is also critical to the scale-up and commercialisation of these NETPs. At present, the CCS value chain within the Union is underdeveloped and faces critical roadblocks in the availability and development of CO2 transport and storage. Indeed, the lack of sufficient injection capacity has been flagged as the "single largest bottleneck for CO2 capture investments to materialise" (COM(2023) 161 final). Mechanisms will be needed to drive the rapid development of the CO2 transport and storage value chain in order to scale up point-source CCS as well as BECCS and DACCS.

A New Mandate-Based Solution: Article 18 of The Net Zero Industry Act

The European Commission's Net Zero Industry Act (NZIA) seeks to introduce a ground-breaking piece of legislation under Article 18 (A18), namely, an unprecedented mandated obligation on oil and gas producers to provide carbon dioxide (CO2) injection capacity to the EU. We refer to this obligation as an Injection Capacity Obligation (ICO). The NZIA as a whole aims to establish a legal framework that promotes the advancement of net-zero energy technology manufacturing within the EU (2023/0081(COD)). The lack of injection capacity was identified by Commission as a key barrier in the development of the CCS value chain. In direct response to this issue, the Act seeks to introduce a Union-wide objective of at least 50 million tonnes of CO2 injection capacity to be achieved by 2030 in geological storage (Article 16). It mandates that this target be met by oil and gas produces within the Union, with their individual contribution to be calculated pro rata on the basis of each entity's share of oil and gas production in the EU between 1 January 2020 and 31 December 2023 (Article 18). On 16 February 2024, the first Permanent Representatives Committee endorsed the final compromise text of the NZIA with a view to agreement (2023/0081(COD)).

The use of obligations, or ``mandates", on the fossil fuel industry to contribute to our climate goals is a policy mechanism that, as yet, has not been seen at any scale globally. Regulatory policy is by no means novel in the context

of the fossil fuel extraction sector, with many aspects of operations controlled by strict regulatory regimes (e.g. HSE powers and environmental legislation controlling discharge of chemicals/waste materials into environment). However, policies mandating responsibility for development of mitigation technologies have been the subject of increasing academic treatment and political discussion, particularly in the context of a Carbon Takeback Obligation (CTBO). A CTBO, briefly, is a sequestration mandate (alternatively `storage mandate'); a proposed government regulation that would obligate fossil fuel producers and importers to demonstrate recapture and permanent storage of the carbon dioxide (CO2) generated by both their activities and the products they sell (Jenkins et. al., 2021). The CTBO was identified by Hickey & Allen (2021) as a proposed mechanism that could increase demand for technological NETPs (Hickey & Allen, 2021, p.14).

The A18 ICO constitutes a novel type of mandate mechanism that may prove valuable in increasing demand for technological NETPs. In this analysis, we outline the novel features of this obligation in the context of mandate mechanisms, and outline several mandate-based policy pathways it may give rise to that could aid the scale-up of CCS value chain, and ultimately, BECCS and DACCS.

Findings and Paper Structure:

We find the ICO to be novel in several respects: (i) It is the first climate-focussed obligation placed on a wide group of fossil fuel producers to reach legislative agreement anywhere globally. (ii) It dictates the use of penalties by Member States on oil and gas entities for non-compliance with their A18 obligations. Penalties on a wide group of oil and gas producers in relation to the provision of CCS infrastructure are likewise unprecedented. (iii) It introduces a sector-specific mandate for CO2 injection capacity, a departure from the more commonly discussed sequestration mandates, like the CTBO. This is a novel subject of obligated demand. As such, Article 18 represents a significant policy development with substantial potential to scale up critical components of the CCS value chain.

The ICO is comparable but distinct to other kinds of proposed mandate mechanisms, such as a Carbon Takeback Obligation (CTBO). We conduct a comparative analysis between these two mechanisms, and find that the ICO varies in regard to eight key characteristics, including the obligation subject, mandated activity, obligated entities, contribution calculation, compliance mechanism, strategic use, purpose, and principle. A CTBO is a long-term supply-side mitigation policy requiring extractors and importers of fossil fuels to recapture and store a progressively increasing fraction of the CO2 generated by their activities and products, eventually reaching 100% by the net-zero date. It is a "backstop" policy in so far as the obligation ensures net emissions are reached by the net zero date in case other measures to reduce and remove CO2 prove insufficient, and is grounded in the principle of extended producer responsibility. In contrast, the ICO is a temporary – or what we term, "band-aid" – obligation that is intended to provide a fast and temporary way of correcting market failure in the development of the CCS value chain in the Union by addressing the bottleneck in CO2 injection capacity. It applies to producers of oil and gas within the EU, and is, we argue, primarily grounded in the ability to pay principle, which stipulates that the burden of climate mitigation and action should fall on those who are most able to meet that burden, as opposed to those who caused the issue (polluter pays principle), benefited from it (beneficiary pays principle), or are responsible for the production of harmful products (extended producer responsibility).

We conclude by identifying three separate pathways the Article 18 legislation may give rise to which may facilitate the scale-up of BECCS and DACCS. We label these the A18 Pathway, the Extended ICO Pathway, and the CTBO pathway, respectively. The A18 Pathway captures the intended route of ICO and NZIA within the context of the EU policy landscape whereby most carbon value chains become economically viable by 2040, and an integral part of the EU economic system beyond 2040 (COM(2024) 62 final). The Extended ICO Pathway refers to a situation in which the CO2 injection capacity obligation is renewed for 2040, and 2050. The third, the CTBO Pathway, outlines how the

A18 ICO may serve as a crucial enabler for the introduction of a CTBO in so far as it introduces a precedent of mandate mechanisms on the fossil fuel industry into the EU policy landscape.

This analysis has four sections. We begin in Section 1 by introducing the NETP policy mechanism framework developed in Deliverable 2.1, and outline the problems and solutions identified by Hickey & Allen (2021) for the scaling of technological NETPs. It is here that we introduce the notion of mandate mechanisms and the CTBO. In Section 2 we introduce the NZIA and the obligation introduced on oil and gas producers for CO2 injection capacity provision in A18, which we term the Injection Capacity Obligation (ICO). Next, in Section 3, we outline the novel features of the ICO, and conduct a comparative analysis between the ICO and CTBO, drawing out several key differences in their design and function. Section 4 outlines the three pathways we identify that may be useful in scaling technological NETPs and that arise from the NZIA ICO. We conclude by reiterating our main findings and outline our key policy takeaways.

1 Policy Mechanisms for Scaling Technological NETPs

Mechanisms that support NETPs are an important part of scaling up the removal capacity required in the majority of net zero modelling scenarios. In Deliverable 2.1, Hickey and Allen (2021) provided a detailed analysis of global commercialisation mechanisms for NETPs.

Below, we introduce Hickey & Allen's framework of NETPs mechanisms (S1.1). We go on to utilise this framework in our analysis of Article 18 in subsequent sections. Next, we outline one of their key takeaways, namely that current mechanisms for the successful commercialisation of technological NETPs are lacking (S1.2). We pay particular attention to the shortcomings of the EU ETS in scaling these NETPs. We conclude the section by outlining the policy solutions that have been proposed to rectify the failure of technological NETPs incentivisation, concentrating on the CTBO, a mandate mechanisms with growing interest (S1.3).

1.1 Categorisation of Mechanisms: A Working Framework

In their categorisation of mechanisms, Hickey & Allen (2021) include both "operational" and "proposed" mechanisms, serving to provide a comprehensive overview of the global policy landscape as of 2021, as well as a canvassing of proposed strategies that could be adopted in the future to scale-up carbon removal activities. Briefly, operational mechanisms refer to mechanisms that have already been implemented and are currently in functional operation. Proposed mechanisms refer to those that have been suggested, planned, or are currently under consideration but have not yet been fully implemented or operationalised. These proposed mechanisms may be outlined in academic literature, draft legislation, policy proposals, or research studies, indicating a plan for future implementation to support carbon removal efforts.

Hickey & Allen identify five types of NETP mechanism categories : (i) Carbon Markets and Prices; (ii) Regulations and Standards; (iii) Results-based Payments; (iv) Subsidy; and (v) Tax Credits. These types are grouped according to how each distribute costs, ranging between (1) market-based mechanisms, (2) market-based incentives, and (3) fiscal incentives. Hickey et. al. use this framework to map global operational and proposed NETPs mechanisms. Figure 1 illustrates this categorisation. Each is unpacked below. For details on the various examples referenced, see Hickey & Allen (2021) and Hickey et. al.(2023).

