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Abstract

In this report the following main recommendations from the GATEWAY project are presented:

R1: Include a H2020 topic in the Work Programme 2018-2020 making it possible to continue and follow-up the GATEWAY Project.

R2: Establish informal meeting arenas for all relevant stakeholders, such as the GATEWAY project, to discuss informally and share ideas for solutions for establishing CO_2 infrastructure in Europe.

R3: Disseminate the results from the GATEWAY project both to the CCS community and more widely to the general public – including in national newspapers. An Executive summary should be actively sent to relevant Member States ministries and EC officials.

R4: Carry out an assessment of the risk perceptions and benefit perceptions regarding the Rotterdam Nucleus project as well as an assessment of the trust in the project developers and the siting process among the citizens in the respective regions.

R5: CO_2 composition measurement requires demonstration in relevant environments, which would bring it to TRL 5. This is in line with the commercial availability of CO_2 transport.

R6: R&I actions is needed focusing on phase changes; avoidance of condensation of species – and interference of impurities.

R7: Communicate that no fundamental technical barriers exist for CCS pipeline design and construction neither onshore nor offshore.

R8: Establish templates for the allocation of relevant chain risks to components.

R9: The Dutch and UK governments to resolve cross-border CO_2 transportation issues, with supporting R&I to develop potential solutions.

R10: Different requirements from governments and private investors, respectively, in terms of risk mitigation and clarity of grant support would merit significant R&I.

R11: The EC could take a lead in encouraging Member States (who are parties to the London Protocol) to ratify the Article 6 amendment. Policy research is recommended to identify the most effective means of government involvement and coordination in this regard.

R12: It is recommended that an investigation of best practices of the regulation of CCS in the North Sea is undertaken in the context of expanding this regulatory regime across Europe.

R13: The application of the Energy Charter Treaty (ECT) to CCS in the European context is recommended.

R14: Further research is recommended to explore a suitable regulatory and contractual regime including the role of a coordinator, perhaps similar to transboundary natural gas regulation in Europe and the role of ACER.

R15: An important area for investigation needed is the impact of Brexit on delivering connectivity of CCS infrastructure between the UK and Europe.

R16: Measures are required to define this legal entity, its mandate and ownership, aligned with a suitable legal and statutory framework.

R17: From a contractual perspective, it is recommended that the Rotterdam Nucleus countries agree a way forward to resolve this matter through a MoU.

R18: Adopting a co-operative strategy (e.g. through pipeline sharing and oversizing) consistently produces a network with an economic performance that is either the best, or very close to it, of all the design algorithms considered in all the case study areas.

R19: Gather sufficient data on emission point sources

R20: Gather information on CO_2 storage possibilities

R21: Build on existing initiatives in the targeted PCI region

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R22: Take steps to promote the development of the PCI application

R23: PCI Project promoters to follow up the EC regarding the PCI/CEF procedures on order to secure maturing of projects. The role of the Regional Groups in this context should be clarified.

R24: Enable the North Sea Basin Task Force (NSBTF) as a strong vehicle for preparing common grounds for infrastructure investment and development.

- *This includes looking for collaborations between the different PCI Promoters/applications that submitted a CO_2 Infra PCI application this spring.*
- *This also includes alignment of National Roadmaps for CCS R&I (see also SET Plan Implementation Plan) – such as through the Norwegian CLIMIT programme, UKCCSRC, and the Dutch CATO programme.*

R25: Follow up unspent NER 300 funds and influence Innovation fund NER 400 expected in 2018

R26: Follow the work of the ETIP ZEP and Element Energy on 'Smart funding pathway to CCS'. The case investigated by Element Energy is in fact rather similar to the GATEWAY Rotterdam Nucleus.

R27: Member States to consider more strongly the role of CCS in their long-term national plans.

R28: Follow the SET Plan Implementation Plan (IP), as the draft IP contains a concrete follow-up of the pilot case.

R29: Dutch politicians to fund the ROAD project.

R30: Follow-up suggestions in the UK Lord Oxborough report on financing and other mechanisms.

R31: Support the Norwegian Full Scale CCS project and contribute to increasing its possible role in the development of hubs& clusters.

R32: European Energy Research Alliance (EERA)'s Joint Programme on CCS and European Technology and Innovation Platform (ETIP) ZEP to continue their efforts, close collaboration and knowledge sharing.

R33: Look for global learning and global, shared R&I efforts in the upcoming Mission Innovation (MI) discussions, such as the workshop to be arranged in Houston the autumn of 2017.

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1 BACKGROUND

The carrying out of the H2020 GATEWAY project has showed that the CSA (Coordination and Support Action) type of action can be extremely efficient and have a high impact. The stakeholder workshops and bilateral discussions with stakeholders have strongly contributed to a common understanding of both challenges and possible solutions related to cross-border infrastructure for CO_2 transport to be developed in the North Sea region. See Figure 1 below illustrating the group of stakeholders having been involved in the Gateway project.

Figure 1: Mode of working in the H2020 GATEWAY project – close dialogue with stakeholders

In the project Description of Work (DoW) the following is written about Task 4.7 from which this deliverable results:

> *Under this task, firm recommendations in support of the main concept and idea of the proposed project will be advocated. These will particularly address the prescribed prerequisites and the next steps to be made. This will slightly differ from the conclusions drawn in Task 4.5 (Business Case development (prospectus)), as these conclusions mainly address the Pilot Case itself.*
> ➔This task will produce one deliverable (D4.5) entitled *Recommendations. Next steps forward*.

The deliverables in the H2020 GATEWAY project are listed below, and all these deliverables include the basis for this deliverable D4.5.

Table 1: Deliverables in H2020 GATEWAY

Deliverable (number)	Deliverable name	Work package number
D1.1	Communication plan applicable to the Pilot Case	1
D2.1	Public perception of the Pilot Case	2
D2.2	Assessment of key technologies	2
D2.3	Recommendation of actions de-risking the Pilot Case via innovation and research	2
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D4.5	Recommendations. Next steps forward	4

In this report, recommendations are presented in the same order and related to the project Work Package, WP1-WP4.

2 PROJECT MANAGEMENT AND COORDINATION (WP1)

The close collaboration with different stakeholders, supported by concrete and very positive feedback to the GATEWAY consortium, forms the backdrop for the following recommendations from work package (WP1)

> ***R1: Include a H2020 topic in the Work Programme 2018-2020 making it possible to continue and follow-up the GATEWAY Project.***

> ***R2: Establish informal meeting arenas for all relevant stakeholders, such as the GATEWAY project, to discuss informally and share ideas for solutions for establishing CO_2 infrastructure in Europe.***

This would enable large-scale CCS across different states in Europe, having unclear risk sharing opportunities and complex business models,

> ***R3: Disseminate the results from the GATEWAY project both to the CCS community and more widely to the general public – including in national newspapers. An Executive summary should be actively sent to relevant Member States ministries and EC officials.***

3 DERISKING – INNOVATION AND TECHNO-ECONOMIC VALIDATION (WP2)

Public perception

Public perception is not the same as public acceptance. Public perception can be defined as the way in which an object or issue is regarded, understood, or interpreted, whereas public acceptance means passive or active approval of an object or issue. A positive perception of the Rotterdam Nucleus will not automatically guarantee that it will be accepted by the affected citizens. The siting of the project will be a complex process during which, amongst others, procedural and distributive fairness will be important factors for the public acceptance of the Pilot Case

One of the first steps of the assessment of the public perception of the Pilot Case should be the assessment of the awareness and knowledge about CO_2 transport among the public affected by the project by means of a representative survey. This way, the prevalence of pseudo opinions among the citizens affected by the Rotterdam Nucleus can be assessed.

