

## **ZEP Advisory Council 61**

**05<sup>th</sup> December 2019**

### ***Agenda Item 11: Review of Network Work Programmes***

#### ***11.a. Network Policy and Economics***

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Appended to this paper is the following pre-read:

##### **11.a. Network Policy and Economics Update**

**11.a.i. ZEP NWPE Agenda 24<sup>th</sup> October**

**11.a.ii. ZEP NWPE Meeting Minutes 24<sup>th</sup> October. Draft**

**11.a.iii. ZEP Policy Brief on Capture Rates**

**11.a.iv. ZEP Response EU Reference Scenario Assumptions**

**11.a.v. ZEP Policy Brief on JRC 2018-2050 EU Energy Outlook**

**11.a.vi. ZEP Partnerships in Horizon Europe Response**

**11.a.vii. ZEP Orientations in Horizon Europe Response**

**11.a.viii. Detailed Innovation Fund Workshop Summary**

**11.a.ix. Response to DNSH Sustainable Taxonomy Comments**

#### ***11.b. Network Technology***

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Appended to this paper are the following pre-reads:

##### **11.b. Network Technology update**

**11.b.i November 28<sup>th</sup> Meeting Agenda**

**11.b.ii November 28<sup>th</sup> Meeting Minutes**

**11.b.iii ZEP NWT TWG Transport ToC**

**11.b.iv ZEP statement on CO<sub>2</sub> transport and storage cost**

**A Draft TWG Hydrogen ToR (TO FOLLOW)**

European Zero Emission Technology and Innovation Platform

ZEP Secretariat,  
Carbon Capture and Storage Association Offices  
Rue de la Science 14b, 1040 Brussels, Belgium  
[www.zeroemissionsplatform.eu](http://www.zeroemissionsplatform.eu)

ZEP AC61 05.12.2019

Agenda Item 11.

Review of Network Work Programmes



European Zero Emission Technology and Innovation Platform

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## **ZEP Advisory Council 61**

**5<sup>th</sup> December 2019**

### ***Agenda item 11.a. Network Policy and Economics update***

*Co-chairs: Lamberto Elderling (Equinor), Kim ByeBruun (Shell), Jonas Helseth (Bellona)*

The Network Policy and Economics meeting took place on the 24<sup>th</sup> October in Brussels. The next Network Policy and Economics meeting will take place on the 13<sup>th</sup> February, venue TBC, Brussels. The agenda is in preparation.

On the 24<sup>th</sup> October, the Network Policy and Economics met in Brussels, please find the agenda and draft minutes attached as pre-reads 11.a.i and 11.a.ii respectively. The meeting was well attended; the meeting concentrated on how the Network can collaborate with other organisations, particularly in light of the proposed green new deal and changes within the European Commission. Valerie Czop then updated the group on the ISO process and how ZEP could potentially help facilitate the European representatives. Rob Van der Meer took the lead to follow up bilaterally on the appetite from ISO TC265 representatives to coordinate European input facilitated by ZEP.

#### Capture Rates Policy Brief:

The network has prepared in conjunction with Network Technology a one-page brief on the IEAGHG Technical Report on CO<sub>2</sub> capture rates which was released to the general public in September, this can be found attached as pre-read 11.a.iii.

#### EU Reference Scenarios 2019

On the 16<sup>th</sup> October the Commission launched a consultation on the technical assumptions which will be used in the EU Reference Scenario modelling for Energy, Transport and GHG emissions. The last models were ran in 2016, and this consultation was to assess the input data to ensure the values are broadly correct.

The deadline for submission was the 31<sup>st</sup> October, which is a very short deadline. After discussion at the NWPE meeting on the 24<sup>th</sup> October, the Network provided very rapid feedback and ZEP response was submitted on the 31<sup>st</sup> October, and can be found attached as pre-read 11.a.iv. In general, the technical assumptions were ok, ZEP raised the 90% artificial limit for CO<sub>2</sub> capture rates, and encouraged the Commission to clarify hydrogen production technology energy usage.

#### EIB Energy Lending Policy

On the 15<sup>th</sup> November the EIB passed a decision to accept the draft Energy Lending Policy as was proposed earlier in 2019. The main amendment to this initial proposal was to delay the cessation of unabated fossil fuel project funding to end-2021 from 2020. Nonetheless, this is a major step towards a 'EU Climate Bank', and will have implications for the next iteration of the Connecting Europe Facility and other EU funding mechanisms.

#### **European Zero Emission Technology and Innovation Platform**

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### Joint Research Centre Report: EU Energy System 2018-2050

The JRC POTEnCIA Central Scenario describes the evolution of the EU energy system from 2018-2050 based on the policy landscape at the end of 2017. The objective of the report is to purely serve as a reference document to which future policy targets or reporting can be compared against. This was performed not only Europe wide but individually for each member state, and the report provides detailed graphics of each member state. The secretariat produced a Policy Brief on the report which is attached as pre read 11.a.v.

### Temporary Working Group Policy and Funding

*Chair: Theo Mitchell (Enerfair)*

#### Horizon Europe

On the 11<sup>th</sup> September, the Commission launched a consultation on the 12 Proposed European Partnerships under the future Horizon Europe R&I Programme. This includes an increased scope partnership for clean hydrogen (phrased as 'nearly-zero carbon hydrogen' in some sections of the consultation). The draft response was circulated to the network for comment, and the final version submitted on the 4<sup>th</sup> November, a copy of the submission can be found attached as pre-read 11.a.vi.

Additionally, on 31<sup>st</sup> October the Commission opened a consultation on the 'Orientations towards the first Strategic Plan for Horizon Europe'. The secretariat prepared a response which was submitted on the 15<sup>th</sup> November, a copy of the brief response can be found attached as pre-read 11.a.vii

#### Innovation Fund

After the Innovation Fund workshop, the questionnaires and feedback were assembled. The secretariat then wrote a longer summary of the workshop, this was submitted, along with all the completed questionnaires into the Commission. The longer summary is attached as pre-read 11.a.viii. The Commission have now appointed a consultant who will be reviewing all available information (including the workshop feedback and questionnaires). After which the consultant will be reaching out to and working with individual projects to test methodologies and base-case scenarios to help design the first call of the Innovation Fund

The tentative agenda for the innovation fund in Q4 2019 and Q1 2020 is as follows:

- 18<sup>th</sup> December: the Innovation Fund Expert Group (IFEG) meeting will be meeting and possibly presented with the first call design consultant report.
- Jan/Feb: 3-4 technical workshops on relevant cost and GHG emission avoidance
- March: one workshop on the other selection criteria.
- April: final meeting of IFEG.

The Network will try to coordinate with the Commission and provide support on technical workshops where possible.

### European Zero Emission Technology and Innovation Platform

### **Temporary Working Group PCIs**

*Chair: Lamberto Eldering (Equinor)*

It was proposed at the ACEC in November that the TWG PCIs be discontinued. The remit of this group has been surpassed by other mechanisms and subject to approval from the AC the group will be discontinued.

### **Temporary Working Group Sustainability Taxonomy**

*Chair: Graeme Sweeney*

The Sustainable Taxonomy consultation response to the TEG report was submitted in mid-September. Since, the taxonomy has been debated in both the European Council, where it was decided to delay the introduction of the taxonomy from 2020 to 2021 ready for implementation by the end of 2022.

At the technical expert group level, the Commission has been synthesising consultation responses which require input from the TEG. There have been a few items raised under the Do No Significant Harm criteria, the CCS relevant items to which the TWG responded and is attached as pre-read 11.a.ix. Additionally, input has been received after requests for ZEP expertise on CO<sub>2</sub> transport and direct-air capture

The Plenary have discussed extending CO<sub>2</sub> transport to include Shipping and Rail, and the input was positively received. The 3<sup>rd</sup> threshold for hydrogen production has been removed, and conversations have begun about a threshold profile which is not linear and ramps over time (as mentioned in the ZEP consultation response). Furthermore, the TEG Energy Sub-group have considered the ZEP input and are working on a solution to the Life-Cycle Emissions in a net-zero 2050 issue.