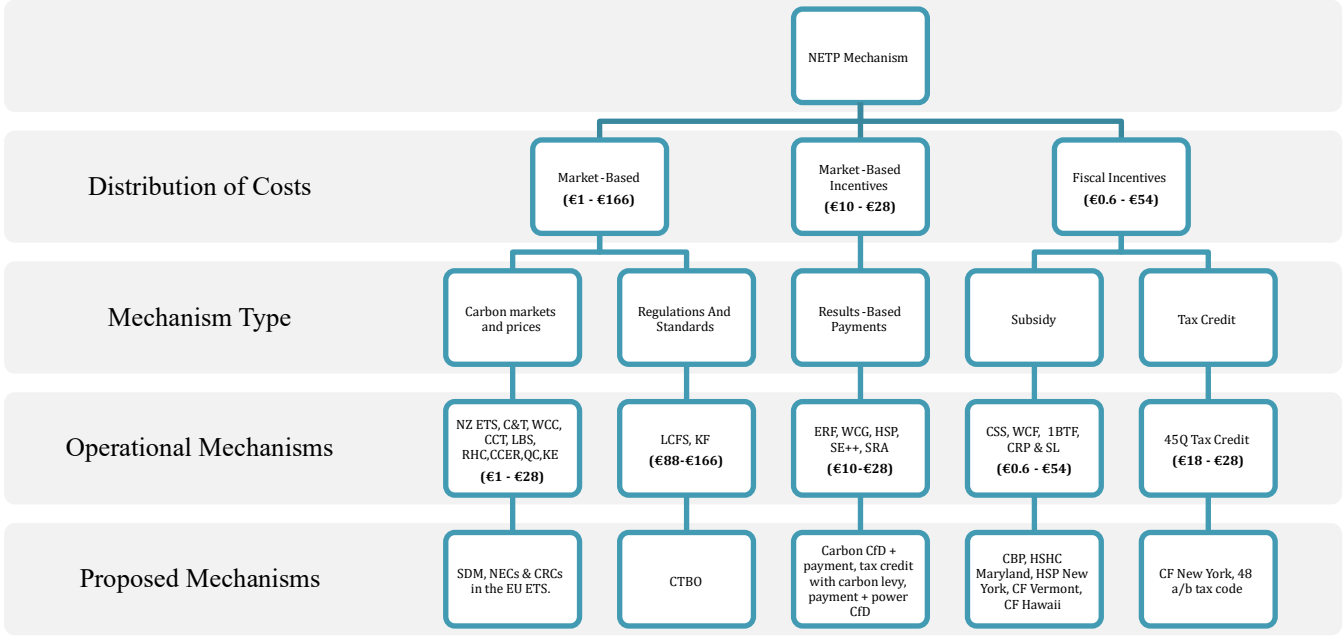

Figure 1 Categorisation of Mechanisms

Key: Countryside Stewardship Scheme (CSS), Woodland Carbon Fund (WCF), Woodland Carbon Code (WCC), Woodland Carbon Guarantee (WCG), Emissions Reductions Fund (ERF), One Billion Trees Fund (1BTF), Conservation Reserve Program (CRP), CDFA Healthy Soils Program (HSP), California Cap and Trade (C&T), New Zealand ETS, Sowing Life (SL), Low-Carbon Fuel Standard (LCFS), Label Bas Carbone (LBS), Registro de Huella de Carbono (RHC), Klik foundation (KF), Colombia's Carbon Tax (CCT), China CCER Certificates (CCER), Québec Cap-and-Trade System (QC), Kazakhstan ETS (KE), Sustainable Development Mechanism (SDM), Negative Emission Credits (NECs), Carbon Take Back Obligation (CTBO), Carbon Removal Credit (CRCs), Contract for Difference (CfD), Carbon Farming (CF), Swedish Reverse Auction (SRA).

1. Market-based mechanisms: Market-based mechanisms are defined as operating on the principle that the polluter or fossil fuel supplier should bear the cost of NETP development, as opposed to government. Two types of mechanisms fall under this category, including (i) carbon markets and prices, as well as (ii) regulations and standards. Examples of carbon market and price mechanisms include the New Zealand Emissions Trading Scheme (NZ ETS) and California's Cap-and-Trade (C&T) program. Examples of regulatory standard setting mechanisms include Low-Carbon Fuel Standards (LCFS) and Carbon Takeback Obligations (CTBO).

2. Market-based incentive mechanisms: The Market-based incentive category of mechanisms fall between the two extremes of fully market-based (1) and heavy fiscal incentives (3). These mechanisms provide fiscal incentives within an existing market-based framework. Ideally, the polluter still bears the cost in these mechanisms, but the state can step in to compensate NETP operators for inadequate returns or even participate in the market. Results-Based Payments (iii) fall under this category, and provide payments based on the results achieved in terms of carbon removal. Examples include the Emissions Reduction Fund (ERF) and the Woodland Carbon Guarantee (WCG).

3. Fiscal incentives: Fiscal incentives place a significant portion of the cost for developing and operating NETPs on the state, rather than the polluter. Subsidy (iv) and tax credit (v) mechanisms fall under this category. These are both understood to be the ``purest form" of fiscal incentives. Examples of subsidies include the Countryside Stewardship Scheme (CSS), and the Woodland Carbon Fund (WCF). A good example of tax credits can be found in the 45Q Tax Credit.

Together, these mechanisms aim to incentivise the development and deployment of NETPs by distributing costs and risks between polluters, governments, and other stakeholders. Each mechanism type plays a specific role in encouraging carbon removal activities and supporting the transition to a net-zero emissions future.

1.2 Inadequate Mechanisms for the Commercialisation of Technological NETPs

One of the key takeaways from Deliverable 2.1 is that current mechanisms across the globe are inadequate, insofar as they fall short of adequately incentivising carbon removal, particularly for hard-to-abate sectors. Existing incentive mechanisms supporting NETPs are, on the whole, under-resourced. Moreover, there is also lack of coordinated portfolios of mechanisms that effectively balance engineered (technology-based) and land-based NETPs. This lack of incentivisation, under-resourcing and absence of co-ordinated portfolios hinders the development of necessary NETPs that will be required for achieving net zero emissions.

Importantly, mechanisms that support the scale up of technological NETPs were found to be particularly lacking. As the authors state, "the majority of operational market-based mechanisms do not pay enough to support engineered removals" (Hickey & Allen, 2021, p.11). Mechanisms were found to focus more heavily upon other NETPs methods like afforestation and soil sequestration, rather than BECCS and DACCS. While carbon capture and storage (CCS) was covered in some schemes, the incentives provided in those schemes were deemed inadequate for BECCS and DACCS. Jenkins et. al. (2021) found that all geological carbon storage projects were reliant upon taxpayers and government funding to varying degrees, utilising direct procurement, subsidies, or tax credits (p.2784). In North America, focus has been placed on a combination of grants, tax credits, commercial incentives, and carbon financing to enhance and incentivise CCS deployment (Zakkour et. al., 2024; Martin-Roberts et al., 2021).

Since the publication of Deliverable 2.1, the Inflation Reduction Act (IRA) has introduced changes to the 45Q tax credit available for CCS, making it more incentivising to technological NETPs (IEA, 2022). These changes provide support for deployment until January 1, 2033, with corporate projects eligible for direct payments for the initial five years following the commencement of carbon capture equipment operations (SWD(2023) 219 final). The tax credit rates are as follows: USD 85 per tonne for industrial and power facilities, USD 60 per tonne for enhanced oil recovery, USD 180 per tonne for DACCS, and USD 130 per tonne for DAC and utilization (SWD(2023) 219 final).

The European Context: Failure of the EU ETS in Scaling CCS, BECCS and DACCS

Hickey & Allen found that support mechanisms for technological NETPs were practically non-existent in Europe as of 2021. The EU Emissions Trading Scheme (EU ETS) is central to the Union's climate governance, and will continue to be a key mechanism that underpins the EU's long-term mitigation strategies and climate neutrality goals (IEA, 2020, p.26). Launched in 2005, the EU ETS has been successful in meeting targeted emissions reductions by its emissions cap, and at reducing emissions from fuel combustion in the power sector in particular (IEA, 2020, p.19; European Environment Agency, 2023).[1]

However, the EU ETS has so far failed to extend CCS incentives to BECCS. Under the EU ETS, operators engaged in CCS are not required to surrender allowances for emissions that have been confirmed as captured and securely stored, as per the Council Directive (2018/410/EC). This exemption does not apply to emissions resulting from biomass used in electricity production, which are outside the scope of the EU ETS. As a result, the benefits designed to encourage point-source CCS activities are not applicable to BECCS (Hickey & Allen, 2021).

Across the board, carbon price policy mechanisms that incrementally increase the cost of emitting GHGs into the atmosphere over time have proven ineffective in supporting the near-term development of large-scale capital-intensive climate mitigation technologies, including CCS and technological NETPs (Zakkour et. al., 2024). Zakkour et.

[1] There is, however, evidence to suggest that, while it may have contributed to reductions, it has not been the primary, and certainly not the sole, driver of reductions in covered sectors, due to, for example, the over-allocation of allowances which resulted in weak price signals (IEA, 2020, p.19).

al. emphasise that these pricing measures, of which the EU ETS is a prime example, establish a compliance cost from the short-run marginal cost of abatement, rather than the long-run cost of meeting future climate change mitigation commitments (Zakkour et. al., 2024, p.1). The result is that prices remain too low and unreliable to propel and incentivise large-scale deployment of net-zero and negative emissions technologies.

The potential shortcomings of pricing mechanisms in this regard were recognised early on. For instance, the Carbon Pricing Leadership Coalition, a governmental partnership body on carbon pricing, have acknowledged that more mechanisms beyond pricing may be needed to incentivise the scale of change required to meet the Paris Agreement targets, and as such may need to be complimented by a portfolio of well-designed policies (Carbon Pricing Leadership Coalition, 2017). The European Commission also recognised that widespread deployment of CCS could not be achieved by carbon pricing alone (COM(2013) 180 final).

The effects of the EU ETS shortcomings in scaling these technologies are now being acutely felt. For example, the lack of storage capacity and transport has been flagged as a key issue affecting the CCS value chain, blocking CCS technology scale up (European Commission, 2023a). BECCs and DACCS are heavily dependent upon the existence of a robust CCS value chain, and their upscaling is also consequently hampered by this bottleneck.

Thus, with the exception of the IRA 45Q revisions, Hickey & Allen's findings highlight the significant gap in incentivising technological NETPs, and stresses the need for enhanced support and targeted incentives to accelerate the development and adoption of technological NETPs to effectively combat climate change and achieve net-zero emissions targets.

1.3 Potential Solutions Horizon: Mandate Mechanisms

There are an array of mechanisms that have been proposed to scale up technological CCS and technological NETPs and overcome the shortfall identified by Hickey & Allen. These range from the use of subsidises and tax credits, to updates to carbon pricing mechanisms, to the implementation of mandated obligations under regulation.[2] For the subsequent duration of this analysis, we focus on mandated obligations, or "mandate mechanisms".

A key mandate mechanism that has been building attention is the CTBO. We briefly introduce the CTBO here. We then go on to introduce A18 of the NZIA, as a key, recent example of a novel mandate mechanism. We proceed to compare the A18 obligation with the CTBO in S3.