> ***R4: Carry out an assessment of the risk perceptions and benefit perceptions regarding the Rotterdam Nucleus project as well as an assessment of the trust in the project developers and the siting process among the citizens in the respective regions.***

If the self-reported awareness, about CO_2 transport is low among the public concerned it will be essential to apply methods disseminating information about the Rotterdam Nucleus project before measuring attitudes in order to avoid pseudo opinions. For this purpose, moderated group discussions, qualitative in-depth interviews, survey instruments (in which respondents are provided with written information before they are asked for their overall opinion) or mixed-method approaches should be applied.

For the assessment of the risk and benefit perceptions moderated group discussions, qualitative in-depth interviews, survey instruments in which respondents are provided with written information before they are asked for their overall opinion or mixed-method approaches should be used. For the assessment of the trust in the project moderated group discussions, qualitative in-depth interviews or experimental approaches would be more suitable

Key technologies

Almost all technologies identified as part of CO_2 transport infrastructure, with a focus on transport by pipeline, are assessed to be at a technological readiness level (TRL) between 5 and 9. For those technologies with TRL between 5 and 8, this means that the technology is ready to be used in large-scale transport infrastructure projects (see Table 2). This will advance the TRL of these technologies, ultimately to TRL 9.

Targeted action is needed in case a technology has not been tested outside lab conditions (TRL 4 or lower).

R5: CO_2 composition measurement requires demonstration in relevant environments, which would bring it to TRL 5. This is in line with the commercial availability of CO_2 transport.

Table 2: TRL levels of key technologies for the Rotterdam Nucleus CO_2 transportation PCI application

Component	TRL
CO_2 composition measurement,	4
Linepipe, concrete-covered linepipe, and associated components, Control valves, CO_2 flow measurement CO_2 injection platform design and steelwork (modification of existing)	5
Pipeline welding procedures, Pipeline NDT procedures, Pipeline corrosion protection, Crack arrestor (if required)	6
Ball valve for CO_2 service,	6
CO_2-compatible PIG	7
Safety valves, PIG launcher and trap components, Support steelwork (for above-ground installations)	8

In this case, appropriate on-line measurement technology requires development, and market pull is needed to develop the CO_2 composition measurement instruments.

There are a number of reasons why the measurement of the CO_2 composition in a pipeline system is important, which include:

- Quality Assurance for the pipeline operator to ensure that the impurities remain within design values: this is particularly important if the CO_2 is derived from a number of different sources, even more so if there is potential for reactions to take place between the impurities themselves.
- Demonstration of compliance with internationally agreed legislature, e.g. London and OSPAR treaties, EU CCS Directive.
- Fiscal measurement of the CO_2 to know accurately the amount of carbon being transported for storage: the presence of nitrogen, for instance, could lead to over-estimating the carbon.
- Trend analysis, which could indicate potential problems with upstream equipment (e.g. a gradual increase in water content could result from mechanical deterioration in a dehydration plant).

Work was carried out by the National Physics Laboratories in 2013 to look at the practicability of measuring the composition of impure CO_2 at up to 201 bar pipeline transporting 2000 tonnes/hour through a 30” pipe. Work was carried out to investigate possible impurities that could be present in the CO_2 from fossil-based electricity generation, including pre-, post- and oxy-combustion options, threshold levels, and likely maxima thereof. The conclusion was that no off-the-shelf equipment was currently available, and that certain fundamental problems required solutions. Of these two main challenges were identified – into which R&I action is needed:

> ***R6: R&I actions is needed focusing on phase changes; avoidance of condensation of species – and interference of impurities.***

The TRL levels of CO_2 composition measurement equipment in pipelines remains therefore at a low TRL level (4), and it would be therefore recommended that R&D is stimulated in this field. Several other technologies in the transport chain are not yet at TRL 9. Deploying these in CCS chains will elevate their technological readiness level and no targeted actions are required.

(*References :* Wuppertal Institute for Climate, E. a. E., 2016. Decarbonization Pathways for the Industrial Cluster of the Port of Rotterdam , Wuppertal: Wuppertal Institute for Climate, Environment and Energy.)

Although transport of CO_2 results in specific requirements, the technology is available to achieve and deliver these. This is evidenced by the FEED for the P18 pipeline developed in the ROAD project.

> ***R7: Communicate that no fundamental technical barriers exist for CCS pipeline design and construction neither onshore nor off-shore.***

It is vital that risk and reward are well matched for Chain participants using along-chain commercial agreements. This allows appropriate commercial returns and debt-financing to be achieved. Such an agreement has been reached in the TLC project and in the ROAD consortium.

> ***R8: Establish templates for the allocation of relevant chain risks to components.***

The highest risks identified are associated with the financing stage of the pipeline project and with cross-border regulations.

> ***R9: The Dutch and UK governments to resolve cross-border CO_2 transportation issues, with supporting R&I to develop potential solutions.***

> ***R10: Different requirements from governments and private investors, respectively, in terms of risk mitigation and clarity of grant support would merit significant R&I.***

4 LEGAL AND STATUTORY FRAMEWORK (WP3)

International Level of Law

London Protocol

The London Protocol's Article 6 restriction requires resolution with a level of certainty that would support investment in transboundary CCS projects in which CO_2 is stored offshore. 'Resolution' will demand action by Member State governments.

Government action could be delivered in accordance with the timeframe recommended by one interviewee (2022 deadline) in Deliverable 3.3.

Moreover, the European Commission could take a leading role, particularly given the recent call for CCS PCI applications, as success of transboundary CCS projects with offshore CO_2 storage, and hence the effective use of public funds, will require a resolution of the London Protocol obstacle.

> ***R11: The EC could take a lead in encouraging Member States (who are parties to the London Protocol) to ratify the Article 6 amendment. Policy research is recommended to identify the most effective means of government involvement and coordination in this regard.***

Regional Regulation

The North Sea could evolve to become a CO_2 storage hub for Europe.

> ***R12: It is recommended that an investigation of best practices of the regulation of CCS in the North Sea is undertaken in the context of expanding this regulatory regime across Europe.***

Where statutory frameworks for CCS projects are developed on a project-by-project or regional basis, the result could be that regional activities dictate outcomes in the Energy Union. Lack of coordination in this approach could result in a fractured regulatory approach.

