Deployment of an industrial Carbon Capture and Storage cluster in Europe: A funding pathway
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

Authors:

The Industrial Innovation for Competitiveness (i24c) initiative is a European platform established by the European Climate Foundation and dedicated to developing and promoting an industrial strategy that secures European industry’s competitive advantage through innovation. It aims to strengthen understanding and confidence in how, through a systemic focus on innovation, Europe’s industries can successfully compete and drive prosperity in the dynamic transition to the new economy, shaped by global technological, social and ecological megatrends. i24c develops evidence to inform the critical debate on these issues in Europe and works to co-create effective and socially fair solutions with a wide range of partners.

About Element Energy

Element Energy is a leading low carbon energy consultancy working in a range of sectors including carbon capture and storage, low carbon transport, low carbon buildings, renewable power generation, energy networks, and energy storage. Element Energy works with a broad range of private and public sector clients to address challenges across the low carbon energy sector, and provides insight and analysis across all parts of the CCS chain.

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7th August 2017

Disclaimer

While the authors consider that the data and opinions contained in this report are sound, all parties must rely upon their own skill and judgement when using it. The authors do not make any representation or warranty, expressed or implied, as to the accuracy or completeness of the report. There is considerable uncertainty around the development of industrial CCS and the available data are extremely limited. The authors assume no liability for any loss or damage arising from decisions made on the basis of this report. The views and judgements expressed here are the opinions of the authors and do not reflect those of the European Climate Foundation or any of the stakeholders consulted during the course of this project.

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We gratefully acknowledge the following stakeholders for the support and feedback they provided:

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Allan Baker (Société Générale)
Andy Read (ROAD)
Caterina De Matteis (IOGB)
Chris Gittins (TAQA)
Dominique Copin (Total)
Graeme Sweeney (ZEP)
Jonas Helseth (Bellona)
Keith Whiriskey (Bellona)
Luke Warren (ZEP secretariat)
Maria Velkova (DG CLIMA)
Martin Porter (i24c)
Michael Schuetz (DG ENER)
Nikki Brain (ZEP secretariat)
Randolf Weterings (Port of Rotterdam)
Silvia Vaghi (GCCSI)
Theo Mitchell (ZEP secretariat)
Thomas Berly (IEA)
Thomas Briggs (EIB)
Vassilios Kougionas (DG Research & Innovation)
Wim Vanderstricht (ArcelorMittal)

ACKNOWLEDGMENTS
FOREWORD

I am proud to present the latest instalment in our series of technical studies examining “bottlenecks” on the way to the full decarbonisation of Europe in line with the aims of the Paris Agreement. Attention-grabbing strides have recently been made in the decarbonisation of electricity and transport, where the continued application of cutting-edge technology, systems thinking, long-term investment and economies-of-scale will be central to sustained progress. This has been the subject of two of the earlier studies in this series.*

Notwithstanding the progress in other sectors, there is now a striking degree of consensus that much larger strides are needed if we are to decarbonise Europe’s Resource and Energy-Intensive Industries (REIs), which are collectively responsible for around 20 per cent of Europe’s emissions and whose products are indispensable to the low carbon transition we need. Without doubt, Industrial Carbon Capture and Storage (ICCS) will have a role to play here, alongside innovative circular materials design and resource and energy efficient manufacturing processes, in helping many of these industries to reduce their emissions, at scale, as cost-effectively as possible while creating sustainable, well-paid employment.

But it is becoming urgent that progress speeds up, to enable ICCS to make a full contribution to European decarbonisation in the short-term. And this requires concerted action now.

The aim of this report is to examine whether current EU and national funding mechanisms are “fit for purpose” when it comes to providing the finance ICCS clusters need – as soon as possible. With the support of Element Energy, we have identified a funding pathway which could see Europe’s first ICCS cluster becoming operational by as soon as 2021. In what follows, we describe this pathway and make detailed suggestions for what key stakeholders should do, to ensure successful deployment.

With long investment cycles, attracting finance remains a major hurdle to ICCS projects. Our analysis confirms that adopting a cluster approach (rather than one based on individual projects) has the potential to deliver by far the best value, as well as securing the volumes of CO2 required to make storage development viable.

The prize is potentially huge. Having assessed the key requirements of a potential ICCS cluster, using The Port of Rotterdam (one of Europe’s largest industrial clusters) as an illustration and guide, we find that a cluster of this scope could store over 30 million tonnes of CO2, by 2035. And it could get started within five years, given the right support. This would bring huge spillover benefits for industrial decarbonisation in the Netherlands and across Northern Europe in general.

The 2020s will be a make-or-break decade for so many aspects of the low carbon transition. CCS in industrial plants needs to be part of the picture. Getting the financing right is clearly an essential first step. But we also need to establish the right frameworks for shared liability between operators and tackle some of the concerns the public and some policymakers still harbour over industrial CCS. This report shows the way for at least one of the hurdles related to CCS. I hope you enjoy reading it.

*Scaling up innovation in the energy union to meet new climate, competitiveness and societal goals (2016), i24c with support from Capgemini Consulting; Driving innovation in the automotive value chain (2016), i24c with support from Ricardo Energy & Environment
EXECUTIVE SUMMARY

1. Industrial CCS clusters are key to European industrial decarbonisation

Carbon Capture and Storage (CCS) is a key to Europe reaching the Paris Agreement objectives of net zero emissions by 2050, and to deeply decarbonise European energy-intensive industry. This report argues that there is a clear value proposition in building CCS projects around industrial clusters, rather than considering site-by-site decarbonisation options. Development of CCS projects as “clusters” and shared transport and storage infrastructure can reduce cost and risk for multiple industrial emitters, which are often located close to each other (e.g. near ports).