A Carbon Takeback Obligation

As outlined in S1.1, a CTBO is a regulatory market-based mechanism. Specifically, it is a proposed supply-side regulation that would require fossil carbon (oil, gas, coal, and limestone) producers and importers to demonstrate recapture and permanent geological storage of the CO2 generated by both their activities and the products they sell (Jenkins et. al, 2021; Kuijper et. al., 2021; Allen et. al., 2009). Phased in over time, this requirement would start at a low and manageable percentage of CO2 to be stored (or stored fraction) (e.g., 1%), and would increase predictably and smoothly to 100% by 2050 to ensure the delivery of net zero emissions (Jenkins et. al., 2021, p.2784). This mechanism would incentivise carbon capture and storage deployment, promote accountability among fossil fuel producers over the full emissions content of the products they sell, and help align the fossil fuel industry with climate goals. By placing the responsibility on the producer (or importer) to balance extraction (or import) of fossil carbon with storage, a level playing field is created where the industry is incentivised to find innovative and efficient ways of addressing the emissions associated with the products they sell. By mandating 100% storage of the CO2 produced

[2] Examples include the Inflation Reduction Act and updates to the 45Q tax credit, proposed updates to the carbon price and EU ETS (Rickels et. al. 2021; Hickey and Allen, 2021, p.14-5) and the introduction of the Carbon Removal Certification Framework in the EU (European Council, 2024).

by the use of fossil carbon after the net zero date, the CTBO provides a flexible pathway and remains agnostic on how energy and industrial demand will be met by and beyond net zero. We further expand upon the details and design of the CTBO in S3.2.

Mandate mechanisms in general, and the CTBO in particular have received increasing academic and political interest (Zakkour et. al., 2024; Hickey et. al., 2023). The CTBO has received formal consideration by Governments in the United Kingdom (Vivid Economics, 2019), and the Netherlands (Kuijper et al., 2021). The application of the CTBO has also been explored in relation to Norway (Mitchell-Larson, 2019; Østby Stub et. al., 2019). Notably, within the last year in the UK, there have been significant developments including a CCUS Council[3] assessment of the CTBO (UK Government, 2023), Baroness Worthington's CTBO Amendment to the Energy Act 2023 (UK Parliament, 2023), and a storage mandate recommendation in the Net Zero Review by Chris Skidmore (DESNZ, 2023).

2 The Net Zero Industry Act and Article 18: A New Direction

Having discussed the framework and categorisation of NETP mechanisms in Deliverable 2.1, highlighting its key findings and addressing the challenges in scaling technological NETPs, we introduced the CTBO, a mandate mechanism gaining interest. We now shift our focus to recent developments within the NZIA. We first outline the NZIA itself, and then introduce Article 18 and the new obligation it places upon oil and gas producers.

2.1 NZIA: An Overview

The NZIA aims to establish a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem. The Act is nearing the end of the legislative process, and the final text has been approved.

The primary objective of Regulation is to improve the functioning of the internal market by establishing a Union-level framework that ensures the Union's access to a "secure and sustainable supply of net-zero technologies" (Article 1) (2023/0081(COD)). This supply will be achieved through a scaling up of the manufacturing capacity and supply chains of net-zero technologies within the Union. This scale-up is considered crucial for safeguarding industry resilience, achieving the Union's climate targets and climate neutrality, and a net-zero emissions economy and society, as well as contributing to quality jobs and Union competitiveness.

Focus on Net-Zero Technologies: Promoting and advancing the deployment, scale-up, and adoption of innovative and strategic net-zero technologies lies at the heart of the Act. These technologies include solar, wind, hydrogen, and CCS technologies among others (Article 3a).

Emphasis on Security of Supply: The securitisation and development of net-zero technologies manufacturing is a key driver of the Act. By accelerating the development and production of net-zero technologies, the Act aims to both reduce the EU's reliance on Russian fossil fuels as well as to prevent the emergence of other strategic dependencies that could hinder access to essential technologies and components required for the transition to a greener economy (SWD(2024) 78 final). The Act seeks to ensure that European supplies can meet more of the growing domestic and international demand for net-zero technologies, thereby aiding industry security, growth and resilience (COM(2023) 638 final, p.9). To this end, it sets the specific benchmark of scaling-up manufacturing of these net-zero technologies in the EU to provide at least 40% of the EU's annual deployment needs by 2030, and reaching 15% of world production by 2040 (SWD(2023) 339 final; (Article 3c) 2023/0081(COD)).

Supportive Regulatory Framework: The development of this common Union level framework is seen as essential to safeguard the functioning of the Single Market in the context of net-zero industry scale up across the Union, and

[3] The CCUS Council is the primary forum for Department of Energy Security and Net Zero ministerial engagement with representatives from the CCUS sector in the UK.

aims to increase the Union-wide resilience and security of net-zero technology supply (2023/0081(COD)). The Act incorporates specific measures such as facilitating investments in net-zero technologies, reducing CO2 emissions, enhancing market accessibility, promoting skill development to generate high-quality jobs in net-zero technologies, encouraging innovation, and instituting a dedicated governance and monitoring mechanism to effectively implement these goals. A substantial focus is placed on measures that will help overcome barriers to net-zero technology scale-up, such as accelerating permitting, focusing R&D investments, and access to existing EU funding schemes (COM(2024) 63 final). As such, it has been described as a "concrete step in creating an industrial business case for the European transition to carbon neutrality", and is essential in overcoming barriers (COM(2024) 63 final).

2.2 The CO2 Injection Capacity Obligation

Of critical importance to the scale-up of technological NETPs is the inclusion of Chapter III on CO2 Injection Capacity within the NZIA. The chapter contains several articles (Articles 16-18a) that combine to establish a comprehensive regulatory framework for the development, monitoring, and scale-up of CO2 transport infrastructure and storage injection capacity within the EU.

Article 16: Union Level Objective of CO2 Injection Capacity: This article introduces a Union-level objective of an annual injection capacity of at least 50 million tonnes of CO2 to be achieved by 2030 in geological storage sites authorised under Directive 2009/31/EC (2023/0081(COD), p.93-4). Importantly, the Act excludes storage sites involving or combined with Enhanced Hydrocarbon Recovery (EHR), instead targeting depleted oil and gas fields, as well as saline aquifers situated within the Union's territory, its exclusive economic zones, or on its continental shelf as defined by the United Nations Convention on the Law of the Sea.

Article 17: Transparency of CO2 Storage Capacity Data: Article 17 stipulates that Member States shall make data on all areas where CO2 storage sites could be permitted on their territory, including saline aquifers, publicly available, without prejudice to requirements regarding the protection of confidential information (p.94-6). The aim of this article is to increase transparency and facilitate the identification and development of suitable CO2 storage sites, which is crucial for the effective implementation of CCS projects, and is essential for stakeholders in assessing the availability of storage capacity, and the planning CCS projects.

Article 17a: CO2 Transport Infrastructure: The addition of Article 17a requires Member States, in collaboration with the Union and relevant companies, to make all reasonable effort to develop the necessary CO2 transport infrastructure, including cross-border infrastructure, while taking into account the economic and environmental benefits of proximity of capture and storage sites (p.96-7). The development of this infrastructure is a critical part of the CCS value chain, and necessary to the scale-up and development of CCS, DACCS, and BECCS.

Article 18: Contribution of Authorised Oil and Gas Producers (ICO Obligation): It is this article that introduces the obligation on oil and gas producers, and with which our analysis is primarily concerned. Article 18 Paragraph 1 stipulates that any entity engaged in the production of oil and gas within the territory of the Union must provide an individual contribution to the Union wide target of 50mt of CO2 injection capacity by 2030 (p.97). We refer to this obligation henceforth as the Injection Capacity Obligation (ICO). Individual contributions are to be calculated pro-rata on the basis of each entities' share of production within the Union between 1 January 2020 to 31 December 2023. In order to meet their targeted volumes of available injection capacity, oil and gas entities may either invest in or develop CO2 storage projects. This may be done alone or in co-operation with other entities, or third-party storage project developers or investors (p.96).

Significant additions to the final text include a cut-off threshold, exemptions and penalties (Bellona, 2023). First, any entity engaged in production below a certain threshold will not be subject to the contribution and excluded from contribution calculations (p.97). Under Article 18 Paragraph 6a, a Member State may request the Commission to

exempt obligated oil and gas entities from their individual contribution. Requests for exceptions can be submitted in cases where the combined yearly injection capacity of all storage sites managed by any entity that has obtained a storage permit as defined in Directive 2009/31/EC and has made a final investment decision within the Member State that "exceeds the sum of the individual contributions of the entities referred to in Paragraph 1 in relation to the relevant production activities" (p.99). Under Article 18 Paragraph 1a Member States must introduce penalties to oil and gas entities that infringe their contribution obligations. These penalties must be introduced within 24 months of the Regulation via administrative procedure or legal proceedings, or both, and must be "effective, proportionate and dissuasive" (p.100).

Article 18a: Regulatory Framework for the Market for Captured CO2: Finally the addition of Article 18a allows for the Commission to propose a legislative act three years from the date of entry into force of the Act to regulate the market in order to address any short-comings identified, notably with regards to hard-to-abate emissions.

3 The Novelty of Article 18: Assessment and Comparison

We now turn to a critical evaluation of the A18 ICO. We first outline several of its novel components (S3.1) and then conduct a comparative analysis of the mechanism against the CTBO, outlining the fundamental differences between their respective designs (S3.2). We have chosen the CTBO as a point of comparison because it is, to date, the main mandate mechanism that has been discussed in relation to fossil fuel producers, and as such serves as a good point of comparison.

3.1 Injection Capacity Obligation: A New Kind of Mandate

A18 is an unprecedented, novel piece of regulation. The ICO it introduces is ground-breaking in at least three respects:

(i) First Legislated Climate-Focussed Fossil-Fuel Sector Mandate: The ICO marks the first successful legislative agreement to introduce a climate-focused mandated-based mechanism on a wide group of fossil fuel producers. As noted, mandated obligations on the fossil fuel sector have been the subject of increasing academic and political attention, particularly in discussions surrounding the supply-side CTBO policy mechanism. However, until now, none of these mandates have been approved for operation.