Policy and legal research that involves participation of the European Commission and NSBTF are suggested.

International Arrangements

The Energy Charter Treaty (ECT) could inform discussions of statutory arrangements in the North Sea. The ECT could also be relevant for regulation of international CCS projects (e.g. between the EU and third countries), with CCS potentially having a new emphasis following the Paris Agreement.

> ***R13: The application of the Energy Charter Treaty (ECT) to CCS in the European context is recommended.***

Policy and legal research that involves participation of the European Commission and NSBTF is also suggested.

National Level of Law

Value Chain

Also noted in Deliverables 3.2 and 3.3., clarity is required in governments' intended role in risk sharing, definition of the CCS business model and certainty of government-provided incentives (whether fiscally or though risk sharing). This is a particular issue for transboundary CCS projects, which involve multiple Member States.

R14: Further research is recommended to explore a suitable regulatory and contractual regime including the role of a coordinator, perhaps similar to transboundary natural gas regulation in Europe and the role of ACER.

One recommended area of research is a more detailed consideration of risk management on ownership models in the creation of international statutory frameworks for full chain CCS. This is particularly relevant in the context of the European Commission delivering CCS PCIs and interconnected infrastructure.

Policy research is recommended to identify the most effective means of government involvement and coordination in this regard.

Brexit

R15: An important area for investigation needed is the impact of Brexit on delivering connectivity of CCS infrastructure between the UK and Europe.

Brexit will evolve in the coming months, which could have a result on the terms by which CCS infrastructure between Europe and the UK is delivered. (See Deliverable 3.2)

Local level of Law

Research is recommended to understand public perceptions of the Pilot Case. Generally, it was viewed that local issues were more of an issue in Belgium and Germany, and not as much for the Rotterdam Nucleus countries, given the location of the pipeline infrastructure.

Statutes and viable ownership agreements

From the perspective of the interest and sovereignty of the nations involved, a legal entity in the current energy system is still missing. In order to fill the gap:

R16: Measures are required to define this legal entity, its mandate and ownership, aligned with a suitable legal and statutory framework.

It is also required that open-ended operations are secured, subject to societal and commercial benefits. Development of the pilot case would require legal issues to be addressed at the international, national and local levels of law.

Model agreements

R17: From a contractual perspective, it is recommended that the Rotterdam Nucleus countries agree a way forward to resolve this matter through an MOU.

Work could proceed on a project in parallel to the London Protocol matter being concluded, with a final investment decision for the CCS project depending on resolution of this legal matter.

5 PILOT CASE; DEFINING A EUROPEAN INFRASTRUCTURE PROJECT FOR CO_2 TRANSPORT – A PROJECT OF COMMON INTEREST (PCI - WP4)

Initial stages of network development

Deliverable 4.2 explored the application of contrasting approaches to the initial stages of onshore CCS carbon dioxide pipeline networks in three European case study areas. The areas selected were in the UK, Germany and the Netherlands, and are comparable to, but not identical to, the candidate Pilot Case areas of the GATEWAY project.

Four development strategies, detailed in Table 3 were implemented in spatially explicit MATLAB codes, partially drawing on previous work by some of the authors in this area. Two automated approaches to identifying economically optimal networks were implemented, as the problem is computationally challenging. The fourth strategy in the table, the “Co-operative strategy” is intended to represent the development approach advocated by the GATEWAY project.

Table 3: Summary of pipeline development strategies.

Strategy Name	Brief Description
Direct connection	Carbon dioxide sources are directly connected to a single offshore connection point using one dedicated pipeline per source
Cluster optimiser	An automated approach to identifying economically optimal network topologies that does not explicitly emphasize collaboration in developing shared pipelines.
Angle optimizer	An alternative automated approach to identifying economically optimal network topologies that does not explicitly emphasize collaboration in developing shared pipelines.
Co-operative strategy	A pipeline network approach that focusses on a high degree of collaboration between sources in building shared pipelines. This strategy is intended to represent the development strategy implicitly embodied by the GATEWAY project.

Taken across the three case study areas, the direct connection approach consistently provided the poorest results with the resulting networks being either the most expensive or second most expensive by a number of measures. With one exception the two automated optimizers produced network topologies that were significantly cheaper than the direct connection approach.

In two of the three cases the co-operative strategy resulted in the most economically attractive network. The exception was the UK, where the result was marginally more expensive than that produced by the angle optimizer. This result can be attributed to the unusually short distances in the UK case, and the fact that the co-operative network does not represent a true mathematical optimum. It is likely therefore that a more refined algorithm representing the co-operative strategy would consistently produce the most attractive network.

R18: Adopting a co-operative strategy (e.g. through pipeline sharing and oversizing) consistently produces a network with an economic performance that is either the best, or very close to it, of all the design algorithms considered in all the case study areas.

As the co-operative strategy represents the ethos of the GATEWAY initiative, developing carbon dioxide pipelines in a collaborative fashion will help to optimize the economic performance of CCS in Europe.

The benefits of co-operation over alternative network approaches were found to increase with the alignment of the sources collaborating in the network and to a lesser extent, the distances to be covered. These conclusions also support the selection of the Netherlands Pilot case for further development within GATEWAY.

PCI Prospectus – business case development

The selection of a PCI should be justified on access to sufficient and reliable data on the CO_2 emission point sources of potential CO_2 transportation infrastructure users. A clear picture must be developed of not just the total amount of CO_2 emissions of an area of interest, but also on the type of the emission source, the operational status and any other plant level detail that is available. Details such as the concentration of the CO_2 emission in the flue gases, and the age of the plant can be used to determine the approximate technical and economic potential for CO_2 capture technology in the area of interest.

R19: Gather sufficient data on emission point sources

For example, in the Rotterdam Nucleus PCI application, a number of hydrogen production facilities are present within close proximity of the proposed pipeline route. As the majority of conventional hydrogen production processes result in an off-gas with high concentration of CO_2 (>80% vol), these plants could have low CO_2 capture costs and could therefore be considered as potential early adopters of the technology, and therefore initial users of the CO_2 transportation infrastructure. For the Rotterdam Nucleus PCI application, a simple marginal abatement cost curve (see Figure 2) for the Rotterdam harbor was constructed to visualize potential future CO_2 sources under different EU ETS price levels.