Industrial CCS can also play an instrumental role in retaining the existing energy-intensive industries, which currently employ more than 1 million people in Europe, by mitigating the long-term carbon price risk. The availability of CCS could reduce the cumulated energy system costs by more than €1 trillion in the EU by 2050 alone and in the longer term, and as European countries move towards net zero emissions, the value of CCS is expected to further increase to more than €50 billion per annum.

Element Energy and i2-4c have sought to develop a funding pathway combining existing and future European funds and other financing instruments to leverage private investment and successfully deliver at least one industrial CCS cluster in Europe. Over a period of six months and with significant input from European CCS stakeholders, the project has assessed the key requirements of a potential industrial CCS cluster using Rotterdam as an illustrative starting point. On that basis, we have suggested specific actions for various stakeholders in order to successfully embark on this pathway and identified key messages for cluster development across Europe using Rotterdam as a case study.

2. The first industrial CCS clusters in Europe can be operational in the early 2020’s

Storage appraisal is the first activity of any CCS project, and is a precondition for further progress. The first industrial CCS clusters in Europe, which already have access to proven storage capacity, can be operational by the early 2020s.

Once the proven storage capacity is available, industrial CCS clusters can be developed in phases:

- Phase 1: The first phase of this project would involve the installation of an onshore backbone pipeline and offshore pipeline connecting onshore industrial emitter(s) to an existing offshore platform, as well as modifications to existing storage infrastructure. This project is estimated to cost €160m and could be operational as early as 2021 (subject to final investment decision in 2019).
- Phase 2: Other industrial emitters in Rotterdam could join the cluster in the second phase and potentially utilise the CO2 infrastructure. The capital cost of increasing the capture rate to 3 million tonnes of CO2 per annum, installation of onshore feeder pipelines, further modifications to existing storage infrastructure, and appraisal of further gas fields for cluster expansion is estimated to be €720 million in total but would require securing €60m for pre-FID activities including appraisal by 2019. The Phase 2 project could be operational by 2025/2026, and could be part-funded by the EU.
- Phase 3: Beyond Phase 1 & 2, the cluster would have the potential of expanding even further by including other emitters in Port of Rotterdam and rest of Netherlands, and enabling the deployment of other nearby industrial clusters including La Havre, Antwerp, Hamburg and Ruhr.

3. European CCS clusters can be unlocked with grants, subsidies and guarantees

Enabling the deployment of strategically important industrial CCS clusters in Europe will require a variety of coordinated funds and subsidies including grants for storage appraisal and construction; loan guarantees to unlock private investment; operational subsidies; and operational guarantees and sharing storage liability to de-risk the cluster. Key requirements of a typical industrial CCS project vary for the pre-FID (pre-Final Investment Decision), Construction, Operation and Post-closure phases.
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

Accessing the Structural Funds post 2020 will be important to secure the required funding for several industrial CCS clusters by 2030. However, these are not currently available for deployment of industrial CCS clusters, as investment to achieve the reduction of GHG emissions from activities included in the ETS Directive is not supported.

Although Horizon 2020 may provide some limited funding for storage appraisal in the short-term, no EU fund or MS funding are available today to support the significant level of storage appraisal activity needed to unlock gigatones of bankable storage capacity over the next decades and H2020 does not typically provide the level funding needed for the appraisal of one aquifer (e.g. €50-100m).

If Project of Common Interest (PCI) status is achieved and Connecting Europe Facility funding application is successful, CEF Energy could potentially part-fund the CO₂ pipeline(s) of the Rotterdam industrial CCS cluster; however, it should be noted that the Rotterdam PCI application included a cross-border CO₂ infrastructure, which would be relevant for Phase 3 of this project.

Private investment can be leveraged for the construction phase with the right incentives and guarantees; however, it should be noted that equity and debt raised for the construction phase, and associated returns should be paid back during the operation phase of the project.

EU ETS related revenues can only be included in the project cash-flow if the carbon price is accompanied with government guarantees/subsidies. Total value of avoided CO₂ emissions could be €1bn for the potential Rotterdam CCS cluster until 2035 depending on the EU ETS price. The guarantee of the EU ETS price will be key given that the price is highly uncertain and EU ETS is unlikely to be a key driver for the deployment of industrial CCS clusters.
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

It may be possible to fund CCS through the European Regional Development Fund as a Research, Technological Innovation Mechanism. A separate funding mechanism is needed to secure all funds, finance, guarantees and subsidies needed to realise the project. CCS clusters should be bankable, reducing the operational risk.

1. COST TO REALISER AN INDUSTRIAL CCS CLUSTER

2. CREATE CLUSTER FINANCING TO SECURE FUNDING

3. SET UP SUPPORT MECHANISMS FOR INDUSTRIAL CCS CLUSTERS

4. PROVIDE SUPPORT FUNDS TO INDUSTRIAL CCS CLUSTERS

5. RAISE FUNDS TO CREATE INDUSTRIAL CCS CLUSTERS

6. WITH GOVERNMENT SUPPORT, EUROPEAN INDUSTRIAL CCS CLUSTERS COULD BE FULLY FUNDED

Some of the funds that have been awarded to the ROAD project may be reused for an expansion of the European Regional Development Fund (e.g. for the ROAD project). Emission reductions from industrial and other pre-FID projects could also reduce EU allowance auctions and structural investments cost. Horizon 2020 calls on storage appraisal, Connecting Europe Facility funding for some projects, and other international funds (e.g. OGCI Climate Investments) could also reduce overall Member State support required.