## ZEP Network Policy and Economics

### Meeting Agenda: 24<sup>th</sup> October 2019

Location: Copernico Science`14, Rue de la Science 14, 1040 Bruxelles, Belgium  
 11:00-15:30 CET

Item		Lead Presenter	Time
1	Introduction, tour de table, safety notices	Co-Chair	11:00
2	European Green Deal: ZEP work plan and messages	Per-Olof Granström	11:10
3	EU Project Landscape: Coordinating EU projects and tackling policy/investment barriers	CCUS Projects Network/ SET Plan SG1	11:45
<b>Lunch</b>			12:45
4	ISO TC265 Collaboration Opportunity	Valerie Czop/ Horacio Hormazabal	13:30
5	Progress update: <ul style="list-style-type: none"> <li>a. Network Policy &amp; Economics               <ul style="list-style-type: none"> <li>• Hydrogen for Europe Study</li> </ul> </li> <li>b. TWG PCIs</li> <li>c. TWG Policy &amp; Finance               <ul style="list-style-type: none"> <li>• Innovation Fund Workshop</li> </ul> </li> </ul>	Co-Chair	14:00
6	London Protocol Feedback from IMO Meeting	Lamberto Eldering	14:30
7	Chair's update <ul style="list-style-type: none"> <li>a. Feedback from ZEP September AC</li> </ul> Feedback from external engagements	Graeme Sweeney	14:45
8	Next steps: <ul style="list-style-type: none"> <li>a. AOB</li> <li>b. Chairs' summary</li> <li>c. Forward work activities</li> <li>d. Next meeting</li> </ul>	Co-Chair	15:15

## **ZEP Network Policy and Economics**

### **Minutes: NWPE meeting, 24<sup>th</sup> October 2019**

#### ***Attendance***

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<b>Name</b>	<b>Organisation</b>
<b>Eric De Coninck</b>	Arcelor Mittal
<b>Keith Whiriskey</b>	Bellona
<b>Lamberto Eldering</b>	Equinor
<b>Brian Murphy</b>	Ervia
<b>Ståle Aakenes</b>	Gassnova
<b>Rob Van der Meer</b>	Heidelberg Cement
<b>Nora Hansen</b>	IOGP
<b>Kim ByeBruun</b>	Shell
<b>Liliana XXX</b>	Trinomics
<b>Chris Gent</b>	ZEP Secretariat
<b>Per-Olof Granström</b>	ZEP Secretariat
<b>BY PHONE</b>	
<b>Tim Peeters</b>	Tata Steel Europe
<b>Graeme Sweeney</b>	ZEP
<b>Valerie Czop</b>	EDF
<b>Horacio Hormazabal</b>	AFNOR

#### ***Item 1: Introduction***

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LE Completed an introduction and round table and Minutes were adopted

RvdM under AOB gave an update on the TWG CCU meeting which was held before the NWPE meeting. The TWG has an increased membership including CO2Value Europe, Shell and Arcelor Mittal including current members Bellona, Mitsubishi Heavy industry and the secretariat.

The group has decided to do a short high-level report identifying key issues for CCU technologies and their impact on the climate. The Commission are asking for a short report by the end 2019. The group have identified 4 factors, Carbon Emission Factor, from 100 to -100% depending on emission amount, Net-Energy Use Factor (energy needed in for CO2 conversion into new product/storage), Energy Carbon Factor (CO2 required from energy used in conversion process), Time (when can these processes be implemented, some are do-able today, others (pure CCS) in 20 years). This paper will give a clearer picture on what the commission can do to help climate change.

This work will be based on emissions factors and fundamental technologies. Not heavily scientific, as there are LCA studies ongoing. This paper is a reactive paper for the Commission to progress projects in 2020/2021 which can demonstrate actual emissions reductions without a detailed LCA study. LE asked who is the audience who is the user?

RvdM – DG CLIMA won't use them, and perhaps no one in the commission will. This is due to a legal perspective as the ZEP instrument will need to be legally defensible. This will be a quick and easy instrument to use within ZEP and for others looking into it. LE – this is difficult to approach and is still very project specific. And cannot consider other wider benefits (eg waste product use for district heating), even a detailed LCA will struggle on this. We need to be clear on the ambition levels and a way to educate the audience. It will be difficult for ZEP to write a formula/algorithm to solve the quick LCA process.

RvdM – There is a lot of false statements about CCU projects. We need a simple instrument to indicate whether the projects make climate abatement sense. This can then trigger more detailed discussions and detailed LCAs. LE This will help with a more educated discussion and help with the CCU vs CCS discussion which ZEP faces. Either ZEP or CO2Value Europe will have to proof/consult on any LCA documentation produced from the Commission. This will be very helpful.

Next steps: Text to be drafted and more examples must be tested (including Blue Hydrogen and Chemicals process). Mid-November for the first solid draft ready for approval at the December Advisory Council meeting.

## ***Item 2: European Green Deal: ZEP Work plan and messages***

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POG mentioned an article published today by Corporate Europe report on oil and gas lobbying and CCUS which will be very difficult for ZEP to navigate. KW – Although this article highlights O&G lobbying, the story needs to be disassociated, as a positive story as NGOs are increasing their interest in CCS.

LE – ZEP should not get involved in an article which criticizes the oil and gas industry as this may invoke more backlash and is not representative of the membership.

POG highlighted the green deal and the new zero commitments, and the new commissioner. The industry strategy will not be through DG GROW, it will be through the Sustainable Finance and Digital Agenda will be responsible for establishing the industrial policy – it isn't clear where this will end up.

The long-term strategy, PL, HU, CZ are resisting the strategy still. The sticking point is still the just transition funds as these countries wish to have more than indicated.

The proposed 55% 2030 target is splitting the member states, GER and POL for example are retracting ambition on this.

First climate package will be proposed in March 2020. The second proposed climate package will be in 2021 together with the EU ETS update, which should include statements on negative emissions technologies such as BECCS.

The decarbonised gas package will be in 2020. NECP presentation from IOGP at the SET-Plan meeting 17<sup>th</sup> October, shows many countries are pushing CCS ambition forward.



Industry strategy, a masterplan of decarbonisation of energy intensive industries document which is very prominent on CCS may not be published. New meeting on 4<sup>th</sup> December to decide whether a document can be produced. EU Parliament when talking about decarbonising industry focus more on CCU than CCS – this is a point of observation.

KBB – asked if this document was available, if so, could it be circulated and interpreted for any messages which ZEP can take forward. KW & POG confirmed the draft report is available and can be circulated

ACTION: Circulate the masterplan draft document to the network and highlight and messages which the platform can use

The Commission are looking to update Reference Scenarios to run 2050 climate models again and update them.

Push from external to push funding up on Horizon Europe to 120bn EUR from parties which are very successful in the past.

LE asked is the green deal a shell/holistic strategic approach around these mechanisms. POG – The green deal with other established initiatives (ETS, decarbonisation package), it looks like two heavy climate packages which will head towards 2050 neutrality. LE – It feels like it is easy to adjust ambition levels but difficult selections will need to be made (should certain industries continue in Europe) this is also difficult for a border tax.

RvdM highlighted that the proposed 50+% GHG reduction 2030 target by the commission is, for the industry very serious and difficult to achieve, particularly without a border tax. – additional measures on top of ETS will be required or industries will stop in 2030.

KW stated that the concept of the border tax is not defined yet – it could become one of many pieces. Much like the ETS a simple concept but in detail very complex.