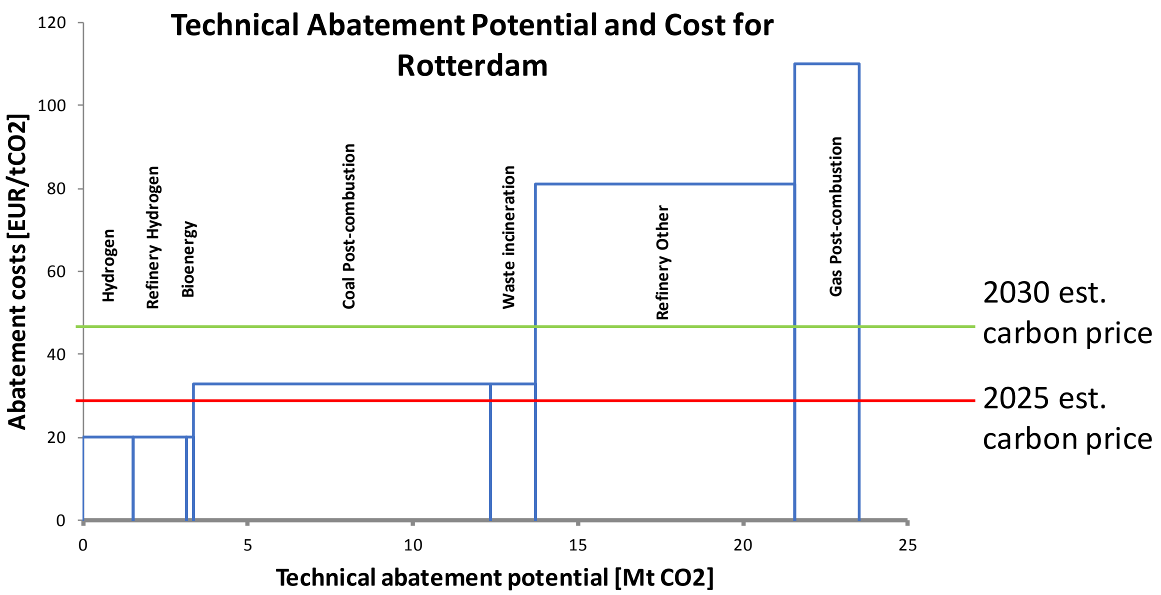

Figure 2: A simplified marginal abatement costs curve for emitters in the Port of Rotterdam

R20: Gather information on CO_2 storage possibilities

The availability of suitable CO_2 storage sites will determine the optimum route of any CO_2 PCI infrastructure proposal. The climate impact and therefore societal benefits of any CO_2 transportation PCI will be defined by the availability of CO_2 storage capacity connected to the pipeline. Gaining access to sufficient information on potential geological CO_2 storage sites is therefore essential for assessing the potential total storage capacity available, pipeline length and routing, and ultimately determines the business case for the PCI in question. The presence of expended or near-expended natural gas fields provide potentially interesting CO_2 storage possibilities, however gaining access to data such as production rates and reservoir pressures may prove difficult due to commercial sensitivity. Saline aquifer formations offer potentially larger capacity storage solutions however far less information is likely to be available to indicate the suitability for CO_2 storage.

For the Rotterdam Nucleus PCI application, the inclusion of two entities from the oil and gas industry, TAQA Energy and Swift Exploration, assisted greatly in the evaluation of storage possibilities in the region. Considerable publicly available information was available to develop a storage strategy for the PCI application and to determine the total CO_2 that could potentially be transported and stored. Based on this information (see Table 4), and the expected CO_2 flow rates, the storage fill order into several prospective CO_2 storage sites could be modelled (see Figure 3).

Table 4: Storage options in the Rotterdam Nucleus PCI application

Reservoir / Platform	Reservoir p (bar)		CO_2 capacity	Fill order
	Initial	End 2016	Million tonnes	
P18-4 / P18-A	340	20	8	1
P18-2 / P18-A	355	25	32	2
P15-9 / P15-E	347	20	10	3
P15-13 / P15-G	288	35	8	4
P15-11 / P15-F	283	15	16	5
Earlham			25	7/8
P01-FA			35	7/8
Q1 structure			100	6

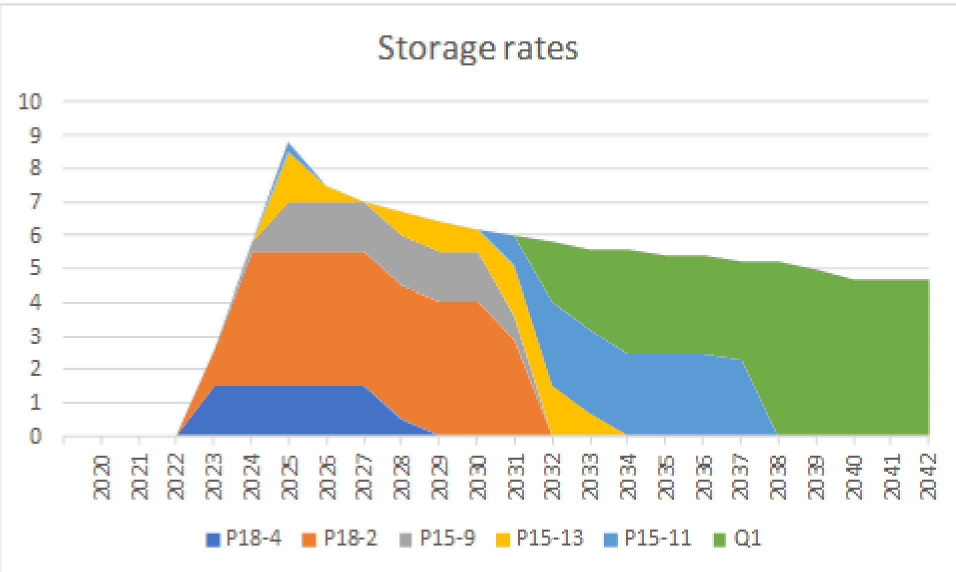

Figure 3: CO_2 storage rates modelled for the stores connected to the Rotterdam Nucleus

R21: Build on existing initiatives in the targeted PCI region

Building on existing CCS initiative (where available) and including stakeholders which have shown interest or been engaged in CCS research and/or demonstration projects is an obvious but important recommendation when developing a PCI application. The Port of Rotterdam has previously been engaged in a number of initiatives to encourage the uptake of CCS by emitters in the area. A number of emitters, such as Uniper/Engie, Shell, Vopak and Air Liquide are either currently, or have been previously involved in CCS demonstration project activities. The Rotterdam Climate Initiative which started in 2009, aimed to reduce the CO_2 emissions of the port by 50% of 1990 emissions by 2025. CCS is one of the key emissions reductions strategies to achieve this. In 2016, the Port of Rotterdam Authority commissioned a report to identify possible decarbonization pathways for the area. In the majority of the possible decarbonization pathways, the use of CCS in the refining, petrochemical and power sectors was unavoidable in making deep emission cuts (80%+ against 1990 levels) in the port before 2050 (Wuppertal Institute for Climate, 2016).

R22: Take steps to promote the development of the PCI application

Support and interest in the PCI application will only be generated if sufficient stakeholders are informed of its existence and progress. Organizing targeted meetings and workshops with both industry and government representatives were pivotal in gaining support for the Rotterdam Nucleus proposal. The awareness amongst many stakeholders of the TEN-E regulations, CO_2 PCIs and the Connecting Europe Facility (CEF) was generally low prior to engagement with the GATEWAY team. A number of affiliates to the Rotterdam Nucleus projects had concerns regarding the legal implications of becoming associated with a PCI application. Intervention of the GATEWAY Team and email confirmation from the European Commission (DG ENER) helped to mitigate these concerns.