Keystone and similar projects are managed by a project delivery vehicle (SPV), with eligibility for operating grant (and other) funds. CCS clusters could be fully funded by securing a pilot of at least 5 clusters by 2030, starting at 2021/22. The overall Member State support required.

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While government support, European industrial clusters can be bankable.
1.1 The need for industrial CCS to achieve the Paris Agreement objectives

Carbon Capture and Storage (CCS) has been recognised, both internationally, and in the EU, as a key technology in reducing CO₂ emissions in the energy-intensive manufacturing industry, which will become vital for meeting long-term greenhouse gas reduction targets. CCS is also key to Europe's Energy Union Strategy as 330,000 jobs could be created and secured in fuel supply, CCS equipment manufacture, plant operation and CO₂ storage facility operation. CCS infrastructure is also important to retain the existing energy-intensive industries, which currently employ more than 1 million people in Europe, by mitigating the long-term carbon price risk.

The whole energy system modelling of 10 European countries, carried out by ZEP recently, showed that:

- The value CCS to the EU could be in excess of €1 trillion by 2050 alone and in the longer term, and as European countries move towards net zero emissions, the value of CCS is expected to further increase to more than €50 billion per annum.
- The future of energy intensive industries including cement, steel and oil and gas is highly dependent on CCS. For these sectors and many more, CCS is critical to retaining high-skilled jobs and boosting economic activity across EU Member States in an increasingly carbon-constrained world.
- Infrastructure investments are needed now to achieve the lowest emissions and lowest costs out to 2050. CCS infrastructure can unlock emissions reductions across the whole energy system with significant potential for cost reductions through cross-border initiatives and sharing of infrastructure.

Development of industrial CCS projects as “clusters” offers significant deliverability and commercial advantages by achieving economies of scale – compared to the isolated and commercially challenging point-to-point projects. Similar to the natural gas pipelines, CO₂ transport and storage infrastructure benefits from economies of scale (e.g. building one large trunk pipeline is more cost effective than building several smaller pipelines). Also, large emission sources such as industrial emitters often historically grew close to each other (e.g. near ports or rivers), which leads logically to the development of CO₂ capture clusters and shared transport and storage infrastructure. Shared infrastructure within industrial clusters can reduce cost and risk for multiple industrial emitters.


1.1.1 The need for industrial CCS to achieve the Paris Agreement objectives
1.2 Purpose of this study and Methodology

Element Energy and i2-4c have sought to develop a funding pathway combining existing and future European funds and other financing instruments to leverage private investment and successfully deliver at least one industrial CCS cluster in Europe. Over a period of six months and with significant input from European CCS stakeholders, the project has assessed the key requirements of a potential industrial CCS cluster using Rotterdam as an illustrative starting point, which hosts one of the largest industrial clusters in Europe. It also has access to the P18-4 gas field, which is already appraised and permitted. On that basis, we have suggested specific actions for various stakeholders in order to successfully embark on this pathway. The project aims to identify key messages for cluster development across Europe using Rotterdam as a case study.

By developing a funding pathway, the project aims to identify the funding gaps, eligibility constraints, and an action list to align future funds to the project requirements and enable an industrial CCS cluster in Europe. The team has examined a potential industrial CCS cluster in Rotterdam. Rotterdam hosts one of the largest industrial clusters in Europe within a relatively dense area and offshore depleted gas fields where captured CO\(_2\) from industrial sources can be stored using potentially existing O&G facilities. The Port of Rotterdam industrial CCS cluster is expected to be an enabler for a wider CCS network including industrial clusters of Antwerp, Ruhr, UK, etc.

Over a period of six months and with significant input from European CCS stakeholders, the project has assessed the key requirements of a potential industrial CCS cluster in Rotterdam and developed a funding pathway for the cluster with specific actions for various stakeholders. The project aims to identify key messages for cluster development across Europe using Rotterdam as a case study.

Section 2 presents the key requirements of industrial CCS clusters.

Section 3 discusses how a potential industrial CCS cluster in Rotterdam can be developed in phases.

Section 4 reviews potential private and public funding/financing options, which can be applied to other (industrial) CCS clusters.

Section 5 presents the funding pathway and the key recommendations for the European Commission, Member States, and project developers.

Energy and Industry

Transport infrastructure to distant emission cluster

*This diagram was adapted from: ZEP report “Executable Plan for CCS in Europe”
2. REQUIREMENTS OF AN INDUSTRIAL CCS CLUSTER

Key requirements of a typical industrial CCS project vary for the pre-FID, Construction, Operation and Post-closure phases. Although each cluster in Europe might have specific challenges and requirements, some generic requirements apply to most prospective projects. In order to address these requirements and support the project throughout its lifetime, a variety of financial support mechanisms is required, including grants, debt, operational subsidies, and guarantees. These requirements are explained below for each phase.

2.1 Pre-FID phase

- This phase includes all of the activities required before the project can take a Final Investment Decision and might take between ~3 and 10 years. The key factor that has an impact on the duration of this phase is whether the cluster already has proven storage capacity. If not, storage assessment and exploration and appraisal activities might take more than 5 years (e.g. for a new aquifer).
- In addition to storage assessment and appraisal, feasibility studies and Front End Engineering Design including the assessment of suitability of existing assets should be carried out.
- CCS is a proven technology but it is not commercial yet, so grants are still vital for pre-FID activities – especially for storage assessment and appraisal.
- Although the cost of pre-FID activities is likely to be significantly lower than the Construction and Operational phases, all of the funds, subsidies, guarantees, business model, regulatory framework (e.g. for storage permitting, long-term storage liability, etc.) and contractual arrangements for the future phases should be defined in this phase so that the project partners can take the FID.
2.2 Construction phase

- This is a capital-intensive phase so a combination of equity/debt and grants might be needed. Depending on balance sheet capacity, equity could be obtained from industrial shareholders or 3rd party sponsors. However, high cost of equity (target return on equity of 10%-15%) means that, for each €1 of equity invested, €2 of public funds might be needed.