POG – The AC supported an active ZEP role in shaping political climate framework. Including an extreme focus on policy and regulation and a separate drive for economics and modelling. The working groups need to be reactivated and a call for more members with TWG will be needed. This is including more coordination within ZEP. The 12<sup>th</sup> November meeting of ACEC will discuss internal process more.

### ***Item 3: EU Project Landscape: Coordinating EU Projects***

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LG – Introduced the Projects Network, the objectives of the network and activities. Focussing on the SET-Plan key alignment points (see slides).

BM – Presented slides on the IWG9. And now figuring out how best to develop synergies between organisations (see slides).

KBB mentioned that leakage liability is an interesting area for many other projects. OGCI would benefit from an overview of legislation and liabilities on European countries. LE Cautioned that the

SG are reliant on input from members and projects and asked how do we get projects into working groups and engaged with the SET-Plan, especially given tight resourcing and timescales?

CCUS Project networks give a window of opportunities to collaborate and engage with the SET-Plan. The SG need to steer without interfering. Both initiatives need to show value to each other to succeed.

POG Mentioned that a list of liabilities and risks is a key component. This is essential for Member State outreach programmes. BM it is vital that these platforms can be used to inform and educate policymakers and government officials.

KBB confirmed that the insurance industry is becoming interested. Platforms, lists and documents need to be present for decisions to be made. KW rhetorically asked the group, is the pricing and amount of risk a byproduct of having no projects to prove risks and liabilities. This is a chicken and egg scenario.

LE Confirmed that through various chairs and members ZEP is heavily involved in both the Project Networks and the SET-Plan IWG9. Studies and work can role out of the work. The ZEP can investigate in more detail issues raised from the SET-Plan/Project Networks.

POG Confirmed that there will be coordination between all 3 platforms at workshops and events.

CG – A valuable document would be a one/two pager which highlights the three platforms and how they work together. ACTION: 1 pager on the three groups and how they coordinate and minimise burden on the projects.

KBB – It is good to highlight themes and target workshops/work between the networks how to proceed, for example on liability.

#### ***Item 4: ISO/TC 265 Collaboration Opportunity***

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VC – Presented quickly the slides outlining the ISO structure, members and working group objectives. WG1 are collaborative and efficient. WG2&3 progress well but slowly. WG4&6 discrepancy between members make the process more difficult, particularly WG4. WG6 is very focussed on Norway & US would be difficult to take these standards in Europe. WG5 – some difficulties in this group.

For the majority of working groups, the work is progressing well. There is difficulties in WG4 due to differences in point of views (USA NO vs majority of European Countries), not only point of view but competencies (EU – technical experts, USA – lawyers). In Europe each country can vote, USA has one. Currently there is no current view in Europe, it is quite difficult to progress, it isn't predictable how European votes will materialise ahead of the plenary. There is no central location/way European votes can collaborate ahead of vital votes. ZEP could be a vital tool to coordinate.

RvdM asked whether CEN would be the best platform to coordinate this. Unless they are all added to ZEP. HH – Stated that CEN are not active in the TC265 and would not be a good platform in the

near term to engage with this. HH also mentioned that there is a possibility to for ZEP to be a liaising member with TC265 to be informed and possibly engage with the process and express a position. RvdM stated that the ZEP need to start the discussion whether ZEP engages with ISO TC265 standardisation processes. LE cautioned that ZEP is already challenged with participation of its own agenda, the resources may not be possible.

KW Asked if ZEP can facilitate the ability to host a 'safe space' event where European groups can come together and discuss this?

RvdM Stated that the ISO members in Europe should be asked first if they are happy to meet under the umbrella of ZEP, in Brussels

POG mentioned that this should be discussed at the AC, but ZEP cannot not promise anything, given the plethora of work which is ongoing. KBB Highlighted that the ongoing ISO process is important as the Commission will point towards ISO standards in future policy.

ACTION: ZEP to discuss at AC (ACEC) whether ZEP can host a 'safe space' for European ISO participants to meet and discuss opinions and positions.

RvdM asked whether VC ad HH are sure ISO delegates will attend meeting on TC 265 ahead of the plenary if ZEP were to host?

VC Confirmed that involvement may be Hosting 1 meeting with ZEP before plenary (1 person from each country is enough), having a deep discussion and the opportunity to discuss. During the plenary there is no scope to discuss opinions. (1-2 meetings max per year. Can also include a select members from ZEP with the correct expertise)

ACTION: RvdM will discuss with VC how to ask TC265 if there is interest for a meeting. If this is something which is taken forward, ZEP will organise a first meeting on this topics – then it can be discussed formally at ACEC/AC for ZEP process.

### ***Item 5: Progress Update***

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POG Gave an introduction to the Hydrogen for Europe study. We have been approached by IOGP, SINTEF, IFPEN, on hydrogen for Europe study. We will be able to host one person on the advisory board and provide input on the technical parameters, and input in the later stages on policy. At the ACEC on Tuesday 22<sup>nd</sup>, this was seen as positive and that ZEP should continue input and participation on this.

NH expanded: IOGP and members have been working for 6months on a pre-study to establish framework report. This is publicly available. The main study will be 1 year long and worth 1.85m EUR. This is well placed given the long term climate objectives of the Commission, lots of studies, but not focussed on the whole energy system including hydrogen interplay with the electricity sector. SINTEF and IFP advanced modelling tools will be used to produce new modelling results of a Europe wide hydrogen study.

Still in the fund raising phase of the report, the focus now would be have a better representative of gas and hydrogen value chains. The first workshop on the parameters and assumptions, the second workshop will be on the final report and the recommendations which come out of the complex modelling study. This is meant to be a very open study with open data which can be used in the future.

LE asked how is the data flow coordinated? Does the project send requests to ZEP or direct access to contacts in the ZEP network. NH The project will ask ZEP representative directly not individuals. LE mentioned that other companies including Equinor are very active on hydrogen. There is little actual data in ZEP on hydrogen. Other industries stakeholders can offer more than ZEP as a whole.

POG Referred to earlier updates and that ZEP are restarting of the TWG Hydrogen could provide the direct contact into ZEP. This needs to be discussed internally. KBB mentioned that some companies are both IOGP and ZEP members, which may have different contact points and duplication doesn't make sense, internal discussions need to take place. LE Observed that the ZEP lens gives companies an outlet to be very CCS focussed, whereas through IOGP it may have a slightly different message.

LE Suggested that the TWG PCI, ToR is no longer valid. BM mentioned that it has been superseded by IWG9 and projects network LE – Proposed that at the next ACEC/AC that this is TWG PCI is stopped.

ACTION: Propose to ACEC/AC that TWG PCI is closed.

### ***Item 6: London Protocol Feedback from IMO Meeting***

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LE Gave a brief update on the passing of the proposal on the London Protocol. Including a presentation to the group on the Northern Lights project. Including the guidelines for storage. Reception was very positive, GER questioned whether this was only for 'unavoidable CO2 emissions' which was pushed back. Additional countries have been rumour to be ratifying the amendment.

ACTION: LE to follow up on Northern Lights letter on the ETS into the Commission.

### ***Item 7: Chairs Update***

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SET-Plan will look at what increased ambition (net-zero) would look like compared to when the SET Plan was established.

Engagements with Horizon Europe will be essential there is still room for improved clarity on how the hydrogen partnerships work. Within horizon Europe, CCS is assigned for Energy, CCU assigned for Industry. How will we ensure they aren't split too much? On the publications of the missions, emissions reductions is not explicit – how will this impact funding, for CCS doesn't fit in the other missions very well? It is important to understand how the horizon Europe works particularly in light of the European green deal process.