Synchronised funding from various sources

The following recommendations are related to the assessment of synchronised funding having being carried out in the GATEWAY project:

R23: PCI Project promoters to follow up the EC regarding the PCI/CEF procedures on order to secure maturing of projects. The role of the Regional Groups in this context should be clarified.

R24: Enable the North Sea Basin Task Force (NSBTF) as a strong vehicle for preparing common grounds for infrastructure investment and development.

- *This includes looking for collaborations between the different PCI Promoters/applications that submitted a CO_2 Infra PCI application this spring.*
- *This also includes alignment of National Roadmaps for CCS R&I (see also SET Plan Implementation Plan) – such as through the Norwegian CLIMIT programme, UKCCSRC, and the Dutch CATO programme.*

R25: Follow up unspent NER 300 funds and influence Innovation fund NER 400 expected in 2018

R26: Follow the work of the ETIP ZEP and Element Energy on 'Smart funding pathway to CCS'. The case investigated by Element Energy is in fact rather similar to the GATEWAY Rotterdam Nucleus.

Final recommendations

The following, final recommendations are based on discussions with stakeholders and/or within the H2020 consortium:

R27: Member States to consider more strongly the role of CCS in their long-term national plans.

R28: Follow the SET Plan Implementation Plan (IP), as the draft IP contains a concrete follow-up of the pilot case (see Figure 4).

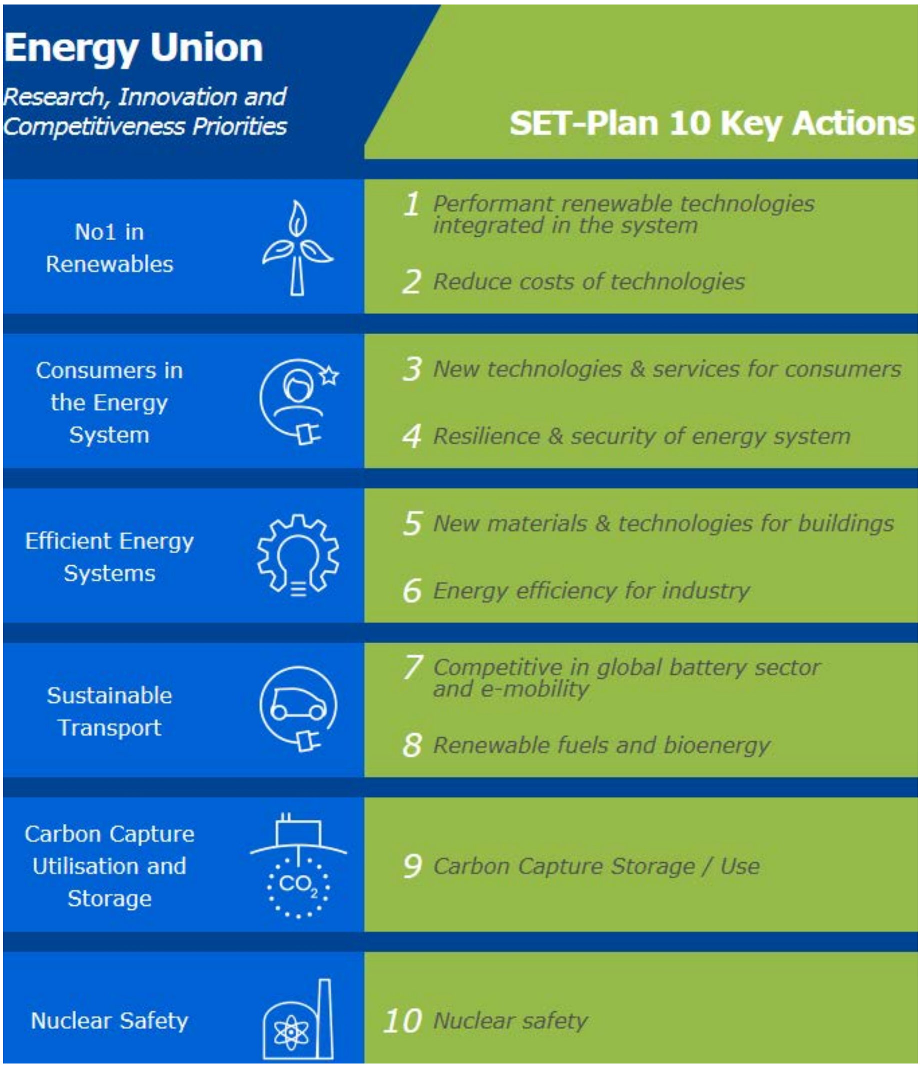

Figure 4: Energy Union and the corresponding SET Plan 10 Key Actions: CCUS is Key Action number 9 (ref SETIS).

R29: Dutch politicians to fund the ROAD project.

R30: Follow-up suggestions in the UK Lord Oxborough report on financing and other mechanisms.

R31: Support the Norwegian Full Scale CCS project and contribute to increasing its possible role in the development of hubs& clusters.

R32: European Energy Research Alliance (EERA)'s Joint Programme on CCS and European Technology and Innovation Platform (ETIP) ZEP to continue their efforts, close collaboration and knowledge sharing.

R33: Look for global learning and global, shared R&I efforts in the upcoming Mission Innovation (MI) discussions, such as the workshop to be arranged in Houston this autumn.

APPENDIX – SOME MORE DETAILED RECOMMENDATIONS

Deliverable D3.1: Legal framework for the Pilot Case

Abstract

The Pilot Case will emphasise a gateway for CO_2 transport in the North Sea Basin. So as to maximise the impact of the proposed project, the GATEWAY project intends that the Pilot Case will be developed as a European 'Project of Common Interest' (PCI), which will provide faster and more efficient permit-granting procedures and improved regulatory treatment.

This deliverable provides a legal analysis concerning four alternative scenarios for the Pilot Case. The legal analysis categorises the law into three levels – international, national and local – and considers the four scenarios in light of these three levels of law. The legal issues for the Rotterdam Nucleus, the chosen Pilot Case are discussed in greater detail.

The recommended Pilot Case (Rotterdam Nucleus) is based on the development of Rotterdam (in the Netherlands) as a southern North Sea hub. Under the Rotterdam Nucleus scenario, captured carbon dioxide (CO_2) will be transported through the Port of Rotterdam to depleted gas fields offshore the Netherlands. CO_2 will also be transported through further links using CCS infrastructure to facilitate the processing of undeveloped gas fields offshore UK. The Pilot case contemplates further expansion opportunities, increasing the capture clusters through additional pipelines, expanding to further gas fields and using the port of Rotterdam for CO_2 shipping – hence the analysis of the other scenarios may be invaluable in the future development of CO_2 networks in the EU.