- Loans and other debt instruments from the European Investment Bank & commercial banks might also be available for industrial CCS projects; however, loan guarantees are likely to be required for first-of-a-kind CCS projects and for parties with credit rating below investment grade.

- Grants are important for this phase, especially for first-of-a-kind projects. Grants can also lower the overall project cost – this will be explained in more detail in Section 3.

2.3 Operation phase

- The main revenue source for the cluster in this phase is expected to be government subsidies and EU ETS emissions allowances.

- Project-on-project or cross-chain risks should also be mitigated via government guarantees that might include storage guarantees to emitters and volume guarantees to transport and storage operators.

- It should be noted that the operation phase includes both the injection and post-injection monitoring activities, which do not generate any CO₂ related revenues but have a cost to the CO₂ storage operator before it is entitled to hand over to government for post closure.

2.4 Post-closure phase

- This phase includes the decommissioning and monitoring liabilities of project developers.

- Long-term storage liability as defined in the European CCS Directive is a key challenge for private storage operators and sharing storage liability might be needed. The storage liability sharing is included in this phase but it is expected that liability will need to be shared with the host country if the project is located in the UK.

- decommissioning costs

- The next section explains the specific requirements of an industrial CCS cluster in Rotterdam over time.

Project partners may create a Special Purpose Vehicle (SPV) for engaging with government, European Commission and banks; or a Market Maker can be established and funded by the government.

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...reviewed and endorsed the figures used in the assessment. ZEP, ongoing, SET-PLAN TWG9 CCS and CCU Implementation Plan...
The described project would store more than 30 million tonnes of CO$_2$ by 2035. Levelised cost of abatement of this cluster (Phases 1 and 2 combined) is estimated to be ~€70/tCO$_2$ if Phase 2 project stays operational only for 10 years. Increasing the lifetime of this project until 2045 (assuming existing storage infrastructure has enough design life) would double CO$_2$ storage and abatement, and reduce the levelised cost of abatement to ~€50/tCO$_2$.

As the CO$_2$ storage site that will be used for the first phase has already been appraised and permitted, the Phase 1 project could be operational by 2021 and enable development of further phases. Working backwards, the project should take final investment decision in 2019 and the project developer(s) should secure ~€160 million of grant for the pre-FID and construction phases by next year, which is the key challenge for this initial phase.

Based on the illustrative timeline, the Phase 2 project (i.e. cluster expansion) should secure €60m for pre-FID activities including appraisal of P18 and P15 gas fields by 2019. Construction funds, operational revenues, subsidies and guarantees should be identified and allocated by 2023 so that the project can take final investment decision. The Phase 2 project could be operational by 2025/2026, and could be part-funded by the EU, as it is expected that further EU funding will be available post 2021. This will be explored in more detail in the next chapter.
Although the cluster has some challenging funding requirements, a variety of public and private funding options might be made available to this potential cluster, which is expected to enable the deployment of other industrial CCS projects in Port of Rotterdam and rest of Netherlands, and other nearby industrial clusters including La Havre, Antwerp and Ruhr. These funding options are explored in the next chapter.

**Figure 5: Illustrative timeline for an industrial CCS cluster in Rotterdam**

<table>
<thead>
<tr>
<th>Phase 1: Preparation (8-10 yr)</th>
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<tbody>
<tr>
<td>Construction work</td>
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<tr>
<td>Technical assistance and financial support</td>
</tr>
<tr>
<td>Upfront investment funding (range: €500 million)</td>
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<tr>
<td>Pilot project is operational (0.5 Mt/yr)</td>
</tr>
<tr>
<td>Construction (backbone onshore pipeline; offshore pipeline; mods to P-18-A and P18-4 field)</td>
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<tr>
<th>Phase 2: Expansion (20-30 yr)</th>
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<tbody>
<tr>
<td>Construction work</td>
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<tr>
<td>Technical assistance and financial support</td>
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<tr>
<td>Secure construction funds (ca. €660 million), operational revenues/subsidies and guarantees</td>
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<tr>
<td>Final investment decision</td>
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<td>Construction work</td>
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<th>Phase 3: Operation (50-60 yr)</th>
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<tr>
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<tr>
<td>Construction work</td>
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<tr>
<th>Initial Phase</th>
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<td>Study and project preparation (Ph 1</td>
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<th>Pre-FID Phase</th>
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<td>Final investment decision</td>
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<td>Construction work</td>
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<tr>
<th>Further Expansion</th>
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<td>Construction work</td>
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<td>Technical assistance and financial support</td>
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<tr>
<td>Phases 1 to 3: Operational (8-10 yr)</td>
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<td>Phase 3: Operation (50-60 yr)</td>
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4. Private Investment

4.1 EU Emissions Trading Scheme

- Initial allowance allocation (Phase 1: €200m)
- Additional allowances (Phase 2: €400m)
- Total EU ETS allowances: €600m

4.2 Operational Costs

- €200m for FID
- €400m for Construction

4.3 Funding Gap

<table>
<thead>
<tr>
<th>Phases</th>
<th>EU ETS Allowances</th>
<th>Private Investment</th>
<th>EU ETS Allowances</th>
<th>Project Cost</th>
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<tbody>
<tr>
<td>Phase 1</td>
<td>€200m</td>
<td>€100m</td>
<td>€100m</td>
<td>€300m</td>
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<tr>
<td>Phase 2</td>
<td>€400m</td>
<td>€200m</td>
<td>€200m</td>
<td>€600m</td>
</tr>
</tbody>
</table>