TWG sustainable taxonomy continues. The TEG are assessing the feedback from the consultation process. TWG is answering questions on environmental performance of CCS projects. Furthermore, it seems that inclusion of shipping and trucks, and the removal of direct for CO2 transport will be incorporated. The 3<sup>rd</sup> criterion on hydrogen production should be removed as things stand. No feedback to date on how groups deal with hydrogen production profiles are presented. End of life discussions: how to deal with emissions closing in on 2050 for net-zero, any plant operating at 2050 how will these be accepted, the proposal is that projects seek to allow appropriately geographically contingent solutions (nearby negative emissions technologies to offset residual emissions (e.g. DACCES or afforestation)).

REDII – It is clear that life cycle analysis used in REDII vs proposal under taxonomy are different. Interesting to see how the commission consider this.

GS Reiterated that the green new deal will be a 'heavy lift' a different kind of landscape with different kinds of conversations needed which will lead to action. This in principle should lead to more not fewer opportunities for CCS. LE - logically yes, politically perhaps not so obvious. We need to be vigilant.

### Item 8: Next Steps

LE – The green deal will continue and be very important for ZEP to stay up to date with. The next projects/IWG 9 meeting will be in January. Invite Sofie NPD on the conclusion on the London Protocol process & the question on the ETS letter/process.

ACTION: circulate the list of meeting dates AC and ACEC

ACTION: Circulate the EU Reference Scenario document to the network.


ACTION discuss future NWPE meeting date with Co-Chairs and in light of a joint session on the IF first call design.

### Actions

Action		Owner	Completed
2	Circulate the Industrial Decarbonisation Master Document draft to the network. Highlight key messages which the platform can continue to use	ZEP Sec	
3	A 1-2 pager to highlight the involvement and objectives of ZEP, CCUS Project Networks and SET-Plan IWG9 should be produced	ZEP Sec / BM/ LG	
4	ZEP upon positive feedback from ISO members, the ACEC and AC will discuss ZEPs potential facilitatory role for European Discussions on ISO standards	ZEP Sec / RvdM	
4	ISO to discuss potential appetite with members for European platform to discuss opinions ahead of Plenary meetings (1-2 meetings per year) and feed back to ZEP	RvdM/VC/HH	

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	contact		
5	Propose to the next ACEC/AC that the TWG PCI is disbanded	ZEP Sec/LE	
6	Northern Lights project partners to track the progress of the EU ETS letter submitted to DG CLIMA earlier in 2019 (uncompleted action from July 2019 NWPE meeting)	LE	
8	When confirmed, Circulate the list of future AC and ACEC dates to the Network	ZEP Sec	
8	Circulate the EU Reference Scenarios consultation material to the network and urge internal responses (and feedback)	ZEP Sec	
8	SEC to confirm future date for NWPE meeting – perhaps tied in with a workshop on the Innovation Fund Consultation on the design of the first call	ZEP Sec	
8	Invite the Norwegian Ministry to round up the London Protocol process and discuss how they are approaching CO2 transport by ship in the EU ETS	ZEP Sec	



# ZEP Policy Brief: CO<sub>2</sub> Capture Rates in the Context of EU Energy Systems Modelling

October 2019

## Summary & Recommendations

- CO<sub>2</sub> capture rates of 95% or higher are possible on CCS-equipped power stations with limited increase to the Levelised Cost of Electricity (LCOE).
- Increasing CO<sub>2</sub> capture rate from 90% to 99% on coal and gas power stations could increase LCOE by as little as 7.4% and 6.2% respectively.
- CO<sub>2</sub> capture technologies are highly-upgradeable, meaning capture rate can be easily ramped-up over time in line with market conditions and an increasing CO<sub>2</sub> price.
- A 95% capture rate on gas power stations could increase LCOE by 1.6% compared with a 90% capture rate.
- An arbitrary 90% capture limit does not reflect the current status of CCS technology and is not an appropriate limit to use in energy systems models looking to achieve net zero emissions.
- EC models should include the option for rising capture rates and associated cost increases to show how capture rates in different climate and energy scenarios may increase over time as policy and economics evolve.
- Further studies should investigate high capture rates for other activities, including hydrogen production and energy-intensive industry processes. These are expected to result in similar cost reductions.

In the past, when CCS was discussed as the main option to decarbonise coal-fired power plants, a CO<sub>2</sub> capture rate of 90% was adopted as standard, regardless of the technology type, the location or fuel type. However, this standard value, adopted so ubiquitously, is actually an artificial limit.

The IEAGHG<sup>1</sup> has investigated the possibility and costs of achieving carbon capture rates higher than 90% for deployment of CCS in the power sector. The conclusion is that there were no technological barriers for increasing capture rates to 99% for all three main capture technologies, with minor financial and process efficiency penalties for post-combustion capture. Techno-economic studies were not performed for the pre-combustion and oxyfuel cases.

**Table 1: Comparison of different post combustion capture rates for coal and natural gas fired power plants in percentage change compared to a 90% post combustion capture plant.**

	Coal: Standard design		Coal: Optimised design	Natural Gas	
Capture Rate	95.0%	99.0%	99.7%	95.0%	99.0%
Net Power Output (MW)	-1.7%	-5.2%	-4.3%	-1.1%	-5.1%
LCOE (€/MWh)	+3.0%	+7.4%	+6.9%	+1.6%	+6.2%
CO <sub>2</sub> avoided cost (€/t CO <sub>2</sub> )	+0.4%	+5.7%	+3.3%	-0.8%	+7.3%

<sup>1</sup> IEAGHG, 2019. "Towards zero emissions CCS from power stations using higher capture rates or biomass", 2019/02.

# Energy Draft Technology Assumptions for the New EU Reference Scenarios

**Response from the Zero Emission Technology and Innovation Platform (ZEP)**  
*30<sup>th</sup> October 2019*

The Zero Emission Technology and Innovation Platform (ZEP) is the technical adviser to the EU on the deployment of Carbon Capture and Storage (CCS), and Carbon Capture and Utilisation (CCU), a European Technology and Innovation Platform (ETIP) under the Commission's Strategic Energy Technologies Plan (SET-Plan).

## CO<sub>2</sub> Capture Rates

In the past, when CCS was discussed as the main option to decarbonise coal-fired power plants, a CO<sub>2</sub> capture rate of 90% was adopted as standard, regardless of the technology type, the location or fuel type. However, this standard value, adopted so ubiquitously, is actually an artificial limit.

The IEAGHG<sup>1</sup> has investigated the possibility and costs of achieving carbon capture rates higher than 90% for deployment of CCS in the power sector. The conclusion is that there were no technological barriers for increasing capture rates to 99% for all three main capture technologies, with minor financial and process efficiency penalties for post-combustion capture. As such:

- CO<sub>2</sub> capture rates of 95% or higher are possible on CCS-equipped power stations with limited increase to the Levelised Cost of Electricity (LCOE).
- Increasing CO<sub>2</sub> capture rate from 90% to 99% on coal and gas power stations could increase LCOE by as little as 7.4% and 6.2% respectively.
- CO<sub>2</sub> capture technologies are highly-upgradeable, meaning capture rate can be easily ramped-up over time in line with market conditions and an increasing CO<sub>2</sub> price.
- A 95% capture rate on gas power stations could increase LCOE by 1.6% compared with a 90% capture rate.
- An arbitrary 90% capture limit does not reflect the current status of CCS technology and is not an appropriate limit to use in energy systems models looking to achieve net zero emissions.
- EC models should include the option for rising capture rates and associated cost increases to show how capture rates in different climate and energy scenarios may increase over time as policy and economics evolve.
- Further studies should investigate high capture rates for other activities, including hydrogen production and energy-intensive industry processes. These are expected to result in similar cost reductions.

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<sup>1</sup> IEAGHG, 2019. "Towards zero emissions CCS from power stations using higher capture rates or biomass", 2019/02.  
Zero Emission Technology and Innovation Platform (ZEP)



Table 1: Comparison of different post combustion capture rates for coal and natural gas fired power plants in percentage change compared to a 90% post combustion capture plant.