(ii) First legislated inclusion of Penalties on Fossil-Fuel Sector for Non-Compliance: The legislation mandates the use of penalties by Member States on oil and gas entities for non-compliance with their injection capacity obligations. Operationalised penalties on a wide group of fossil fuel producers in relation to climate policy are likewise unprecedented.

(iii) First Injection Capacity Obligation: The ICO introduces a novel subject of obligated demand, namely, a sector-specific mandate for CO2 injection capacity. This is a departure from the more commonly discussed sequestration (or "storage") mandates, like the CTBO; removal mandates, as seen in the proposed SB308 (California State Legislature, 2023); or reduction mandates, like carbon intensity reduction that is mandated by California's Low-Carbon Fuel Standard (LCFS) (California Air Resources Board, 2024). As such, the ICO reinforces the adaptability of mandate mechanisms in regards to their purpose and role in climate policy, and the flexibility of the territory they may cover. We discuss the difference in focus in further detail below.

As a result, Article 18 represents a significant policy development on multiple fronts. In the subsequent section, we expand upon the differences in design between the ICO and the CTBO. In S4, we then examine the substantial potential the NZIA A18 development carries in terms of the pathways it may facilitate that lead to the needed scale up critical components of the CCS value chain, and, consequently, technological NETPs.

3.2 ICO and CTBO Comparative Analysis

In this section, we compare and analyse the ICO introduced in A18 (henceforth, A18 ICO) against the CTBO. The comparison serves to emphasise the unique, identifying components of the ICO, and outlines notable points of difference between the two mandate policies in terms of their design and function. We make comparisons against eight criteria: (1) subject, (2) mandate, (3) obligated entities, (4) contribution calculation; (5) compliance mechanism; (6) strategic use; (7) purpose; and (8) principle. Figure 2 summarises this comparative assessment between the two mechanisms.

	Subject	Mandated Activity	Obligated Entities	Contribution Calculation	Compliance Mechanism	Strategic Use	Purpose	Principle
CTBO	CO2 sequestration	Recapture and store a progressively increasing fraction of the CO2 generated by their activities and products	Fossil carbon (oil, gas, coal, limestone) extractors and importers	Stored fraction that increases over time, reaching 100% by net-zero date. Coverage over all production regardless of scale.	Non-compliance penalties (financial), ultimately resulting in loss of license to operate	Long-term "Backstop"/ safety net	Ensure net-zero emissions by target date	Producer responsibility principle / expertise and ability principle
ICO	Injection capacity provision	Contribute to union wide target of 50 million tonnes of annual C02 injection capacity by 2030	Producers of oil and gas in the EU	Pro rata according to Union production levels between 1 January 2020 to 31 December 2023. Coverage limited to fraction of 50 million tonnes injection capacity target.	Non-compliance penalties	Short-term "Band-Aid" /bottleneck relief	Address the CCS bottleneck; Build up supply and security of net-zero technologies and industry	Ability to pay principle

Figure 2 CTBO and ICO Design Comparison

1. Mandate Subject

As mentioned above, the ICO is the first obligation mechanism to mandate the provision of CO2 injection capacity. "Injection capacity", while not explicitly defined in the text, can be understood as referring to the physical volume of CO2 that is able to be injected down into geological reservoirs. This requires the availability of certain infrastructure, including injection wells, wellhead equipment, surface facilities, pumps, and monitoring and control facilities (Ringrose, 2020). In short, providing injection capacity means providing the ability to inject CO2 underground, and in the case of A18, being able to inject 50 million tonnes, annually, by 2030. Injection capacity can be modelled and demonstrated without physical injection.

Injection capacity is distinct from "injectivity" which refers to the efficiency and rate at which CO2 can be stored and distributed within subsurface formations (Ringrose, 2020, p.15). Ringrose outline that this can be influenced by features such as the properties of the injection fluid, reservoir permeability, and well design (Ringrose, 2020, p.15). Injection capacity is likewise distinct from "capacity", which refers to the maximum amount of CO2 volume that can be stored over a project's lifetime within the reservoir (Ringrose, 2020, p.15).[4]

[4] There are further categories of capacity contained within the definition, briefly: "theoretical capacity" – how much could be potentially stored. This category assumes that "the entire reservoir can store CO2" (Holloway et. al., 2006, 12; "realistic capacity" – how much could be pragmatically stored. This is determined by a comprehensive assessment of the geological thresholds, engineering requirements, stratigraphic boundaries, stratigraphic traps, fault-line stresses, and whether there are competing interests in the reservoir (Holloway et. al., 2006, 12); and "viable capacity" – how much storage is actually viable in current socioeconomic, legal and political contexts. This builds on the realistic capacity but also considers the economic, legal, and regulatory barriers to geological storage (Holloway et. al., 2006, 12). Realistic and viable capacity are significantly smaller than the theoretical capacity of a site.

The CTBO, in contrast to the ICO, mandates geological sequestration – this refers to the physical act of recapturing and permanently storing CO2 in reservoirs. This can be done via point source capture, or by using technological NETPs. Sequestration will be dependent upon reservoir capacity, and will necessarily require injection capacity. It will also require transport infrastructure (a point that is also addressed in Article 17a of the NZIA and is distinct from the A18 ICO).

2. Obligation

The A18 ICO obligates entities to contribute to the Union-wide target of 50 million tonnes of annual CO2 injection capacity by 2030. The CTBO conversely obligates its targeted entities to sequester CO2 at a progressively increasing rate, until ultimately reaching 100% or geological net zero (GNZ) -- when all fossil-origin CO2 extracted or imported into a jurisdiction will be recaptured and stored -- by a net-zero target date (Jenkins et. al., 2021; Jenkins et. al., 2023). The obligation and stored fraction can continue beyond 100% to support net CO2 removal and net-negative targets after 100% has been achieved (Jenkins et. al., 2021).

3. Obligated Entities

The obligated entities under the CTBO are the extractors and importers of fossil carbon, including oil, gas, and coal, as well as non-fuel sources such as limestone for the production of cement. The A18 ICO, however, has a more limited scope. It only applies to authorised oil and gas entities that are producing within the territory of the Union. This would exclude any European entities that exclusively produce outside of the Union, even if they have a presence within Europe and supply oil and gas to the EU market.

The Committee on the Environment, Public Health and Food Safety within the European Parliament proposed an amendment that would instead target “each economic operator offering petroleum products, natural gas or coal on the Union market”, with each entity’s contribution being calculated on the basis of their “share in the Union's greenhouse gas emissions stemming from the combustion of the volumes of fossil fuels products offered on the Union market” (2023/0081(COD)). However, the amendment was rejected. We return to this issue under discussion of purpose and principle.

A18 Paragraph 1 also stipulates a cut-off for the obligation, such that any entity that produces oil and gas below a certain threshold will be made exempt from the ICO obligation and excluded from the total contribution calculation.

4. Contribution Calculation

Each entities’ contribution to the 50 MtCO2/yr injection capacity target, under the A18 ICO, is calculated pro rata on the basis of the entity’s share of production within the Union between 1 January 2020 to 31 December 2023. The CTBO, conversely, mandates that sequestration of CO2 resulting from the downstream use of fossil fuels within a jurisdiction progressively increases, starting at a low rate, for example 1%, and ultimately reaching 100% or GNZ, and possibly continuing beyond 100% to support net CO2 removal. In essence the CTBO can be considered an intensity target on the use of CO2 storage within a jurisdiction, guaranteeing balancing of CO2 production and CO2 storage at net zero. This balancing is not guaranteed for the A18 provisions for pro-rata contributions to a pre-set injection capacity threshold.

5. Compliance Mechanism

To fulfil the CTBO obligation, extractors and importers must pay for geological carbon storage. These additional costs are passed on to consumers through the products sold in the wider economy. Within this, the concept of tradable storage units (CSUs) is an integral part of the compliance mechanism of the CTBO (Jenkins et. al., 2021). When entities pay for geological carbon storage this leads to the generation of CSUs. These CSUs represent the stored fraction of CO2 and can be traded among storage providers, creating a liquid market for carbon storage and enabling competition and price discovery in the storage industry. The use of CSUs facilitates compliance with the CTBO by allowing entities to meet their storage obligations through trading and purchasing storage capacity. As such, the

CTBO is sometimes categorised as a Tradable Obligation Scheme (Hickey et. al, 2023), alongside LCFS where projects that directly capture CO2 from the air generate LCFS credits that are likewise able to be sold and traded to entities that exceed their carbon intensity benchmark (Townsend and Havercroft, 2019). The CTBO is defined as a license-to-operate condition, whereby non-compliance with the mandated CO2 storage obligation alongside their sale of fossil fuel products into a jurisdiction ultimately would result in the loss of the license to operate within that jurisdiction.

The A18 ICO, conversely, does not explicitly introduce a system of tradable units. Rather, it stipulates that entities can meet their targeted volumes of available CO2 injection capacity through the development of or investment in CO2 storage projects, agreements with other obligated entities, or agreements with third-party storage project developers or investors. Given that multiple ways are given for contributions to be met, the ICO provides flexibility in its design which may encourage a variety of approaches and foster innovation in CO2 injection capacity and storage development projects.

However, the structure of the A18 ICO is not incompatible with a system of the trading of obligations, given that it allows entities to enter into agreements with other entities or third-party developers in order to meet their obligations. If the legislation were amended to allow for the creation and trading of such units, it could potentially introduce a market mechanism similar to that seen in CTBO or LCFS, creating a market where entities trade their obligations or capacities.