4.4 Funding Pathway

- Private investment (i.e. equity and/or debt)
- Member State and other funding options
- EU ETS is the primary driver but not sufficient

- Discounted cash-flows show the effect of different funding options, including:
  - EU emissions trading scheme (EU ETS)
  - Private investment (i.e. equity and/or debt)
  - Member State and other funding options

Enabling the deployment of Europe’s first-of-a-kind industrial CCS clusters will require a combination of public and private investments. This section explores the key financing options, including:

- Private investment
- Member State and other funding options
- EU emissions trading scheme (EU ETS)

The cash-flows below show the project costs and potential EU ETS-related revenues (in green) for two scenarios:

Scenario 1: No government guarantees
- €160m in Phase 1 and €1.2 billion in Phase 2

Scenario 2: Government guarantees
- €160m in Phase 1 and €1.2 billion in Phase 2

The project costs are €4.2 billion, which includes:

- €1.2 billion for construction
- €300m for FID
- €600m for member state and other funding options

The project will generate EU ETS-related revenues of €1.6 billion, assuming all industrial emitters in the cluster will be included in EU ETS throughout the project lifetime.

The following diagram illustrates the cash-flows for the project under different funding scenarios.
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY


Climate & Strategy Partners, 2017, Finance for innovation: Towards the ETS Innovation Fund

http://ner400.com/

More detailed information is available at:

European Investment Bank offers loans and other debt instruments to projects with demonstrated bankability so they are

explained in the "Private investment" section.

European funding options for industrial CCS clusters are limited at present but important potential

sources of funds are expected to become available in 2019-2021. A variety of European funds have been

listed in Annex I to the ETS Directive

Unlike the Innovation Fund, Member States are

responsible for setting up programs.

In this context, additional funding modalities and different budget allocation between funds can be

assessed and four relevant options for an industrial CCS cluster in Rotterdam have been identified.

It should be noted that the EU is still developing the Multiannual Financial Framework post-2020.

ERDF can cover up to 50% of project cost.

In this framework, programmes have a technology-neutral approach.

The key initiative so far is the European Energy Programme for

Recovery (EEPR).

As an exception to the above, CCS

activities fall within scope if they are for research, development and testing of new products and

innovative industrial technologies.

Examples of GHG emissions from activities

considered for funding under the EEPR include electricity generation (for example, conventional power plants),

renewable energy, CCU, energy storage and other

mitigation measures such as transport fuels.

The EEPR focuses on energy efficiency and the development of low-carbon technologies and

operations will receive a lesser share of capital expenditure.

The majority of funding is likely to be

needed in the form of investment to achieve the reduction

investigated for CCS development.

In the case of NER300 funding mechanism, getting

back if the project does not go ahead) is unlikely to

be an attractive option for industrial CCS project

developers.

Majority of the budget is expected to become available

after 2021; however, some limited funds might become


If funding is linked to verified CO2

storage (as was

the case in NER300 funding mechanism), getting

upfront funding/grant (that may need to be paid

in advance) and €10bn (assuming an average EUA price of

€25).

€2m.

€3m.

€1m.

€4m.

€42m.

€38m.

€34m.

€30m.

€26m.

€22m.

€20m.

€18m.

€14m.

€10m.

€6m.

€2m.

Notes

Table 3: Summary of relevant EU funding options

<table>
<thead>
<tr>
<th>Fund</th>
<th>Overview</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERDF</td>
<td>European Regional Development Fund</td>
<td>Covers up to 50% of project cost for eligible activities.</td>
</tr>
<tr>
<td>NER300</td>
<td>National Energy Resource Fund</td>
<td>Focuses on low-carbon and energy efficiency projects.</td>
</tr>
<tr>
<td>Innovation Fund</td>
<td></td>
<td>Supports demonstration projects of innovative industrial and innovative low-carbon technologies.</td>
</tr>
<tr>
<td>Private Investment</td>
<td></td>
<td>Includes debt, equity, and grants with varying levels of support.</td>
</tr>
</tbody>
</table>

Figure 7: Potential impact of private investment on project cash-flow

Undiscounted cost (€million)

Expected to cover up to 60% of relevant costs and might

increase) and €10bn (assuming an average EUA price of

€25).

€2m.

€3m.

€1m.

€4m.

€42m.

€38m.

€34m.

€30m.

€26m.

€22m.

€20m.

€18m.

€14m.

€10m.

€6m.

€2m.
The deployment of an industrial CCS cluster in Europe: a funding pathway

Sandbag, 2015, Consultation Response Revision of the EU ETS Directive

EIB, 2015, EIB’s Debt Financial Instruments under the Connecting Europe Facility


More information is available at: https://ec.europa.eu/programmes/horizon2020/

The definition of “relevant costs”, Innovation Fund contribution in 2026 could vary between €36m and €20m including ~€135m of operational expenditure and ~€35m for equity return and loan repayment. In the Operational phase, total annual cost would be €170m/year of equity (10%) and loan (30%), total annual cost in the Operational phase would be €170m/year.

Costs are covered by Innovation Fund (~€400m) and remaining 40% is funded by a combination of equity (10%) and loan (30%).