	Coal: Standard design		Coal: Optimised design	Natural Gas	
Capture Rate	95.0%	99.0%	99.7%	95.0%	99.0%
Net Power Output (MW)	-1.7%	-5.2%	-4.3%	-1.1%	-5.1%
LCOE (€/MWh)	+3.0%	+7.4%	+6.9%	+1.6%	+6.2%
CO <sub>2</sub> avoided cost (€/t CO <sub>2</sub> )	+0.4%	+5.7%	+3.3%	-0.8%	+7.3%

Please find below comments on the Draft Technology Assumptions for the New EU Reference Scenarios, organised as per the available *E3M\_PRIMES\_tech\_assumptions\_ENERGY* document on the Commission website.

## Domestic

Row #	Cell	Comment
N/A	N/A	Cost figures for hydrogen fuels appliances and heating should be added. Hydrogen will be one solution for heat decarbonisation which could play a major role in the future of EU domestic heating.

## Power & Heat

Row #	Cell	Comment
N/A	N/A	Note that gas turbines can also run on hydrogen and should be included as low carbon option in the scenario development
23	E	The post combustion plant should be cell E23-E13 = 860 EUR/kW with 90% capture on kW = 0,282 g/kW thus the capture plant cost is equal to 350 EUR/per tCO <sub>2</sub> per year

## New Fuels

Row #	Cell	Comment												
NEW	N/A	<p>Hydrogen from natural gas autothermal reforming (ATR) centralised – large scale CCU (per 1 kW or 1 MWh HHV).</p> <p>Values:</p> <table><tr><td>600</td><td>550</td><td>500</td><td>24.0</td><td>22.0</td><td>20.0</td><td>1.20</td><td>1.05</td><td>1.06</td><td>1.14</td><td>1.05</td><td>1.13</td></tr></table> <p>Data from 2019 H21 North of England Report <sup>2</sup>.</p>	600	550	500	24.0	22.0	20.0	1.20	1.05	1.06	1.14	1.05	1.13
600	550	500	24.0	22.0	20.0	1.20	1.05	1.06	1.14	1.05	1.13			

<sup>2</sup> <https://www.h21.green/wp-content/uploads/2019/01/H21-NoE-PRINT-PDF-FINAL-1.pdf>

8 10	C, D C, D	Electrolyser will require site preparation, utilities, sub-stations etc similar to SMR facilities. These elements will have limited cost reduction potential and normally contributes to 150-200 EUR/kW output <sup>3</sup> .
8	H	Efficiency of electrolysis must take into account cell degradation and cell replacement. It seems to be based on start-of-life operation.
21	A	It is assumed that "per 1 tCO <sub>2</sub> " is "per 1tCO <sub>2</sub> per year" similar to row 51.  Noting that the power plant with post combustion capture had an ultimate CAPEX of 350 EUR/tonnes with almost no significant cost reduction, it seems unrealistic that a similar technology for air (with 100 times lower CO <sub>2</sub> concentration) has an ultimate cost which is just 30-40% higher than the post-combustion carbon capture on gas power generation
22	A	Absolute cost and cost curve seems too optimistic for a technology that inherently depends on partial pressure to drive the capture process
29 30	A A	Heat rate is missing from H <sub>2</sub> compression and liquefaction refuelling technologies
30	D	It is not realistic to see hydrogen liquefaction becoming cheaper than LNG noting the cooling temperatures and energy needs
45	A	For all technologies the distance and capacity plays a significant role in the cost
50	A	CO <sub>2</sub> distribution by ship is missing (road transport of H <sub>2</sub> is considered). CO <sub>2</sub> transport by ship will provide a key enabling transport mechanism for some CCS projects, particularly in the early deployment phase.
53	A	H <sub>2</sub> distribution by ship is missing (road transport of H <sub>2</sub> is considered)
66	B	Several studies indicates a cost 300 EUR/MWh for underground hydrogen storage in salt caverns <sup>4</sup>

<sup>3</sup> [https://www.amprion.net/Dokumente/Dialog/Downloads/Studien/Studie-Sektorenkopplung/Study-Smart\\_Sector\\_Integration.pdf](https://www.amprion.net/Dokumente/Dialog/Downloads/Studien/Studie-Sektorenkopplung/Study-Smart_Sector_Integration.pdf)

<sup>4</sup> <https://www.h21.green/wp-content/uploads/2019/01/H21-NoE-PRINT-PDF-FINAL-1.pdf>

# CCS and CCU in the JRC Science for Policy Report: The POTEnCIA Central scenario: An EU energy outlook to 2050

November 2019

The JRC POTEnCIA Central Scenario<sup>1</sup> describes the evolution of the EU energy system from 2018-2050 based on the policy landscape at the end of 2017. The objective of the report is to purely serve as a reference document to which future policy targets or reporting can be compared against. This was performed not only Europe wide but individually for each member state, and the report provides detailed graphics of each member state. Furthermore, this report highlights the disparity between EU and Member State ambition and the policy framework which underpins those ambitions.

## Summary

- The report describes evolution of the EU energy system from 2018-2050 using European and member state policy at the end of 2017.
- The report is designed to serve as a reference document
- The 2030 the EU energy and GHG emissions reductions targets set by the EU framework for climate and energy are missed.
- The 2050 EU climate targets are missed, and emissions reductions only total a 47% reduction from 1990 levels, well above the climate-neutrality target.
- Investment expenditure totals 72.5 trillion EUR over the period 2016-2050, 11.5% of GDP. Primarily (68%) linked to the satisfaction of energy needs (electric vehicles and appliances).
- CCS accounts for 8% of the EU net-electricity generation in 2050. Ramping up from 2040. This is a blend of gas (5%) and coal (3%) power generation with CCS at 90% capture rate, totalling 171.5Mt/CO<sub>2</sub> pa from power generation alone.
- CCS is viewed as a technology to address process emissions for the cement and iron & steel industry, resulting in 98Mt/CO<sub>2</sub> p.a. capture (81Mt and 17Mt respectively).
- Hydrogen with CCS, CCU, BECCS and DACCS are all not considered.

## Carbon Price Trajectory

The modelling was based on a carbon price trajectory which from 2030 – 2050 increases from 25 EUR/tonne to 121 EUR/tonne (Figure 1).

<sup>1</sup> MANTZOS LEONIDAS; WIESENTHAL TOBIAS; NEUWAHL FREDERIK; RÓZSAI MÁTÉ, 2019. The POTEnCIA Central scenario: an EU energy outlook to 2050. Publications Office of the European Union JRC118353. DOI [10.2760/32835](https://doi.org/10.2760/32835). Available at: [https://publications.jrc.ec.europa.eu/repository/bitstream/JRC118353/potencia\\_central\\_scenario\\_online.pdf](https://publications.jrc.ec.europa.eu/repository/bitstream/JRC118353/potencia_central_scenario_online.pdf)