<u>RECOMMENDED PILOT CASE: ROTTERDAM NUCLEUS</u>

The Rotterdam Nucleus is based on the developing CO_2 capture nucleus of Rotterdam, which includes the Rotterdam Climate Initiative (RCI), ROAD project and potential additional cluster connections (e.g., CAR project—see Case D below). The CO_2 is then transported via a high pressure, medium (100 km), oversized (457 mm) pipeline. The pipeline follows a transboundary offshore route from CO_2 sources in the Netherlands to storage sites offshore Netherlands (P18 and P15), as well as from the Fizzy field offshore UK (and which facilitates a natural gas exploitation opportunity). (See Figure 1). As stated in the introduction, the Pilot Case has evolved to be a combination of the Rotterdam Nucleus and CO_2 Antwerp to Rotterdam case, and hence this should be read in conjunction with Case D below.

<u>Conclusion:</u>

At the international level of law, the Rotterdam Nucleus pilot case comprises the Netherlands and the UK – countries that have an existing working relationship in the NSBTF and that have signed the London Protocol amendment, reflecting their support of CO_2 export for CCS.

At the national level of law, both countries have regulatory and permitting regimes in place. However, from a policy perspective, the CCS policy of the Netherlands is more consistent and clearer than that of the UK. The UK's policy seems to be in transition, following the UK's cancellation of the CCS competition, and the subsequent Lord Oxburgh report, setting out a strategy for CCS in the UK.

<u>Case A: UK - Norway EOR</u>

The UK-Norway Enhanced Oil Recovery (EOR) case contemplates a pipeline linking a varied cluster of CO_2 sources in the North East of England to EOR opportunities in the UK and Norwegian sectors of the Central North Sea (CNS). The CO_2 source is the Teesside Collective, a mixed cluster of sources including industry (agriculture), power and gas reformation.

The proposed transport infrastructure is a high pressure, long (500 km), oversized (28 inch) pipeline from the Teesside Collective in northeast England, which runs offshore to storage in the CNS oil fields. A fully scoped route for the pipeline already exists, following existing lines located away from populated areas. The target CNS oil fields are high CO_2 fields, being Brae (100Mt), T block (60Mt) in the UK sector and Jotun, Ula and Oseberg (100s MT) in the Norwegian sector.

Conclusion

At an international level, the UK-Norway EOR case probably faces the challenge of the London Protocol's Article 6 prohibition on the export of waste. While this is also an issue for the other CCS development scenarios, both the UK and Norway have signed the amendment, which suggests the parties could work to overcome this challenge.

The existing North Sea working relationship between the nations also presents conditions for success of the UK-Norway EOR case. Development of CCS under the UK-Norway case could be aided by the UK/Norway Framework Agreement and its links with nations' decommissioning legislation for oil and gas production facilities.83

At the national level, the policy of Norway's government is one that supports CCS. The UK's CCS policy is currently not clear, however, the interest in CCS remains. Both countries have laws in place to enable CCS, having incorporated the CCS Directive into their national law.

Case C: German Backbone

The German Backbone case would link the major concentration of CO_2 emissions in the Ruhr valley in Germany to the main North Sea oil fields in the CNS. The initial CO_2 sources would be the coal/lignite power stations of RWE and EON in the Ruhr valley in Germany.

The proposed transport infrastructure is a high-pressure, long (900 km), oversized (44 inch) pipeline, which includes an onshore component in Germany, and then follows a transboundary, offshore route from Germany to storage in Norway. Specifically, the pipeline would run through western Germany near the Netherlands border to the North Sea coast at Wilhemshaven where it will follow the offshore route of Europipe I to the CNS around the Sleipner area of the Norwegian sector.

Conclusion

From a legal perspective, the issues associated with Germany suggest difficulties in delivering the German Backbone case. In particular, Germany's lack of endorsement of the Article 6 amendment to the London Protocol and potential public objection for onshore CCS activities reveal potential challenges for this case.

Case D: CO_2 Antwerp – Rotterdam (CAR) Pipeline

The CAR Pipeline case requires the development of a CO_2 pipeline to transport CO_2: 1) from a centralized location in the Antwerp region of Belgium; then 2) transboundary to the Netherlands at the Port of Rotterdam; and 3) to the P18 block offshore the Netherlands.

The onshore pipeline route involves multiple canal, river, road and rail crossings. It is approximately 80 km long along a pre-zoned pipeline route, which is expected to enable an efficient permitting process. The CAR pipeline has evolved to be part of the Pilot Case as outlined in the introduction and later in the conclusion. The significance of this addition is that it brings in an additional EU Member State, Belgium, to the Pilot Case.

Conclusion

Belgium and the Netherlands are participating in international forums that enable cooperation for CCS activities between the nations, which could provide a foundation for addressing international agreement for transboundary CO_2. However, Belgium has not ratified the London Protocol amendment, which could present an additional legal hurdle at the international level.

CCS does not appear to be an important aspect of policy in Belgium. Although the Flemish region recognizes the potential for CCS to address CO_2 emissions in the Port of Antwerp area, CCS is not a clear policy priority (as compared to, e.g., Norway).

Deliverable D3.2: Statutes and viable ownership arrangements

From the perspective of the interest and sovereignty of the nations involved, a legal entity in the current energy system is still missing. In order to fill the gap, measures are required to define this legal entity, its mandate and ownership, aligned with a suitable legal and statutory framework. It is also required that open-ended operations are secured, subject to societal and commercial benefits. Development of the pilot case would require legal issues to be addressed at the international, national and local levels of law.

Summary
We highlighted several key issues. First, the statutory framework for the Pilot Case is unique compared to other CCS projects, as the transboundary transportation of CO_2 gives rise to international legal issues not faced in other standalone CCS projects or domestic projects. This increases the complexity of establishing and delivering a statutory framework to support the project.

Second, the proposed value chain structure of the Pilot Case introduces complexity of the project's ownership structures, as different owners/operators will be involved across the value chain. This has implications for risk allocation in the value chain.

In addition, as observed in CCS projects internationally, including in the UK's recently proposed commercial structures to facilitate deployment of CCS, both government and the private sector commonly share project ownership (either concurrently or sequentially). This also has relevance for risk allocation and investment incentives. These points are also relevant for partnerships from a legal and policy perspective. It was noted that project support by Member States will be essential, which entails early support with participation required for development of the PCI application. Learnings from the nuclear industry, including allocation of risk and partnership structures among nations and with private industry was explored.

Finally, a communication plan was presented, which set out key issues to be addressed with Member States when partnerships must be established. As resolution of many issues require the agreement of sovereign nations, we highlighted the potential long lead times of these items for early international CCS projects (such as the Pilot Case). The extended time periods to resolve international legal matters for CCS could result in project delays. These challenges could be overcome in the future, using a standardized regulatory model (such as observed in the natural gas industry in the EU) as well as the involvement of a transnational coordinator (such as ACER).