Another limiting factor for the Innovation Fund is the potential impact of EU ETS price both on the total cost of the Innovation Fund and the funding requirement of an industrial CCS cluster in Rotterdam. Under a conservative assumption that “relevant costs” do not include financial costs and net of ETS related revenues, total cost of Phase 2 construction is likely to be implemented. Potential contribution of Innovation Fund also depends on how “relevant costs” are defined for the operational costs. For instance, assuming 60% of Phase 2 construction costs are covered by Innovation Fund (~€400m) and remaining 40% is funded by a combination of equity (10%) and loan (30%), total annual cost in the Operational phase would be €170m/year of equity (10%) and loan (30%).

- If the EU ETS price (€8/tCO2) is sustained, contribution required from Innovation Fund would increase to more than €1 billion for the industrial CCS cluster. On the other hand, due to the low EU ETS prices, total IF budget would go down to only €3bn as illustrated in the table below.

Table: Impact of EU ETS price on Innovation Fund contribution

<table>
<thead>
<tr>
<th>Year</th>
<th>EU ETS Price</th>
<th>Innovation Fund Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>€8/tCO2</td>
<td>~€400m</td>
</tr>
<tr>
<td>2020</td>
<td>~€1b</td>
<td>~€950m</td>
</tr>
<tr>
<td>2026</td>
<td>~€1b</td>
<td>~€1.3bn</td>
</tr>
</tbody>
</table>

To the extent that the Rotterdam CCS cluster is part funded by the EU’s Connecting Europe Facility (CEF) Energy, CEF funding is only available to CO2 Projects of Common Interest (CO2PI) and carved out budget for industrial CCS projects might be limited as a technology neutral approach – 2020.

EIB can also offer a number of debt instruments under CEF Energy for infrastructure projects. Projects of Common Interest (CO2PI) can be projects mainly supporting gas and electricity infrastructure projects. CCS is now included in the priority areas and the regulation on “guidelines for trans-European energy infrastructure” specifically refers to the development of CO2 transport infrastructure (e.g. gas interconnectors). Any CCU related infrastructure may be relevant for storage appraisal and other pre-FID work.

CEF FID work. Applications submitted against the current call for CEF Energy for a gas interconnector pipeline project in the context of the Baltic Energy Corridor are likely to be funded under CEF Energy. The project is part of the trans-European gas infrastructure and is not CCU. Carbon capture and storage (CCS) is defined as the removal of CO2 emissions from stationary sources and their safe and permanent storage. CCS is a technology that enables the further reduction of CO2 emissions from industrial processes through enhanced oil recovery and geological sequestration.

The European Commission may be relevant for storage appraisal and other pre-FID work. A number of research and innovation projects might potentially be funded by H2020. It is believed that future calls in the current framework programme (i.e. in the period 2018-19) may be relevant for storage appraisal and other pre-FID work. The 2019 call for CEF Energy may also be relevant for storage appraisal and other pre-FID work.

In the 2019 call for CEF Energy, the specific actions have been defined and the scope of the CEF Energy call has been stated. CEF Energy aims to improve the EU’s energy infrastructure to meet future energy demand. CCS is now included in the priority areas and the regulation on “guidelines for trans-European energy infrastructure” specifically refers to the development of CO2 transport infrastructure (e.g. gas interconnectors). Any CCU related infrastructure may be relevant for storage appraisal and other pre-FID work.

Carbon capture and storage (CCS) is defined as the removal of CO2 emissions from stationary sources and their safe and permanent storage. CCS is a technology that enables the further reduction of CO2 emissions from industrial processes through enhanced oil recovery and geological sequestration. CCS is a technology that enables the further reduction of CO2 emissions from industrial processes through enhanced oil recovery and geological sequestration.
The deployment of an industrial CCS cluster in Europe: a funding pathway

which might bring down the costs and/or speed up processes especially for exploration and appraisal.

Available at: http://www.oilandgasclimateinitiative.com/news/announcing-ogci-climate-investments

In summary, the Dutch government can provide for multi-billion investment that was announced in 2016, providing a substantial investment in key technologies and enabling the road to deployment.

Figure 9: Timeline of potential EU funds compared to key project requirements

The remaining funding gap after EU ETS, private investment, and EU funding options is expected to be €120m before 2020 is likely to be extremely limited.

As illustrated in the timeline below, European funds can be used to fund the construction and operation of the low-cost project.

Figure 10: Cash-flow illustrating funding sources for Rotterdam industrial CCS cluster

Providing operational subsidies can be part-funded by EUA auctions, since at least 50% of auctioning revenues are suggested below. Total MS support needed is estimated to be €220m before 2020 for pre-FID and construction.

With support from Member State, the project could be fully funded as illustrated in the cash-flow.

Potential contribution of Innovation Fund to only one industrial CCS cluster project

The current funding gap for the Phase 1 project and the pre-FID activities of the Phase 2 project including storage appraisal is expected to be €90m before 2020.

The gap might also be summarised as follows.

Figure 8: Gap between undiscounted cost and funding required for Rotterdam industrial CCS cluster

Undiscounted cost (€million):

- €34 for the Phase 1 project is estimated to be €160m.
- €60m is needed for storage appraisal before 2020.
- €30m is needed for transport and storage from industrial emitters.

The difference between the agreed strike price and the EU ETS price (net of any other EU funding options) is expected to be €30m.

Difference subsidies (e.g. SDE+ in Netherlands) provided to the renewable energy projects – i.e.

For instance, the ROAD project was awarded €150m by the Dutch Government in 2010, and €50/annum on average for the operational phase. It should be noted that potential Member State allowances beyond 2020, emitters could return their free allowances to the Member State and receive the full payment.

The remaining €20m and €30m is needed to fill the funding gap.