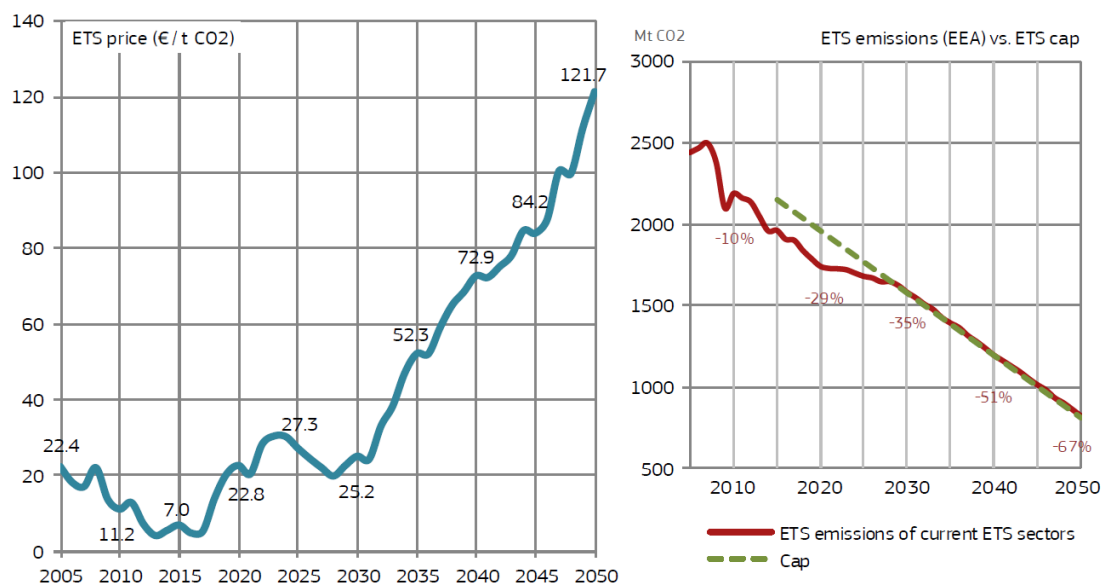


Figure 1: Future CO<sub>2</sub> price and ETS emissions trajectories used from 2017 - 2050.

## Carbon Capture and Storage

### Power Generation:

Carbon capture and storage is mentioned at length in the Central scenario. However, the industry does not start until 2030, with the real increase in volume from 2040, when carbon reaches 72.9 EUR/tonne. The deployment of CCS is initially all for coal power, but an increase in gas power generation with CCS results in a total of 8% of the 2050 net-electricity generation produced using CCS (3% coal, 5% gas) (Figure 2). This corresponds to a total of 171.5Mt/CO<sub>2</sub> capture per annum from power generation.

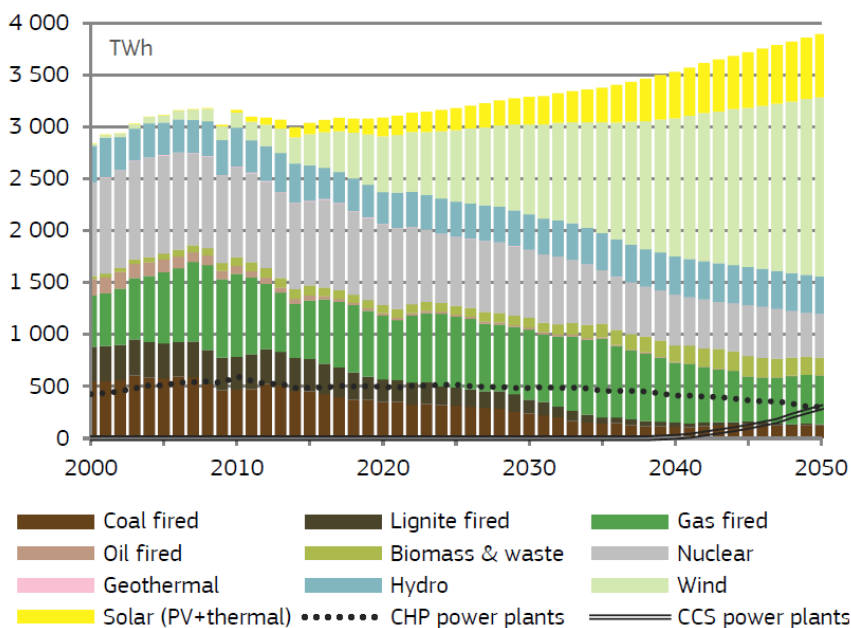


Figure 2: Past and Future European Electricity Generation Technologies 2000-2050

*Industry:*

CCS is not seen as a major solution for industry; however, the report does recognise the need for CCS to address process emissions in the cement and iron & steel manufacturing sectors. In 2050 across Europe it is predicted that there will be approximately 81Mt/CO<sub>2</sub> pa and 17Mt/CO<sub>2</sub> pa capture for the cement and steel industries respectively.

*Hydrogen:*

Hydrogen manufacture is seen as only from electrolysis. The uses of which will be predominantly for the transport industry, with a slight focus of heavy transport. In 2050 1.5% of total electricity generation (~55TWh) will be specifically for electrolysis produced hydrogen.

Minor amounts of hydrogen will also be used for the steel industry as a reducing agent in the coking process.

Aside from this, hydrogen from methane reforming and CCS is not even mentioned as an option. This is one of the largest take away messages from 2017 policies and the missed climate targets.

*CCU, DACCS, BECCS:* These are not mentioned at all in the Central Scenario

# Public Consultation on 12 proposed Institutionalised European Partnerships under the future Horizon Europe Research and Innovation programme

Fields marked with \* are mandatory.

## Introduction

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With a proposed budget of nearly 100 billion euro from 2021 to 2027, the Horizon Europe framework programme represents the largest collaborative multinational research and innovation investment in Europe and is open to participants worldwide.

The European Parliament and the Council have provisionally agreed on the Horizon Europe legislative package (COM(2018)435)[1]. Based on the agreement, Horizon Europe promotes a more strategic, ambitious and impact-oriented approach to public-public and public-private partnerships (European Partnerships), ensuring that they can effectively contribute to the Union's policies and priorities.

European Partnerships allow to bring together a broad range of actors to work towards a common goal, develop synergies with EU, national and regional programmes and strategies, and accelerate societal and market uptake. Different forms of European Partnerships can be implemented depending on specific needs, type of activities and criteria: Co-funded, Co-programmed or Institutionalised European Partnerships.

Institutionalised Partnerships are implemented only when other parts of the Horizon Europe programme, including other forms of European Partnerships (Co-funded or Co-programmed), cannot achieve the objectives or generate the necessary expected impacts. The preparation of such Institutionalised Partnerships requires new EU legislation and the setting up of specific legal structures (funding bodies) based on Article 185 and 187 of the Treaty on the Functioning of the EU (TFEU)[2]. As such all Institutionalised Partnerships must be justified with an impact assessment prior to the preparation of the legislative proposals.

The European Commission is currently running the impact assessment of 12 candidate Institutionalised European Partnerships in the following priorities:

1. EU-Africa research partnership on health security to tackle infectious diseases (Global Health)
2. Innovative Health Initiative
3. Key Digital Technologies
4. Smart Networks and Services
5. European Metrology
6. Transforming Europe's rail system

7. Integrated Air Traffic Management
8. Clean Aviation
9. Clean Hydrogen
10. Safe and Automated Road Transport
11. Circular bio-based Europe: sustainable innovation for new local value from waste and biomass
12. Innovative SMEs

This public consultation aims to collect the views of stakeholders and citizens on the need for such Institutionalised European Partnerships and will feed into the impact assessment process. This consultation is structured in two parts: Part 1 covering all candidate Institutionalised European Partnerships and Part 2 specific to each candidate. We invite you to provide feedback on any of the candidate Institutionalised European Partnership.

The questionnaire is available in English, French and German and you can reply in any EU language. You can pause any time and continue later. Your contribution is downloadable once you have submitted your answers.

Responses received after the closing date will not be considered. Questionnaires sent by e-mail or on paper will not be analysed except those due to accessibility needs of people with visual disabilities and their representative organisations.

A summary on the outcome of the public consultation will be published by the Commission services on the '[Have your say](#)' portal.

We thank you for your participation.