<u>Future research</u>
Future research is suggested in the areas of transfer of ownership and transfer of liabilities for international CCS projects (i.e., which liabilities will be transferred to the new owner – e.g., no leakage liability, monitoring liability only, all liabilities, etc.). This was not an item explored in depth in this paper, as the ownership structure of the project is not yet known.

Deliverable D3.3 Model agreements

Issues at the International Layer of Energy Law and Policy

<u>Resolution of theLondon Protocol restriction</u>
Was clearly viewed by interviewees as being the responsibility of governments. When asked how governments should resolve the issue, opinions were mixed, but the common theme was that governments must take action if transboundary CCS projects are to proceed in Europe. In the

Rotterdam Nucleus case, this action would need to be taken by the UK, the Netherlands and Belgium.

Recommendations:

Generally, it was acknowledged that the London Protocol restriction is a project risk which could be resolved by governments. But, it is a risk that may take time to resolve. Thus, work could proceed on a project in parallel to the London Protocol matter being concluded, with a final investment decision for the CCS project depending on resolution of this legal matter.

From a contractual perspective, it is recommended that the Rotterdam Nucleus countries agree a way forward to resolve this matter through an MOU. Project parties may wish to include a similar obligation/condition precedent upon government to encourage government to act. It would be reasonable to include resolution of the London Protocol issue as a condition precedent in contracts to enable a contract exit in the event legal certainty is not achieved to the standard required by project participants.

Government action could be delivered in accordance with the timeframe suggested by one interviewee (2022 deadline). In addition, as suggested by another interviewee (Category Industry), the European Commission could take a lead in encouraging Member States (who are parties to the London Protocol) to ratify the Article 6 amendment. Moreover, European Commission involvement could be driven by PCI funding, as success of transboundary CCS projects will require a resolution of the London Protocol obstacle.

Issues at the National Level of Energy Law and Policy

3 Hypothesis':

1) Magnitude of risk exposure from geological storage;

2) Identification of a suitable regime for regulation of CO_2 transport; and

3)Value chain integration and certainty of government fiscal incentives to encourage investment.

Recommendations:

Value Chain

From a contractual perspective, risk allocation must be considered within each phase of the CCS value chain (capture, transport and storage) as well as across the value chain. However, allocation of risk at a contractual level cannot be determined before understanding the business structures intended by government. And while the risks and liability exposures found in the storage phase seemed to be a greater concern for interviewees than the transport phase, it was generally acknowledged that appropriate risk transfer and coordination across the value chain are issues that governments need to address. This includes the need for clarity of governments' intended role in risk sharing, definition of the CCS business model and certainty of government-provided incentives (whether fiscally or though risk sharing).

Thus, it is recommended that the governments in the Rotterdam Nucleus case determine the commercial structures that will be the foundation of the CCS project. That is, how will risk be shared between government and the private project participants? For example, would it be the case that government acts as a 'middle man' as noted in the Norway example by one participant? And, if so, how would that work in an international project?

Moreover, where the government acts as an intermediary or 'middle man' sovereignty waivers may need to be considered, in the event of a lawsuit against project parties arising from a fault (e.g., negligence) of a sovereign government. In addition, how would cost exposure be addressed for risks that are uninsurable, such as long term liability exposures of storage?[1] The terms and conditions of the contract would be case-specific, but understanding what the business case would be is first required. It is noted that the UK is also considering the notion of shared risk and suitable commercial structures for CCS,[2] and as such, UK developments would be pertinent to development of the Rotterdam Nucleus pilot case.

Given the complexities of having multiple operators across the value chain in an international project, it may be that having one operator would be the simplest solution. Risk mitigation of cross default exposures in a transboundary CCS project would need to be addressed when structuring contract terms and conditions across the value chain. However, would require knowledge of the project's commercial structure and business case.

Transport Contracts

The majority of interviewees viewed the natural gas regime (contractual and regulatory) as the logical reference point for developing CO_2 transport regulation and contracts. However, interviewees' consistently noted the technical dynamics of CO_2 differ to natural gas. These would need to be addressed, for example, managing flow rate, quality, shut downs, supply, etc. For the GATEWAY project, consideration of these issues would be from a transboundary perspective, which adds the complexity of accounting for nuances in Member States' national laws.

Issues at the Local Level of Energy Law and Policy

Given the recognized importance of public support for CCS projects, project parties (both industry and government) may wish to document contractually how the public will be engaged. It is noted environmental impact assessment (EIA) can be required (either automatically or by imposition) for certain CCS activities, including CO_2 pipelines. This would include public engagement, such as in the UK.[3] While public engagement would be undertaken through the EIA process, in absence of this or as a measure of additional assurance, the parties may wish to agree the strategy for these engagements contractually.

This contractual documentation of efforts to encourage public support could be made in an MOU or even in an enforceable contract. The difficulty of including this obligation in contract could be, as noted by one interviewee, determining whether the requirements have been met. As such, project parties may prefer to have the obligation in a non-binding agreement.

For the Rotterdam Nucleus pilot case, public support for the project would need to be gained in multiple locations. And, as noted by one of the interviewees, these are in areas where onshore CO_2 has been the subject of public opposition historically. While the pilot case entails offshore storage of CO_2, ensuring the public understands the intentions of the project could be essential, and messaging from both government and the project parties on this point could be necessary.

The sway of public opinion may take time. Thus, the parties who would be involved in project development should undertake early public engagement. (UK and Netherlands governments in

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[1] Behdeen Oraee-Mirzamani, Tim Cockerill and Zen Makuch, 'Risk Assessment and Management Associated with CCS' (2013) 37 Energy Procedia 4757.

[2] Lord Oxburgh, 'Lowest Cost Decarbonisation for the UK: The Critical Role of CCS' (2016) (Report to the Secretary of State for Business, Energy and Industrial Strategy from the Parliamentary Advisory Group on Carbon Capture and Storage).

[3] Meyric Lewis and Ned Westaway, 'Public Participation in UK CCS Planning and Consent Procedures' in Ian Havercroft, Richard Macrory and Richard B Stewart, *Carbon Capture and Storage: Emerging Legal and Regulatory Issues* (Hart Publishing 2011) 277.

the base case, along with the Port of Rotterdam, and extending to Belgium and the Port of Antwerp, as well as operators along the value chain).

CCS Value chain integration
Hypothesis 6: Integration of the CCS value chain will present liability concerns that the stakeholders will view differently
Recommendations:
The main observation from this hypothesis is that clarity is required as to how the value chain will be integrated. This will dictate the terms and conditions of contracts across the value chain. It is recommended governments in the Rotterdam Nucleus case identify what the business case for the project will be. That is, how much governments will be involved in risk sharing and the provision of investment incentives.

The transboundary aspect of the GATEWAY project introduces complexity in value chain integration that is not faced by domestic projects. Moreover, it necessitates Government coordination in the sharing of risks among private and public participants, and the provision of government incentives for project development.

This suggests that not only is public engagement important (as explored in Hypothesis 5) but also government engagements are important to enable international alignment for project delivery. Thus, it is recommended that governments of nations involved in the Rotterdam Nucleus case are engaged early to enable project success. And, as noted by one interviewee (Category Industry), the European Commission could have a coordination role here.