An important compliance mechanism embedded within the A18 ICO is the use of penalties. Penalties serve as deterrents to ensure entity compliance in meeting their ICO. Under 18 Paragraph 1a Member States must introduce penalties to oil and gas entities that infringe their contribution obligations. These penalties must be introduced within 24 months after entry into force of the Regulation via administrative procedure or legal proceedings, or both, and must be “effective, proportionate and dissuasive” (2023/0081(COD), p.100). What this means is that penalties should be severe enough to discourage non-compliance, balanced in relation to the severity of the infringement, and strong enough to dissuade entities from considering non-compliance as a viable option. The exact nature of these penalties is not specified in the text and is left to the discretion of the Member States. Potential candidates include financial penalties, restrictions on operations, or other forms of sanctions. Proposals for the CTBO, so far, have not included explicit discussions of penalties. It is likely any CTBO proposal would require the definition of similar financial and/or loss of license-to-operate penalties as the A18 ICO to safeguard against market manipulation or the fraudulent sale of non-compliant fuels.

An additional feature of the ICO compliance mechanisms is that entities are required to submit regular reports detailing their progress towards meeting their contribution, as stipulated under Article 18 Paragraph 6. This not only holds entities accountable and aids compliance, but also ensures transparency, which could be crucial for public trust and policy success.

6. Strategic Use

Strategic use refers to how specific mechanisms are employed and designed to fit within a broader portfolio of strategies or policies. Strategic purpose is a major point of difference between the CTBO and ICO. While both are designed to be compatible with a portfolio of policies such as carbon pricing, the CTBO functions as a long-term “backstop” policy that is designed to act as a fail-safe in achieving net-zero by a target date in case other measures fail. The ICO, however, is a temporary “band-aid” policy, designed to achieve the specific goal of addressing a bottleneck in one part of the CCS value chain. We expand upon each in turn.

In all discussions of the CTBO, it is envisioned that the policy mechanism would serve to reinforce already existing political climate efforts, working alongside them in a supportive capacity (Zakkour et. al., 2024). In this context, the mechanism is often described as a “backstop” or “safety net policy”. Its full-effect is deigned to kick-in, in order to

prevent climate goals and targets beings derailed, in the event that other mechanisms, like carbon pricing, prove insufficient, inefficient, or fail. Zakkour et. al. explain:

> Rather than replace more conventional forms of climate policy and carbon pricing, the CSO/CTBO play a more significant role if these instruments do not yield sufficient emission reductions. In the event that carbon pricing reaches a level sufficient to deploy CCS/CDR without the need for additional support measures, the value of CSUs may be significantly eroded to the point of not having any utility (i.e. capturers would be keen to dispose of CO2 and willing to pay high prices for such services). As such, the CSO/CTBO can be viewed as a backstop or safety net policy in the event of imperfections in the effectiveness of carbon pricing to deliver the mitigation solutions needed to meet the Paris Agreement goals (Zakkour et. al., 2024, p.4).

Thus, as Jenkins et. al. (2021, p.2791) note, the CTBO can be introduced unilaterally by a region or country, can work alongside a carbon border adjustment mechanism, and can be supported by a carbon price, whether in the form of an ETS or carbon tax, or dividend. The CTBO is specifically designed to signal long-term investment confidence and stabilise a nascent market over the multi-decade timescales necessary to sustain large-scale infrastructure investment. Indeed, the CTBO policy defined in Jenkins et al. (2021) requires supplementing with demand-side carbon pricing policy in the first decade following its implementation, since the CTBO itself is relatively ineffective at low stored fraction obligations.

The A18 ICO, conversely, is a short-term policy. It introduces a once-off obligation on entities that will be in effect until 2030, or until the CO2 injection capacity target is achieved, after which the obligation dissipates. Hence, the ICO has a narrower, more targeted, and precise scope. It is strategically designed to eliminate a bottleneck in the storage part of the CCS value chain. It does not address the root cause of the bottleneck, but provides bottleneck relief – a temporary way to overcome the lack of injection capacity. The hope is that the A18 ICO will be sufficient to correct the market, and for carbon pricing to take back over, thus eliminating the need for the obligation. This is suggested both by the fact that the obligation only lasts until 2030, and by the stipulation provided in Article 18a Paragraph 1 that states that, three years into force of the regulation, the Commission will conduct an assessment of the "the functioning of the market for captured CO2", and determine whether, "the obligations set out in Article 18(1) effectively promote the development of the CO2 storage market in the Union" (2023/0081(COD), p. 101). In this way, we can understand the ICO as a "band-aid" policy or obligation: it strategically intervenes in a specific part of the system, providing a precise, temporary solution to a bottleneck in the CCS value chain, much like a band-aid provides immediate relief to a wound, allowing the natural healing process (in this case, the market and carbon pricing) to subsequently take over.

7. Purpose

The CTBO and A18 ICO, while both contributing to the broader goal of achieving net-zero emissions, serve distinct purposes within the context of Europe's policy landscape. The CTBO is first and foremost a climate mitigation policy (Jenkins et. al., 2021). Its purpose is to provide a "low-risk pathway to net-zero emissions by 2050" and ensure both early emissions reductions, and a rapid scale-up of permanent CO2 storage (Jenkins, et. al., 2021, p. 2777). This is envisioned as a key policy mechanism for driving the growth of CCS, and carries potential to ensure that all remaining fossil fuel use is fully abated, drive global momentum, signal investor certainty, and identify funding sources. The CTBO also provides opportunities to drive down oil and gas consumption by "putting a price on pollution" (Boot and Sundvor, 2024).

The A18 ICO, however, is situated within the broader context of the NZIA. The primary purpose of the NZIA is to scale-up Europe's "clean" technology industry (C/2023/1565). More specifically, it aims to strengthen Europe's net-zero technology products and manufacturing ecosystem, and in doing so, improve the functioning of the internal market, increase the EU's economic resilience, increase the competitiveness of European industries, achieve the EU's climate goals, and ensure the Union's future access to a secure and sustainable supply of net-zero technologies (SWD(2023) 219 final). The NZIA is a direct response to the competition threats from the heavy subsidy and rapid

scale-up of net-zero industry, particularly in the US under the Inflation Reduction Act, and China, and fits within the context of Europe's broader ambitious climate goals which will require a significant decarbonisation of industry (SWD(2023) 219 final). The European Commission outlines this clearly in the Staff Working Document for the NZIA:

> The international clean- tech race is in full swing, as the largest economies in the world, from the United States and Canada, to China, India, and Japan, have all started to significantly support their net-zero industries through comprehensive sets of measures, combining regulation and financing. This has created an unlevel playing field putting pressure on the economic viability and growth prospects of the EU's industries manufacturing net-zero technologies across their supply chain. These global supply dynamics, coupled with EU demand side aspects within the context of EU's ambitious energy and climate targets and the resulting high ambition for net-zero technology deployment, may lead to distortions of purchasing of those technologies, and result in potentially high import dependencies (SWD(2023) 219 final, p.3).

Within this context, A18 ICO is introduced to address one aspect of the NZIA response: the bottleneck in the CCS value chain which is blocking the scale-up of CCS – a critical net-zero technology – and, inevitably, BECCS and DACCS. We identified this as the strategic purpose of the ICO above. The problem of the CCS bottleneck and role of the A18 ICO in addressing it is indicated in several of the European Commission Documents. For example, the NZIA Staff Working Document (SWD(2023) 219 final) outlines that the EU currently faces a market failure that is common in emerging technology markets with limited demand and supply, heavy infrastructure capital investments, and uncertainty based on interdependence between operators of a future value chain. It explains that, despite having the EU ETS and a legal framework for the environmentally safe geological storage of CO2 in place (the CCS Directive), less than 2 million tonnes of CO2 are being stored geologically per year today in the European Economic Area, none if which falls within the Union territory (SWD(2023) 68 final, p.12). The limited supply of storage capacity results in prices that undermine the incentive to take final investment decisions to capture CO2 instead of emitting it. Analysts estimate that up to 88 capture projects could start up by 2030 and face this constraint (Rystad Energy, 2023). European stakeholders estimate a resulting demand for annual storage services in the European Economic Area (EEA) to be as high as 80 million tonnes per year by 2030, which could grow to at least 300 million tonnes per year in 2040.

A18 ICO was conceived as the solution to this bottleneck. As the Staff Working Document states, "by requiring sectorial contributions from the oil and gas companies to the establishment of the front- runner storage projects, a reliable quantity of storage services supply will become available" (SWD(2023) 219 final, p.45) This in turn will increase certainty to underpin investment decisions for the development of CO2 capture projects in hard-to-abate industries. Without the 2030 injection capacity target in place, companies along the CO2 value chain may continue to de-risk their investment decisions in parallel, which favours integrated projects with smaller scale and therefore higher prices, all of which are subject to permitting procedures for this new market.

Thus, while both the purpose of CTBO and ICO fits within the context of the EU's climate goals, the former is more directly a mitigation policy, while the latter is primarily concerned with removing the CCS bottleneck and developing net-zero industry within Europe.

8. Principle

The final important point of difference to mention is the difference in principles that underpin each mechanism. The CTBO is grounded in the principle of Extended Producer Responsibility (Kalimo, 2006) which seeks to identify producers, like fossil fuel companies, and charge them with responsibility for managing emissions that are generated as a result of their products. It is this principle that drives the CTBO, which would oblige fossil fuel producers to ensure that the emissions their fuels produce are captured and permanently stored via geological sequestration (Jenkins et. al., 2021).

The A18 ICO conversely, seems to be primarily grounded in an alternative principle, the ability to pay principle. According to the ability to pay principle, burdens should be borne in proportion to an agent's capacity to bear those burdens (Shue, 2014; Moellendorf, 2014; Duus-otterstrom, 2014). Page, in a discussion of state responsibility, sums up this principle well. He explains: "states should bear climatic burdens in proportion to their relative capacities to bear such burdens: the more a state is able to remedy climatic disadvantage through financing climatic mitigation and adaptation, that is, the more they should do so" (Page, 2012, p.305). Ability or capacity may refer to financial means, but it may also be refer to other factors such as resource, technical, or political, ability.