[Protection of personal data](#)

[Privacy statement](#) on the protection of personal data in EU Survey

[1] Legal texts for Horizon Europe to be found here: [https://ec.europa.eu/commission/publications/research-and-innovation-including-horizon-europe-iter-and-euratom-legal-texts-and-factsheets\\_en](https://ec.europa.eu/commission/publications/research-and-innovation-including-horizon-europe-iter-and-euratom-legal-texts-and-factsheets_en)

[2] Following Article 8(1)(c) of the proposed Regulation for Horizon Europe

## About you

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### \* Language of my contribution

- ☐ Bulgarian
- ☐ Croatian
- ☐ Czech
- ☐ Danish
- ☐ Dutch
- ☒ English
- ☐ Estonian
- ☐ Finnish
- ☐ French
- ☐ Gaelic
- ☐ German

- ☐ Greek
- ☐ Hungarian
- ☐ Italian
- ☐ Latvian
- ☐ Lithuanian
- ☐ Maltese
- ☐ Polish
- ☐ Portuguese
- ☐ Romanian
- ☐ Slovak
- ☐ Slovenian
- ☐ Spanish
- ☐ Swedish

\* I am giving my contribution as

- ☐ Academic/research institution
- ☐ Business association
- ☐ Company/business organisation
- ☐ Consumer organisation
- ☐ EU citizen
- ☐ Environmental organisation
- ☐ Non-EU citizen
- ☐ Non-governmental organisation (NGO)
- ☐ Public authority
- ☐ Trade union
- ☒ Other

\* First name

Chris

\* Surname

Gent

\* Email (this won't be published)

chris.gent@zeroemissionsplatform.eu

\* Organisation name

*255 character(s) maximum*

ETIP Zero Emission Platform (ZEP)

\* Organisation size

- ☒ Micro (1 to 9 employees)



- ☐ Small (10 to 49 employees)
- ☐ Medium (50 to 249 employees)
- ☐ Large (250 or more)

## Transparency register number

*255 character(s) maximum*

Check if your organisation is on the [transparency register](#). It's a voluntary database for organisations seeking to influence EU decision-making.

793300922868-60

## \* Country of origin

Please add your country of origin, or that of your organisation.

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\* Publication privacy settings

The Commission will publish the responses to this public consultation. You can choose whether you would like your details to be made public or to remain anonymous.

☐ **Anonymous**

Only your type of respondent, country of origin and contribution will be published. All other personal details (name, organisation name and size, transparency register number) will not be published.

☒ **Public**

Your personal details (name, organisation name and size, transparency register number, country of origin) will be published with your contribution.

☒ I agree with the [personal data protection provisions](#)

## Part 1: General questions on European Partnerships

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As per the political agreement on Horizon Europe, an Institutionalised European Partnership shall be implemented only where other parts of the Horizon Europe programme, including other forms of European Partnerships (co-programmed, co-funded), would not achieve the objectives or would not generate the necessary expected impacts; they should be justified by a long-term perspective and high degree of integration.

There will be three types of European Partnerships under Horizon Europe [1].

**Co-programmed European Partnerships** are based on memoranda of understanding and/or contractual arrangements between the Commission and private and/or public partners. They are expected to be best suited to partnerships involving industry, but also Member States, foundations, international partners etc. They are jointly implemented by the Commission (Union contribution via Horizon Europe work programmes) and partners (contributions under their responsibility), with full application of Horizon Europe rules for the Union contribution, whereas partners rules apply to their contributions. They allow for more flexibility over time as regards the composition of partners, objectives and activities and require the relatively lowest effort for set-up and implementation compared to the other forms of European Partnerships.

**Co-funded European Partnerships** are implemented under the responsibility of the partners, that receive a substantial budget contribution from Horizon Europe (Grant Agreement) to cofound their joint programme of activities. They are expected to be best suited to partnerships involving Member States, with research funders and other public authorities at the core of the consortium, and possibility to include foundations and international partners etc. By default national rules apply to calls launched by the consortium. They require a relatively moderate effort for their set-up and implementation compared to other forms of European Partnerships.

**Institutionalised European Partnerships** are based on the Union participation in and financial contribution to research and innovation programmes undertaken by several Member States (under Article 185 TFEU) or by bodies established under Article 187 TFEU, for partnerships involving typically industry, research organisations but also Member States, foundations and international partners. They are expected to be best suited for long-term collaborations with stable partners and provide only limited flexibility for adaptation during their implementation. Compared to other forms of European Partnerships, they require a relatively high and long-term effort for their preparation and set-up, including the establishment of dedicated entities (funding bodies) for their implementation. By default the rules for participation of Horizon Europe apply for the calls launched under Institutionalised European Partnerships.

[1] Article 8 of COM(2018)435

\* 1. Have you been involved in the on-going research and innovation framework programme Horizon 2020 or the preceeding Framework Programme 7?



Yes



No

2. To what extent do you think that the future European Partnerships under Horizon Europe need to:

	1 (Not needed at all)	2	3	4	5 (Fully needed)	Don't Know
* Be more responsive towards EU policy objectives	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
* Be more responsive towards societal needs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

* Be more responsive towards priorities in national and regional research and innovation strategies, including smart specialisation strategies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
* Make a significant contribution to achieving the UN's Sustainable Development Goals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
* Make significant contribution to the EU efforts to achieve climate-related goals	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
* Focus more on the development and effective deployment of technology	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
* Focus more on bringing about transformative change towards sustainability in their respective area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
* Make a significant contribution to EU global competitiveness in specific sectors/domains	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
* Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

\* (Other) Please specify:

*500 character(s) maximum*

Throughout the questionnaire hydrogen and fuel cells should be Clean Hydrogen, which correctly reflects the increased scope of the partnership to include the development of hydrogen production technologies for gigawatt scale handling, processing and application across multiple sectors.

\* 3. What would you see as main advantages and disadvantages of participation in an Institutionalised European Partnership (as a partner) under Horizon Europe?

*500 character(s) maximum*

Advantage: A partnership can include multiple industrial, academic, public and other stakeholders. Often with a mixed background, partnerships can draw together a variety of specialists to drive the development of hydrogen technologies across multiple sectors to help reach the EU climate and energy goals.

Disadvantage: The technological scope & partnership synergies for hydrogen (and other) partnerships in the past have been too narrow. Limiting the spread of the technological research.

4. For which of the candidate Institutionalised European Partnership(s) would you like to specifically provide your views through this consultation (you may provide your views for more than one)?

- ☐ EU-Africa research partnership on health security to tackle infectious diseases - Global Health
- ☐ Innovative Health Initiative
- ☐ Key Digital Technologies
- ☐ Smart Networks and Services
- ☐ European Metrology
- ☐ Transforming Europe's rail system
- ☐ Integrated Air Traffic Management
- ☐ Clean Aviation

- ☐ Circular bio-based Europe: sustainable innovation for new local value from waste and biomass
- ☒ Clean Hydrogen
- ☐ Safe and Automated Road Transport
- ☐ Innovative SMEs

## Part 2 - Questions on problems, objectives, policy options and impact tailored to each candidate European Partnership

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The following questions allow to assess the necessity of a partnership approach, as well as the need for an Institutionalised Partnership for each candidate partnership.

### Clean Hydrogen

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The European Commission is assessing whether to propose an Institutionalised European Partnership on Clean Hydrogen under Horizon Europe. Its overall objective would be to create a strong, innovative and competitive European Clean Hydrogen sector, fully capable of underpinning the European energy transition by accelerating the market entry of nearly-zero carbon hydrogen-based technologies and delivering a wide range of socio-economic benefits to the European society.

The proposed partnership would build on the experience gained in the existing Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU), but could significantly revise its scope, expand partners and take account of the strengthened scientific, societal, economic and technological impact criteria of Horizon Europe. FCH 2 JU is a public-private partnership between the EU and the Hydrogen and Fuel Cells industry, established under Horizon 2020 (on the basis of Article 187 TFEU) and which functioning is currently planned until 31 December 2024.

The [inception impact assessment](#) outlines an early description of the problems, objectives, options and likely impact of a candidate European Partnership in this field.