Transboundary CCS and Value Chain
While the issue of the London Protocol prohibition was the primary discussion point with interviewees from an international law perspective (as testing Hypothesis 1), the countries of the Rotterdam Nucleus would need to agree means of managing the transboundary value chain of the project. This is a logical expansion of the discussions with interviewees regarding value chain integration risks (such as in Hypothesis 6 and Hypothesis 2), in which it was identified that government has a responsibility to de-risk the value chain. For example, one interviewee (Category Industry) gave the example of a project in Norway, in which the government accepted the risk of managing the middle portion of the CCS value chain (linking CO_2 suppliers with CO_2 storage).
Recommendation
Following from this logic, risk sharing among governments and private parties across the value chain in a transboundary scenario is not as clear cut. For instance, assuming government steps in to share risk, who would bear the risk for reduced CO_2 supply that would have effects across the value chain—Belgium or the Netherlands? This would need to be established in an agreement between the Rotterdam Nucleus nations.

Additional issues:
For example, one interviewee (Category Industry) commented that each country is slightly different, but there is not a clear framework for identifying and determining storage networks. Another issue is the idea of water transport as a suitable regime for CO_2 transport. While this was mentioned in the context of Hypothesis 3, it was a point that was of interest to several interviewees when the idea was mentioned to them during the course of the interviews. It was mentioned that perhaps analogizing CO_2 transport to water could facilitate CCS becoming more accepted by the public, rather than people associating CO_2 to methane (the latter of which is an explosive gas).

One interviewee observed there seems to be a new line of thinking in the industry of moving away from large scale developments toward smaller scale, with this being a more effective means of delivering CCS. The example given was the ROAD project, which contemplates a smaller storage capacity, resulting in the project entering into the post-operations maintenance phase sooner and thereby demonstrating the actual risks of this phase. The use of smaller scale projects could then allay concerns by stakeholders (including insurers, financiers, etc.) and enable CCS to finally be developed in the EU. And these correspond directly with the aims of the GATEWAY Pilot Case project, which is to provide a ***replicable*** pilot case that can be utilized around Europe to develop over the long-term a CO_2 transport network.

A consistent theme was the need to understand the government's business structure for CCS (both for the GATEWAY Pilot Case project and other projects) in order for risk allocation to be determined. As explained by one interviewee (Category Industry), cross chain risk is a potential issue, but it would depend on how project is funded (not an issue if government funds project).

Conclusion- for the D3.3

This paper explored the key risks and liabilities that may be faced by transboundary CCS projects in the EU, and more specifically in the GATEWAY pilot case (the Rotterdam Nucleus). As energy law issues are considered at the levels of international, national and local law and policy, the key risks identified reflect matters at each of these levels. Following discussions with interviewees, recommendations were made for means of potentially addressing these key risks going forward.

The importance of government participation was highlighted. Government has a role in resolving the restriction of the London Protocol, in defining risk sharing between government and private parties and in incentivizing CCS development. The European Commission could influence realization of transboundary CCS by encouraging Member States to resolve the London Protocol Article 6 restriction.

The results of the analysis (as informed by the literature review and research participants' inputs) are presented below. Means by which key issues could be addressed contractually are presented below. Where parties seek certainty on how these risks could and would be addressed before investment is undertaken or binding contracts are signed, parties may wish to enter into Memoranda of Understanding (MOU). Then, the outcomes and risk allocation could be subsequently memorialized and defined in binding contracts.

Table A1. MOU and Contractual treatment of risks.

Level of Law	Issue	Parties	Category		Comment
			MOU	Contract	
International	London Protocol	National governments	☑	☑	This contemplates treaty level action between governments. The understanding of the parties as to how they will engage other contracting parties or how the parties will resolve the London Protocol article 6 restriction could be set out in an MOU. Resolution of the issue could be the result of bilateral or multilateral agreements.
	London Protocol	National governments and project operators (storage and	☑	☑	An MOU between governments and parties could provide a level of certainty for project participants and clarity of the intended actions of governments to address the London Protocol limitation

Level of Law	Issue	Parties	Category		Comment
			MOU	Contract	
		international pipeline)			issue. In contract, the parties could include resolution of the London Protocol as a condition precedent.
	Transboundary Transport of CO_2 and Value Chain Integration	National governments	☑	☑	Where CO_2 is transported across borders, nations will have to agree the terms and conditions for the international pipeline. The Energy Charter Treaty could be a logical starting point for drafting these frameworks, and setting out the expectations of the parties in an MOU could be useful to structuring the negotiations.
National	Financial incentives and uncertainty	National governments and project parties Between project parties	☑	☑	Project parties may wish to include the government's incentive obligations in the MOU and the licence (contract). Incentives could be project financial incentives (e.g., subsidies) or even risk incentives (e.g., the government accepting certain risks such as acting as the 'middle man' with responsibility for linking CO_2 suppliers with storage operators).
	Leakage – risk exposure from storage	Between project parties	☑	☑	Governments could provide limitations of liability for project parties in law. Where this is not achieved, the project parties would need to agree the allocation of liabilities in contract, with the MOU providing the roadmap for contract negotiations. Liability limits would need to accord with corporate legal requirements.
	Liability risks-transportation	Between project parties	☑	☑	In the absence of government defined value chain structures, much of this will be conjecture (i.e., whether operatorship will be bundled or unbundled, etc.). Clarity of the government's business model is required.
Local	Public Support	National governments and project parties Between project parties	☑	☑	Project parties could agree the actions/conditions for public engagement and support and document in MOU. Whether the obligation is included in a contract will depend on the level of risk the parties wish to accept, as some parties may be concerned about the enforceability or measurement of the obligation. However, given the recognized importance of the obligation, the parties may wish to include it in the non-binding MOU and begin addressing the public engagement requirement before commercial contracts are signed. For the CAR Pipeline extension, the Flemish region of Belgium would need

Level of Law	Issue	Parties	Category		Comment
			MOU	Contract	
					to be engaged in the first instance. See deliverable 4.1 for discussion on Belgium and issues at local/regional levels).

The above list of items is high level and not comprehensive. This is due in large part to the fact the commercial structure of the GATEWAY project is not yet defined. At this early stage of the GATEWAY project, recommendation of specific contract terms and conditions and structures is premature, as clarity of the commercial structures and business case for the CCS value chain are required. However, this paper describes contractual mechanisms by which the key risks could be addressed should the GATEWAY project or other transboundary CCS projects proceed.

Clarity of risk sharing between government and industry as well as the operation of the value chain (whether operation of the value chain will be segmented or bundled) is required to enable drafting of specific contract terms and conditions.

This paper includes the opinions and experience of senior stakeholders in the CCS industry, including researchers, government and industry. Further research will be valuable in this area once government action on CCS has progressed. Recommendations can be made to reflect government decisions on risk allocation and commercial structures.