Discussions of the NZIA and the A18 ICO, consistently refer to the fact the oil and gas producers are best placed to fulfil the obligation. For instance, the European Commission Staff Working document states that, "oil and gas companies as they are best placed to deal with the subsoil assets, considering their knowledge and experience" (SWD(2023) 219 final, p.45). Another document speaks of "recognising the sector's specific know-how in this field" (COM(2024) 62 final). The final text of the NZIA itself stipulates that the oil and gas industry "possesses the assets, skills and knowledge needed to explore and develop additional storage sites" (2023/0081(COD), p.15). This clearly indicates that oil and gas entities are primarily being picked out by the ICO given that they are best place to rapidly deliver on the obligation as a result of their ability and expertise in the area, rather than because they contribute to global emissions (polluter pays), or produce the products that cause emissions, and as such should be responsible for their end-of-life disposal (extended producer responsibility).

Interpreting the A18 ICO through the lens of the ability to pay principle can provide clarity on why the obligation is specifically targeted at producers of oil and gas within the Union, rather than market suppliers or producers of coal and limestone.

Consider, for instance, Eni SpA, an oil and gas supermajor, and Wintershall DEA, an independent European oil and gas company. In 2022, Eni's EU oil and gas production was 82 kBOE/day, while their global production reached 1610 kBOE/day (Eni, 2022). Eni produces within Italy within the Union, but also has extensive non-EU operations in locations such as Norway, the UK, Algeria, and Libya. Conversely, Wintershall's EU oil and gas production totalled 207 kBOE/day in 2022, while their global production was 321 kBOE/day in the same year (Wintershall DEA, 2022; Wintershall DEA, 2024). These respective figures for European Union production figures are depicted in Figure 3, while global production figures are shown in Figure 4.[5]

To put these figures into perspective, the total EU oil and gas consumption in 2022 was 16'100 kBOE/day (Energy Institute, 2023), while the total EU oil and gas production was only 1'000 kBOE/day (Statista, 2023a; Statista, 2023b). This is illustrated in Figure 5. This stark contrast between consumption and production underscores the significant role of non-EU producers in supplying the EU market.

From the perspective of the polluter/producer pays principle, it seems counterintuitive that Wintershall, a smaller producer, would bear a greater obligation than Eni, a larger producer and supplier of oil and gas to the EU in terms of volume. The principle, which encapsulates the notion that all polluting/producing actors should "clean up their own mess", should in theory apply evenly to all polluting or producing entities.

[5] Figure 3 compares Wintershall and Eni against total EU oil and gas production which was approximately 1'000 kBOE/day in 2022 (Statista, 2023a; Statista, 2023b), which is approximately 71.1% when compared to Wintershall and Eni. Figure 4 compares Wintershall and Eni against total global oil and gas production which was approximately 160,000 kBOE/day in 2022 (IEA, 2023; IEA 2024), which is approximately 98.8% when compared to Wintershall and Eni.

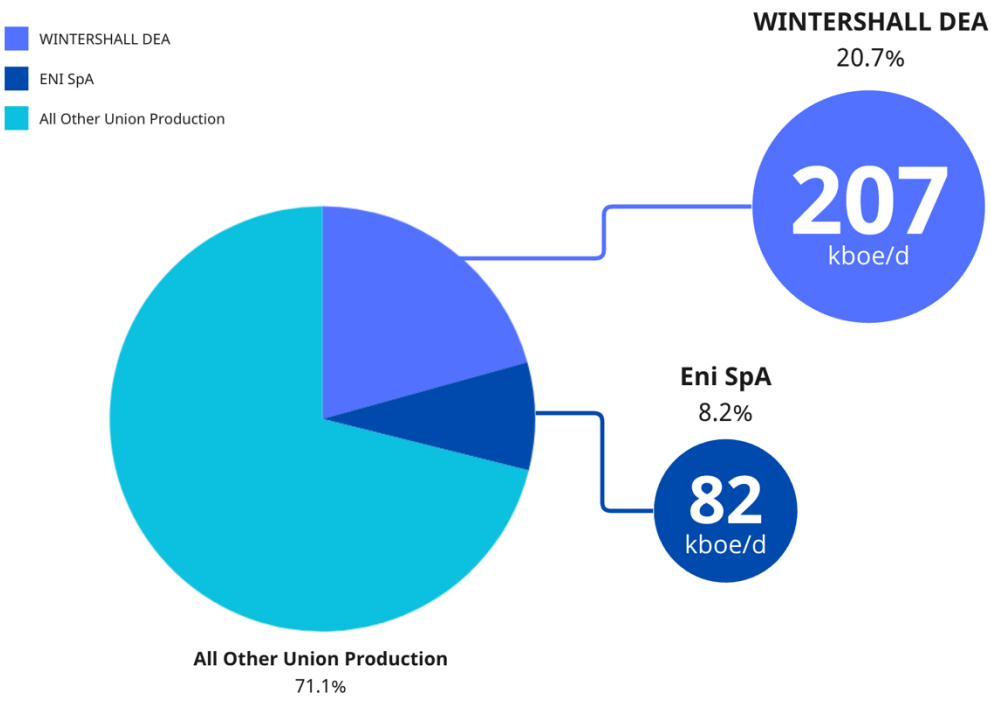

Figure 3 European Union Production of Oil and Gas 2022: Wintershall DEA, and Eni SpA

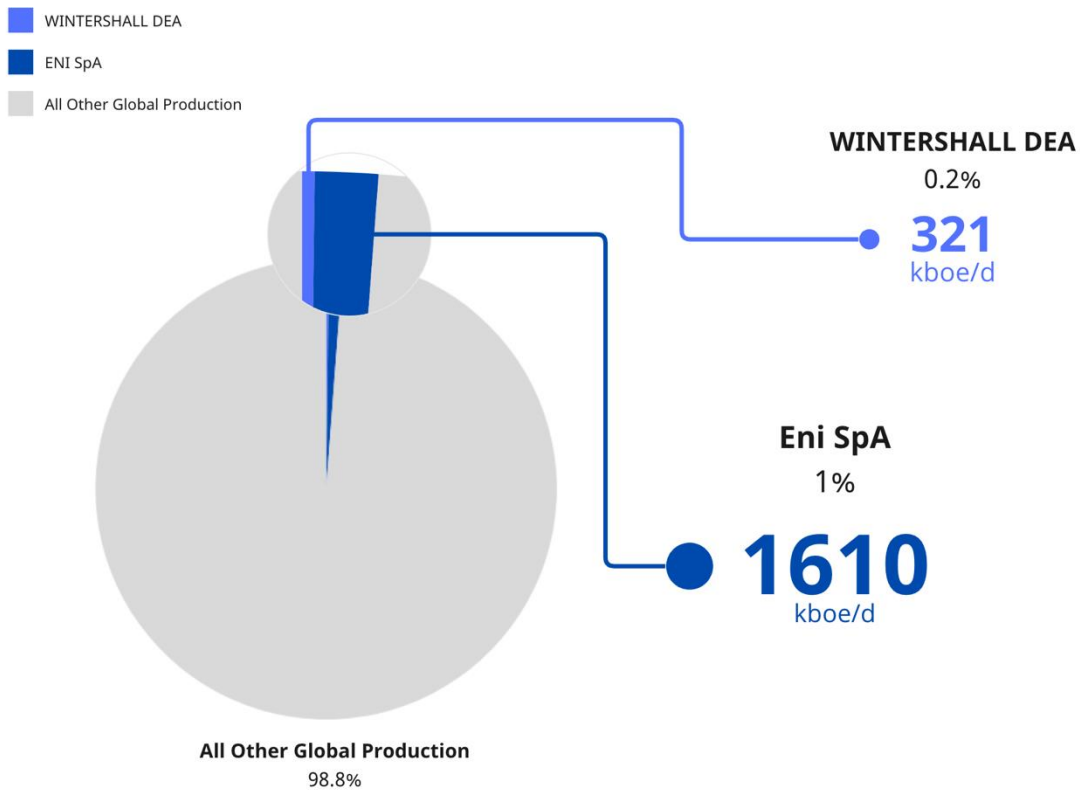

Figure 4 Global Production of Oil and Gas 2022: Wintershall DEA, and Eni SpA

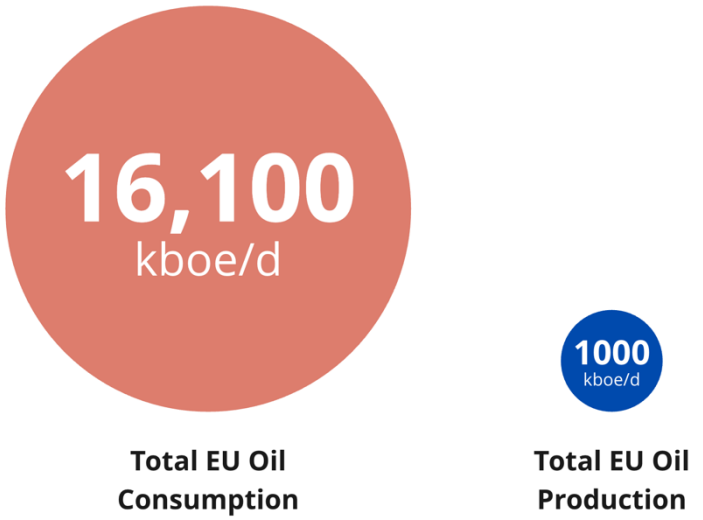

Figure 5 European Union Oil and Gas Consumption and Production 2022

However, the ability to pay principle provides a compelling rationale for targeting only EU producers. This principle is predicated on the notion that CO2 injection capacity must be developed within the Union's territory, and the entities that hold licenses to explore and develop these sites are oil and gas producers. Therefore, the obligation is placed on them, not because they are the largest contributors to global emissions (as per the polluter pays principle), or because they produce the products that cause emissions and should thus be responsible for their end-of-life disposal (as per the extended producer responsibility), but because they are best placed to rapidly deliver on the obligation due to their ability, technical expertise, licensing, and resource availability in the area. This interpretation aligns with the consistent references in discussions of the NZIA and the A18 ICO to the fact that oil and gas producers are best placed to fulfil the obligation. The ability principle thus offers a coherent explanation for the rationale behind targeting of EU producers in the A18 ICO, highlighting the importance of considering different principles in understanding and evaluating climate policies.