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The remaining €20m and €30m is needed to fill the funding gap.
5. RECOMMENDATIONS

AND KEY MESSAGES

### Table 5: Split of funds until 2035 (€million)

<table>
<thead>
<tr>
<th></th>
<th>3.650</th>
<th>1.770</th>
<th>660</th>
<th>60</th>
<th>160</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. Contribution</td>
<td>710</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>EU via Innovation Fund</td>
<td>400</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>210</td>
<td>610</td>
</tr>
<tr>
<td>Project Investment</td>
<td>260</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>260</td>
<td>260</td>
</tr>
<tr>
<td>Carbon Saving</td>
<td>1.070</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.070</td>
<td>1.070</td>
</tr>
</tbody>
</table>

Total: 5.650 \(€\) million until 2035.
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

action 1: set up funds to kick-start an industrial CCS cluster in Rotterdam

• Member States (e.g. Dutch Government)

- Accessibility to finance is being impaired by the lack of coherent CCS policy in Europe. Without visibility on how CCS fits into energy and industrial policy, it is unlikely that private investors will fund a project without government guarantees. If debt is required, it is likely that a loan guarantee will be needed for first-of-a-kind industrial CCS projects and for parties that private investors will consider to be credit risk.

- The funding for the Rotterdam CCS cluster and the European Commission.

- Potential Member State support can be part-funded by EUA auctions, since at least 50% of auctioning revenues are suggested to be used for climate and energy related purposes, and Structural Funds (e.g. SDE+ in Netherlands). Alternatively, if the European Commission continues to provide free allowances beyond 2020, emitters could return their free allowances to the Member State and the European Commission.

- The timeline below (Figure 11) illustrates the key actions for the Dutch government, Rotterdam, and the European Commission to deliver an industrial CCS cluster.

5.2 Rotterdam cluster

5.1 Member States (e.g. Dutch Government)

- Grant funding may be sufficient for the Phase 1 (low-cost) project; however, the development of this cluster should not be delayed to wait for these funds.

- Operational subsidies through the ERDF as a Research, Technological Development and Innovation (RTDI) activity, provided the relevant Member States include it in their research and innovation strategies for smart specialisation.

- For the Phase 2 (expansion) of the CCS cluster, the transport and storage operations should be de-linked from industrial emitters by developing a collective liability and storage operator(s) and storage guarantees to the industrial emitters. Long-term storage will likely be a challenge for private storage operators so storage liability needs to be shared with the governments.

- Loan guarantees allow storing the existing 0.5 Mt of CO₂ in Rotterdam to be part-funded by EUA auctions.

- The timeline below (Figure 11) illustrates the key actions for the Dutch government, Rotterdam, and the European Commission to deliver an industrial CCS cluster.

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European CCS clusters provide access to significant amounts of funding to accelerate industrial decarbonisation. The total investment required to deploy a CCS cluster can range from €50-100m to €600m – €1bn, depending on the size of the cluster.

5.3 European Commission

- Additionally, Funk mentions that an investment of €40-50m can be sufficient for storage appraisal activities for an industrial CCS cluster.

5.4 Summary of key messages

- Action 4: Provide sufficient funds to industrial CCS clusters in Europe

- Action 5: Raise private and public funds to expand industrial CCS clusters in Europe

- Action 6: Create funds for further storage appraisal in Europe

- Important messages for all European industrial CCS clusters and Member States were identified. CCS activities fall within scope if they are for research, development and testing of new TRL CCS applications. This could be justifiable considering the funding stall caused by the risk of carbon leakage.

- Further funding may be available in the form of grants and loans, including grants for storage appraisal and construction; loan guarantees, risk-sharing instruments and revenue-generating measures of European industrial CCS clusters.

- CCS infrastructure is also important to European industrial decarbonisation projects, which have significant cost advantages compared to the point-to-point approach. CCS clusters in Rotterdam are key to unlock gigatonnes of bankable storage capacity over the next decades. It is therefore suggested that a separate funding mechanism is created for storage exploration and appraisal activities.

- Other important elements of CCS projects are key to retaining the existing industrial jobs in Europe. Member States could also use the Structural Funds in part to provide the required financing.

- CCS clusters in Europe might require €50-100m initially depending on the size of the cluster.

- An initial funding of €40-50m now for storage appraisal would suffice for an industrial CCS cluster in Europe. Additional funds may also be required to progress, which can be fully or partly funded by the Dutch government. Each cluster described in this report requires a variety of incentives and funding pathways to de-risk the cluster.

- Enabling the deployment of strategically important industrial CCS clusters in Europe will require substantial funding. However, funds should not be linked to strict FID and financial closure deadlines.

- CCS clusters in Europe represent a viable funding pathway for a variety of funds and subsidies. CCS activities are not currently available for deployment in Europe.

- CCS clusters are a crucial part of the EU’s strategy to reduce greenhouse gas emissions. CCS also examines the learnings from the NER300 programme.

- An illustrative cluster in Rotterdam might require €600m – €1bn from Innovation Fund as capital and operational grants (assuming the Innovation Fund’s budget cap for one project is not currently available for deployment of industrial CCS clusters).

- CCS activities fall within scope if they are for research, development and testing of new TRL CCS applications.
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

3. Storage assessment/appraisal is the first activity of any CCS project, and is a precondition for further progress. First industrial CCS clusters in Europe, which have access to proven/bankable storage capacity, can be operational by the early 2020s. Although Horizon 2020 may provide some limited funding for storage appraisal in the short-term, no EU fund is available today to support the significant level of storage appraisal activity needed to unlock gigatonnes of bankable storage capacity over the next decades.

4. Industrial CCS clusters can be developed in phases: First, low-cost, short-term opportunities (such as re-using existing infrastructure and starting with low-cost CO₂ capture) near existing industrial clusters can be identified and funded to deliver the enabling T&S infrastructure. Other industrial emitters can then join the cluster in the second phase based on the business model and incentive mechanism defined for a given cluster and Member State.