In this context, it is worth noting the similarities between the ICO and the U.S. Defense Production Act (DPA). Adopted by the U.S. Congress in 1950, the primary focus of the DPA is on increasing domestic production of essential materials and goods deemed necessary for national defence in times of crisis (Neenan & Nicastro, 2023). The Act imbues the President with the power to direct private entities to prioritise government purchases for national defense and fulfil production contracts. Like the ICO, the DPA is grounded in the ability principle, as it targets entities that have the capacity to rapidly deliver and fulfil contracts due to their ability, technical expertise, and resource availability.

In a recent important development, the DPA has been used as a mechanism by the US to address the security of supply of critical minerals (IEA, 2023b). In 2022, President Biden signed Presidential Determination No. 2022-11, authorising the use of the DPA to strengthen domestic battery capacity, including directing increases in domestic mining and processing capacity for battery materials (The White House, 2022; IEA, 2023b). This action underscores a need to secure a reliable domestic supply of critical materials for large-capacity batteries, which is essential for a net-zero economy. This use of the DPA bears a striking similarity with the NZIA, which is likewise focused on increasing the supply and security of net-zero technologies and industry. This comparison further emphasises the importance and potential effectiveness of the ability principle in driving climate policy and mechanisms like the ICO.

In sum, we have compared the ICO and CTBO against eight criteria: subject, mandate, obligated entities, contribution calculation, compliance mechanism, strategic use, purpose, and principle. In doing so, we have identified key differences between each mandate mechanism.

4 NZIA Pathways for the Commercialisation of Technological NETPs

In this section we identify several potential routes that the A18 ICO may facilitate for the scale-up of technological NETPs, BECCS and DACCS. We label the first the "A18 ICO Pathway" – this is the intended pathway of the NZIA. The second, we term the "Extended ICO Pathway", and would involve the renewed implementation of injection capacity obligations for 2040 and 2050 respectively in order to meet EU needs. The third, we label the "CTBO pathway", and is a pathway that the ICO may prove critical in facilitating. Each pathway is represented in Figure 6. We examine each in turn.

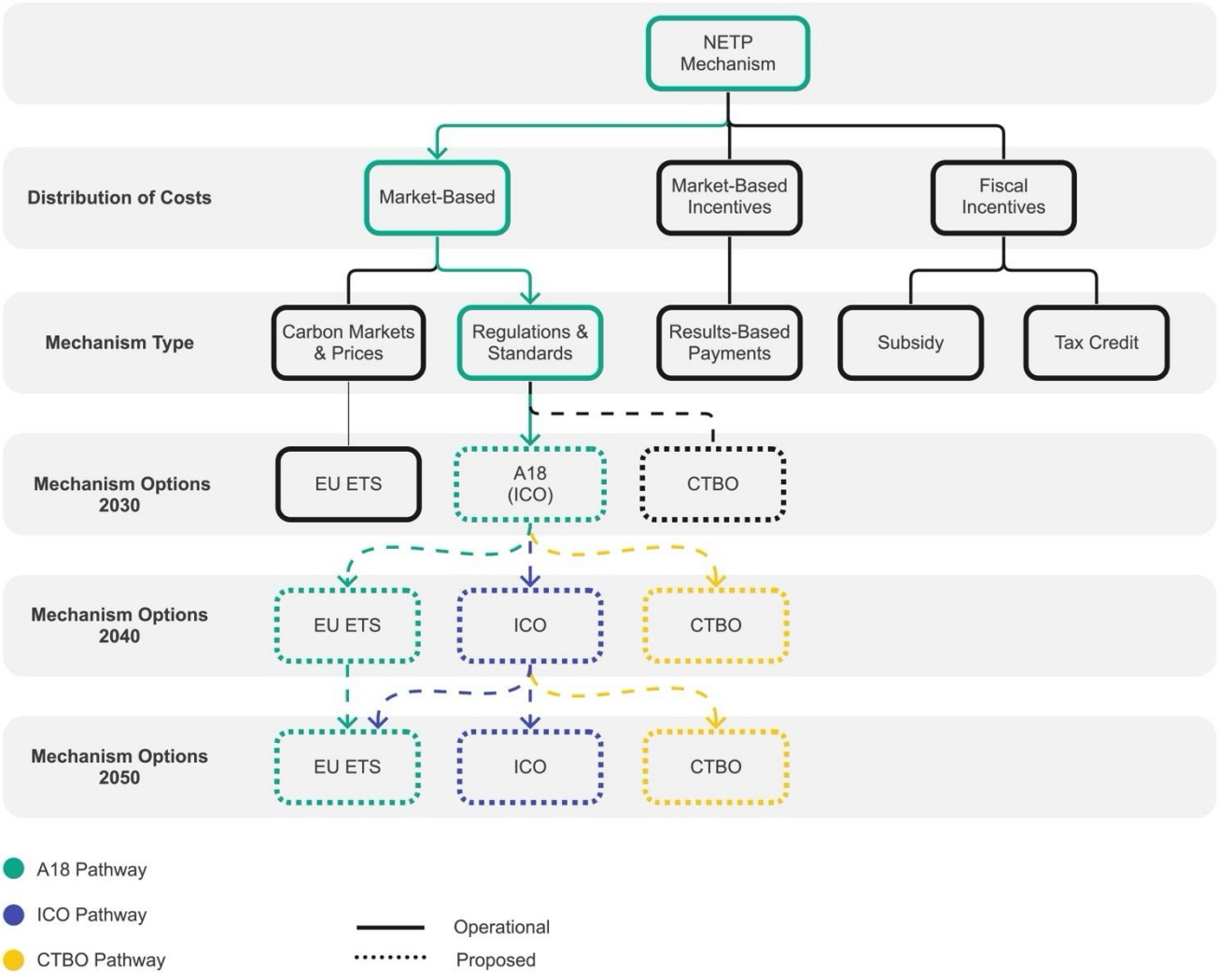

Figure 6 NZIA A18 Policy Pathways

Note: A18 ICO is represented as proposed since it is not yet operational. However, the final text has been agreed upon. This is a simplified illustration, and does not fully capture the range of policy mechanisms employed within the EU, that may work in tandem with these measures and pathways.

4.1 A18 Pathway

This pathway tracks the intended trajectory of the A18 ICO as laid out under purpose in S3.2 above. As such, it aligns with the suit of EU policies that concern CCS as a net-zero technologies under the NZIA in general, as well as carbon management, including the EU ETS, and the Carbon Management Strategy that has recently been outlined by the European Commission (COM(2024) 62 final).

As discussed in S3, the mechanism is envisioned as a short-term policy intended to alleviate the bottleneck in storage availability in the CCS value chain in the Union, which represents a market failure. If successful, the ICO is intended to enable the CCS value chain to be scaled up predominantly using market forces after the obligation has been met. We have mapped this pathway, albeit in an simplified fashion, in Figure 6 in green. It indicates the implementation of the A18 ICO to meet its 2030 target, after which the mechanism lapses. It is important to note that the EU ETS, a predominant mechanism, continues to operate throughout this period and beyond.

The Carbon Management Strategy is key in understanding how this pathway towards the scale up of the CCS value chain and technological NETPs in meant to unfold. As the European Commission communication on "Towards an Ambitious Industrial Carbon Management Plan for the EU" makes clear, the carbon price signal in the EU ETS will be key to making CCS projects commercially viable, factoring in the costs of capture, transport, and storage of CO2, as well the price of emitting the same amount of CO2 (COM(2024) 62 final).

The European Commission's vision for 2040 is one where the majority of carbon value chains have become economically viable, enabling EU climate objectives to be met (COM(2024) 62 final). This vision is predicated on the idea of CO2 as a tradable commodity, either for storage or use within the EU's single market. Beyond 2040, the Commission envisages a scenario where industrial carbon management becomes an integral part of the EU's economic system. In this future, the primary source for carbon-based industrial processes or transport fuels would be biogenic or atmospheric carbon. The realisation of this vision, of a well-functioning and competitive market for captured CO2, necessitates a partnership with industry and Member States. This partnership is crucial to ensure the viability of carbon value chains and the integration of industrial carbon management into the EU's economic system (COM(2024) 62 final, p.6).

4.2 Extended ICO Pathway

We refer to the second as the Injection Capacity Obligation (ICO) pathway. As shown, the A18 ICO is a short-term policy set to a 2030 target. As discussed in S3.2, the hope is that the A18 ICO will be sufficient to correct the market failure it is addressing, and for carbon pricing to take back over once the bottleneck has been addressed. There is scope, however, for the ICO to be extended to cover a 2040, and even a consecutive 2050 target, if the bottleneck is not resolved, and appropriate and needed targets of injection capacity are not met. We have mapped the introduction of these extended 2040 and 2050 ICO obligations in blue in Figure 6. Recall that Article 18a Paragraph 1 requires a review of the effectiveness of the obligation in correcting the storage market to take place within three years into entry into force of A18. Based on this assessment, the Commission is entitled to propose "a legislative act to regulate the market in order to address any short-comings identified, notably with regards to hard-to-abate emissions" (18a Paragraph 2) (2023/0081(COD), p.101). This provision suggests capacity for the European Commission to review and reassess any need to extend and renew an ICO.

Extending the ICO approach requires the EU to progressively estimate the required scale of point-source CCS and engineered, technological NETPs activities which will be taking place in the EU at the time of net zero, in order to scale the capacity of the storage market up to meet that scale in time for net zero. The EU suggests this may require 0.45 GtCO2/yr injection capacity within the EU market by 2050 (COM(2024) 62 final), a ten-fold increase in the capacity generated by the original A18 ICO by 2030. This increase in injection capacity would likely require the expansion of the mandate to cover (i) all fossil fuels, (ii) pro-rata contributions based on import and direct extraction of fossil fuels within the EU market.

4.3 The CTBO Pathway

The third pathway we identify is the Carbon Takeback Obligation (CTBO) pathway. We depict this final pathway in yellow in Figure 6. On this pathway, the NZIA A18 would serve to pave the way for a CTBO to be introduced within Europe. A18 does this insofar as it sets a introduces a precedent for climate-focused mandate mechanisms on fossil fuel producers in the EU policy landscape for the first time. As stressed throughout this analysis, this is a significant, novel achievement of the NZIA.

For these reasons, the A18 ICO has been welcomed by the academic and policy community advocating for the CTBO. The regulation has been described as a potential "gamechanger in driving climate action" (Carbon Gap & Carbon Balance Initiative, 2023), as the "first iteration of a `storage mandate' policy" (Boot & Sundvor, 2024), and an example approach to the implementation of a storage obligation, alongside the 10% domestic storage obligation recommended in the UK's Net Zero Review (Jenkins et. al., 2023).[6] The Carbon Balance Initiative states that, "its enforcement could kickstart a market for CO2 storage and ensure that fossil producers, who are current and historic contributors to climate change, are now on the hook for climate impacts caused by their products".[7]

While the ICO is, as we have stressed, distinct from a storage mandate, and focused exclusively on injection capacity provision, there is no doubt that it may boost support for such a storage mandate on the fossil fuel sector. A CTBO, then, may take over from the A180 ICO, serving as a more stable, long-term safety net policy for CO2 storage that could accompany EU policy up until 2050 and beyond. It would do so via a complimentary and relatively natural extension to the ICO mandate, envisaged as sitting as a backdrop below the ETS framework to ensure delivery of a CO2 storage market of the correct scale and function to balance residual CO2 production at the time of net zero. The extension would require a reframing of the ICO provision from an absolute capacity target to an intensity target in the 2030s, before a stored fraction trajectory was outlined for the CTBO mandate through the 2030s and 2040s. This would likely require substantial re-negotiation of the provisions outlined in the NZIA text, including recognition of importers as well as extractors to level the playing field, and the creation and regulation of a robust carbon storage unit trading system.

5 Conclusion

This deliverable has conducted a comprehensive assessment of Article 18 (A18) of the European Commission's Net Zero Industry Act (NZIA). The obligation under A18 – what we have termed the Injection Capacity Obligation (ICO) – represents a significant step forward in the EU's efforts to mitigate climate change. By placing an obligation on oil and gas producers to contribute towards CO2 storage injection capacity, the NZIA has introduced a novel policy instrument that could play a crucial role in the commercialisation and scale-up of technological negative emissions technologies and practices (NETPs), namely BECCS and DACCS.

The ICO is a first-of-its-kind. It mandates oil and gas producers in the European Union (EU) to contribute towards CO2 storage injection capacity, proportionate to their rate of oil and gas extraction within Europe. Utilising the framework and assessment of NETPs mechanisms developed in Deliverable 2.1, we have identified the ICO policy mechanism to

[6] Jenkins, Stuart, Mirte Boot, Rebecca Bell, Ingrid Udd Sundvor, Olivia Powis, Ruth Herbert, and Myles Allen. "Markets and Mandates: How Best to Drive Pace in CCS Deployment? Briefing Note," 2023. https://www.ccsassociation.org/wp-content/uploads/2023/11/Briefing-Note.-Markets-and-Mandates-How-best-to-drive-pace-in-CCS-deployment.pdf.; Rt Hon Chris Skidmore MP. "MISSION ZERO: Independent Review of Net Zero," 2023, p.116.

[7] Carbon Balance Initiative. "Article 18, Net Zero Industry Act." Accessed March 11, 2024. https://www.carbon-balance.earth/library/article-18-net-zero-industry-act.

be novel in several respects. It is the first climate-focussed obligation placed on a wide group of fossil fuel producers to reach legislative agreement anywhere globally; it introduces penalties on these entities for infringement of their obligations (again first-of-its-kind for a wide group of fossil fuel companies); and its focus is specifically on developing geological CO2 storage injection capacity to compliment existing European policies for market growth in CO2 capture capacity (as opposed, for example, policy which directly supports the CO2 capture or sequestration activities).

We compared the ICO with another proposed mandate mechanism that has been gaining interest, the Carbon Takeback Obligation (CTBO), highlighting key differences in their design and function along the following criteria: obligation subject, mandated activity, obligated entities, contribution calculation, compliance mechanism, strategic use, purpose, and principle. We summarise our key findings in S5.1. We also identified three potential policy pathways that the A18 legislation may give rise to, and which would assist in facilitating the scale-up of Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS). We termed these pathways the A18 Pathway, the Extended ICO Pathway, and the CTBO pathway respectively. Each offer distinct approaches to addressing the challenges of commercialising and scaling up technological NETPs.

In conclusion, the ICO represents a significant step forward in climate-focused obligations placed on fossil fuel producers. It provides a temporary solution to address market failure in the development of the carbon capture and storage (CCS) value chain in the Union. However, its effectiveness and long-term impact will depend on the successful implementation of the identified policy pathways and the continued commitment of oil and gas producers to meet their obligations.

5.1 Policy Relevant Findings and Key Takeaways

Our analysis of the obligation under Article 18 of the European Commission's Net Zero Industry Act (NZIA) has revealed several key findings:

1. The Injection Capacity Obligation (ICO): The ICO is a pioneering policy instrument that mandates oil and gas producers in the EU to contribute towards CO2 storage injection capacity. This obligation is unique in its focus on developing geological CO2 storage injection capacity, a critical component of the carbon capture and storage (CCS) value chain.

2. ICO vs CTBO: The ICO is distinct from other proposed mandate mechanisms such as the Carbon Takeback Obligation (CTBO). While the CTBO is a long-term supply-side mitigation policy grounded in the principle of extended producer responsibility, the ICO is a temporary measure aimed at addressing the bottleneck in CO2 injection capacity. The ICO is grounded in the ability to pay principle, which stipulates that the burden of climate mitigation and action should fall on those who are most able to meet that burden. Appeal to the ability to pay principle is novel, and emphasises both the flexibility of the mandate mechanisms as well as the principles we appeal to in policy design.

3. ICO and the DPA: The ICO shares a striking similarity with the U.S. Defense Production Act (DPA), both being grounded in the ability to pay principle. The DPA empowers the U.S. President to direct private entities to prioritise government purchases and fulfil production contracts to increase domestic production of essential materials and goods deemed necessary for national defence in times of crisis. It targets entities capable of rapidly delivering and fulfilling contracts due to their ability, technical expertise, and resource availability. Recently, the DPA was used to address the security of supply of critical minerals, underscoring the need for a reliable domestic supply of critical materials for large-capacity batteries, essential for a net-zero economy. This use of the DPA mirrors the NZIA's focus on increasing the supply and security of net-zero technologies and industry. This comparison underscores the importance and potential effectiveness of the ability principle in driving climate policy and mechanisms like the ICO.

4. Backstop vs Band-Aid Policy: The CTBO is a 'backstop' policy that ensures net zero emissions by the target date if other CO2 reduction measures fall short, based on extended producer responsibility. On the other hand, the ICO is a temporary 'band-aid' solution designed to quickly rectify market failure in the Union's CCS value chain by addressing CO2 injection capacity issues.

5. Three Policy Pathways for Scaling Technological NETPs: Our analysis has identified three potential policy pathways arising from the Article 18 legislation that could facilitate the scale-up of Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS).

A18 Pathway: This pathway aligns with the suite of EU policies concerning Carbon Capture and Storage (CCS) as net-zero technologies under the NZIA. It is envisioned as a short-term policy to alleviate the bottleneck in storage availability in the CCS value chain in the Union, which represents a market failure.

Extended ICO Pathway: This pathway involves the renewed implementation of injection capacity obligations for 2040 and 2050 respectively, if the bottleneck is not resolved and appropriate targets of injection capacity are not met. This approach requires the EU to progressively estimate the required scale of point-source CCS and engineered NETPs activities which will be taking place in the EU at the time of net zero.

CTBO Pathway: On this pathway, the NZIA A18 would serve to pave the way for a CTBO to be introduced within Europe. A CTBO may take over from the A180 ICO, serving as a more stable, long-term safety net policy for CO2 storage that could accompany EU policy up until 2050 and beyond.

5.2 Further Research

Our findings underscore the potential of the A18 ICO as a policy tool to drive the commercialisation and scale-up of NETPs in the EU. We aim to develop the main body of this deliverable, in collaboration with other NEGEM partners, for submission as a peer-reviewed publication.

This deliverable also highlights the need for further research and policy development to fully realise the potential of the ICO as a NETP mechanism. As we move towards a net-zero future, such policy innovations will be crucial in ensuring that we meet our climate objectives.

There are several issues our report has raised that warrant further attention. For instance, the A18 Pathway, while promising, presents several areas that warrant deeper investigation. The reliance on market forces post-2030 introduces a degree of uncertainty, as these forces are subject to economic fluctuations and potential shifts in the wider policy landscape. The viability of carbon value chains, crucially dependent on partnerships with industry and Member States, may encounter challenges due to divergent priorities, regulatory frameworks, and economic conditions across different Member States. Future research should aim to explore and anticipate these potential barriers and propose strategies to navigate them effectively, ensuring the successful implementation of the A18 Pathway.

For preparing this report, the following deliverable/s have been taken into consideration:

D#	Deliverable title	Lead Beneficiary	Type	Dissemination level	Due date (in MM)
D2.1	Quantitative survey of commercialisation mechanisms	UOXF	Report	PU	M18

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