5. Achieving coordinated pre-FID, construction and operation activities across CO₂ capture, transport and storage is a complex task, which may be simplified via the establishment of a single cluster entity (e.g. Market Maker or Special Purpose Vehicle) in charge of coordinating the CCS cluster activities.

6. European funding opportunities including Innovation Fund and Structural Funds may be available, but funding availability before 2020 is likely to be extremely limited. Member States will therefore need to provide grants to fill the funding gap until 2020; operational subsidies; and risk mitigation instruments including loan guarantees to unlock loans, operational guarantees to de-link the transport and storage from industrial emitters, and sharing storage liability to make the project bankable. Potential Member State support can be part-funded by EUA auctions and Structural Funds. Potential Horizon2020 calls on storage appraisal and CEF funding for CO₂ pipelines in the region could also lock in crucial funding for CCS projects in Europe.
APPENDIX 1: EU FUNDING SOURCES

Figure 12: Relevant EU funds for an industrial CCS cluster in Rotterdam

APPENDIX
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

Funds in support of ETS

European Investment Bank

Like other funds managed by EIB, these two offer loans or other debt instruments to projects with demonstrated bankability.

What is available before 2028

Innovation Fund

Budget depends on auction price of emission allowances; if €15/t, budget could be €10B

• Expected to cover up to 60% of relevant costs or 15% of total budget

• Aimed not only at CCS, but also at other renewable energy projects

• Expected budget could be sufficient to fund only a few industrial CCS clusters, also considering funding competition

• Regulated by ETS Directive If payments possibility of upfront funding is maintained and milestone-based payments are not linked to verified storage, fund could be suitable for all phases.

Conditions for project eligibility:

• Each CCS project has to implement the full chain

• Capture rate of at least 85%

• Projects have to demonstrate that they could start operations within 4 years from funds receipt

• Exploration permit procedure must be under way

What is available after 2020

InnoFin

• Up to €50m, or 50% of project costs, via a number of debt instruments

• To de-risk investments in projects that demonstrate first-time commercial viability

• Projects should have high replicability and with prospects of long-term cost efficiency

• Projects required to become bankable in 4 years, and high share of co-funding from sponsors / operators is required

• Focussed at RES & Fuel Cells, although there are talks to include CCS

Projects need to contribute to EU objectives, e.g., sustainable growth and employment.

Energy demo projects: 9 EU33B in number of demonstration projects in eligible fields

• Projects need to coordinate with ETP operators 6G

Promotional

Funds in support of ETS

Energy Investment Bank
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

EU Structural and Investment Funds (ESI)

Other EU funds

Energy Efficiency (EeE)

Eligibility considerations

EU Horizon 2020

Energy efficiency

What is available

Other EU funds

Energy efficiency

Eligibility considerations

EU Horizon 2020

Energy efficiency

What is available

Other EU funds
DEPLOYMENT OF AN INDUSTRIAL CCS CLUSTER IN EUROPE: A FUNDING PATHWAY

and practitioners

Source: APEC, 2013, Building capacity for CO2 capture and storage in the APEC region: A training manual for policy makers

Source: Chris Gittins (TAQA), 2016, Short term offshore CO2 storage possibilities

P15 and P18 gas fields are included as storage sites.

Loan interest and return on equity are assumed to be 3% and 12%, respectively.

Decommissioning costs are assumed to be 25% of capital costs.

Transport and storage costs are based on simplified estimates provided by the project team.

Capture costs are based on the median capex, opex, gas and electricity requirements for a variety of energy-intensive industries (Source: Element Energy for DECC and BIS, 2014, Demonstrating CO2 capture in the UK cement, chemicals, iron and steel and oil refining sectors by 2025) and consistent with the figures included in the SET Plan.

Figure 13: Industrial emitters in Rotterdam

APPENDIX 2: MODELLING ASSUMPTIONS

The Rotterdam industrial cluster is divided into clusters. Each industrial cluster is allocated a budget for CO2 capture in the industrial sector.
**Table 6: “Archetypal” Rotterdam industrial CCS cluster – pre-FID and construction costs (€million)**

<table>
<thead>
<tr>
<th>Cost Element</th>
<th>First Phase</th>
<th>Second Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cap</td>
<td>€70</td>
<td>€570</td>
</tr>
<tr>
<td>Transport: Feeder pipelines</td>
<td>€2</td>
<td>€30</td>
</tr>
<tr>
<td>Transport: Offshore pipeline (Maas to P18-A platform)</td>
<td>€45</td>
<td>€70</td>
</tr>
<tr>
<td>Storage: Appraisal for P18 and P15 gas fields</td>
<td>€30</td>
<td>€50</td>
</tr>
<tr>
<td>Storage: Mods to P18-A platform and P18 gas fields for cluster expansion</td>
<td>€35</td>
<td>€100</td>
</tr>
<tr>
<td>Storage: Mods to P18-2 field wells (2 for injection of CO₂ and 2 for observation/monitoring)</td>
<td>€5</td>
<td>€5</td>
</tr>
<tr>
<td>Storage: Mods to P18-A platform for more CO₂ wells</td>
<td>€5</td>
<td>€5</td>
</tr>
<tr>
<td>Single well</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Transport: Offshore pipelines other than feeder pipelines (e.g., FEED)</td>
<td>€25</td>
<td>-</td>
</tr>
<tr>
<td>ROAD to OCP platform</td>
<td>€2</td>
<td>€5</td>
</tr>
<tr>
<td>Capacities reduced in the first phase</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: € denotes Euros.