1. To what extent do you think this is relevant for research and innovation efforts at EU level to address the following problems in relation to hydrogen and fuel cells?

#### Research and innovation problems:

	1 (Not relevant at all)	2	3	4	5 (Very relevant)	Don't Know
Lack of understanding of or knowledge about hydrogen and fuel cells	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

Innovation gap in the EU in translating the results of hydrogen and fuel cells research into new products	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lack of interest of major market players to engage in hydrogen and fuel cells research	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Structural and resource problems:

	1 (Not relevant at all)	2	3	4	5 (Very relevant)	Don't Know
Limited collaboration and pooling of resources between public actors and private actors	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Limited role of the current industrial policy in framing the market perspectives related to hydrogen and fuel cells innovation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

### Problems in uptake of hydrogen and fuel cells innovations due to:

	1 (Not relevant at all)	2	3	4	5 (Very relevant)	Don't Know
Small current market size	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Market failures due to inadequate industry investment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Lack of refuelling infrastructure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Lack of funding or de-risking financial instruments for large-scale hydrogen/fuel cell projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Overly restrictive regulation in the field of hydrogen and fuel cells	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Overly restrictive regulation in energy markets and in particular for energy carriers that enable sector coupling across different areas (power, gas, fuels for transport networks)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
High financial risk for early movers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Fragmentation among players and lack of critical mass	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Fragmentation among Member States and lack of EU binding targets and bonding networks	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

High costs of clean hydrogen and fuel cells solutions that hinder mass commercialisation until serial production is achieved, factoring-in economies of scale	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
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## 2. In your view, how should the specific challenges described above be addressed through Horizon Europe intervention?

European Partnerships may take any of the following forms:

- a) Co-programmed European Partnerships: based on memoranda of understanding and/or contractual arrangements between the Commission and private and/or public partners;
- b) Co-funded European Partnerships: based on participation in and financial contribution to a programme of R&I activities, using a Programme co-fund action; or
- c) Institutionalised European Partnerships: based on participation in and financial contribution to R&I programmes undertaken by several Member States (under Article 185 TFEU) or by bodies established under Article 187 TFEU (Institutionalised European Partnerships)

- ☐ Traditional calls under Horizon Europe work programmes
- ☐ Co-Funded partnership
- ☐ Co-Programmed partnership
- ☒ Institutionalised Partnership

### \* Please explain briefly your choice:

500 character(s) maximum

Institutionalised Partnerships are well understood and can offer opportunities to leverage EU and private funding.

## 3. In your view, how relevant are the following elements and activities to ensure that the proposed European Partnership would meet its objectives?

### Setting joint long-term agenda with strong involvement of:

	1 (Not relevant)	2	3	4	5 (Very relevant)	Don't Know
Member States and Associated Countries	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Academia	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Foundations and Non-Governmental Organisations	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other societal stakeholders (e.g. end users, regulators, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

### Pooling and leveraging resources (financial, infrastructure, in-kind expertise etc.) through coordination, alignment or integration with:

	1 (Not relevant)	2	3	4	5 (Very relevant)	Don't Know
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Member States and Associated Countries	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Academia	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Foundations and Non-Governmental Organisations	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other societal stakeholders	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Partnership composition:

	1 (Not relevant)	2	3	4	5 (Very relevant)	Don't Know
Flexibility in the composition of partners over time	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ensuring a broad range of partners, including across disciplines and sectors (e.g. academia, research performing organisations, Member States representatives other EU Agencies like EDA, EMSA and other partnerships, etc.)	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Implementing the following activities:

	1 (Not relevant)	2	3	4	5 (Very relevant)	Don't Know
Joint R&I programme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Collaborative R&I projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Deployment and piloting activities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Input to regulatory aspects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Co-creation of solutions with end-users	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

4. In your view, how relevant is to set up a specific legal structure (funding body) for the candidate European Partnership to achieve the following?

	1 (Not relevant at all)	2	3	4	5 (Very relevant)	Don't know
Implement its activities more effectively	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Implement activities faster to respond to sudden market or policy needs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Implements activities more transparently	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Increase financial leverage	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Ensure better links to regulators	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Ensure better links to practitioners on the ground	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Obtain more buy-in and long-term commitment from other partners	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ensure harmonisation of standards and approaches	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Facilitate synergies with other EU and national programmes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Facilitate collaboration with other relevant European Partnerships	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

5. What is your view on the scope and coverage proposed for this candidate institutionalised European Partnership, based on its inception impact assessment?

	Too narrow	Right scope & coverage	Too broad	Don't know
Technologies covered	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Research areas covered	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Geographical coverage	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Types of partners covered	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Range of activities covered	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sectoral coverage	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please provide any comment you may have on the proposed scope and coverage for this candidate Institutionalised Partnership:

*500 character(s) maximum*

Hydrogen is one of the key solutions for the decarbonisation of several sectors including heavy industry. The clean hydrogen partnership should focus of all sectors not only fuel cells. Furthermore, there is a bias towards electrolysis produced hydrogen, the production of hydrogen should be technologically neutral provided is sourced from a low-carbon hydrogen production threshold.

6. In your view, would it be possible to rationalise the candidate European Institutionalised Partnership and its activities, and/or to better link it with other comparable initiatives?

- ☒ Yes  
☐ No

(Yes) Please explain why? Which other comparable initiatives could it be linked with?

*500 character(s) maximum*

Clean hydrogen is a solution for the decarbonisation of multiple sectors. Allowing linked initiatives will ensure that research is accelerated and hydrogen plays a key role in the future of the Circular Economy, Clean Aviation, Europe's Rail, Shipping and industrial processes.

7. In your view, how relevant is it for the candidate European Institutionalised Partnership to deliver on the following impacts?

### Societal impact:

	1 (Not relevant at all)	2	3	4	5 (Very relevant)	Don't know
Improved public health: reduction of pollutants, particulates and noise emissions compared to direct fossil fuel combustion	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Improved working conditions (e.g. for transport professionals, or on construction sites) by eliminating toxic and harmful local emissions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
Novel competitive cross-sectoral solutions for decarbonisation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

### Economic/technological impact:

	1 (Not relevant at all)	2	3	4	5 (Very relevant)	Don't know
Increased industrial leadership in hydrogen technologies and uptake of new technologies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Preparation of re-skilling of human resources towards high value-added markets with increasing weight in the economy (adaptation to phase-out /replacement of old technologies)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Provision of a solution for storing renewable energy for later use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Creation of jobs in the low-carbon economy by strengthening the European hydrogen sector	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
New demand-side solutions to decarbonise the energy and transport systems (also in remote /isolated areas)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Better cross-fertilisation of innovative ideas from SMEs to large companies that can bring them to mass market	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Highly skilled jobs in industry	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>

Low-carbon and competitive solutions for heavy duty and long-distance transport	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Low-carbon and competitive solutions for all modes of transport	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Scientific impact:

	1 (Not relevant at all)	2	3	4	5 (Very relevant)	Don't know
Contribution to the advancement of science by stimulating innovation along the entire hydrogen value chain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
New scientific knowledge and reinforcement of EU scientific capability	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Contact

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# Horizon Europe Strategic Planning Revised Orientations towards the first strategic plan

Fields marked with \* are mandatory.

With a proposed budget of 100 billion Euro from 2021 to 2027, the Horizon Europe framework programme represents the largest collaborative research and innovation investment in the world and is open to participants worldwide. The European Parliament and the Council, the co-legislators, have provisionally agreed on the Horizon Europe legislative package. A co-design process has been launched in order to optimise the targeted impacts for the first four years of implementation. It has been organised first through a web-phase consultation (28 June to 4 October) and then in the European Research and Innovation Days (24-26 September, via dedicated sessions and the village), more than 10000 contributions from stakeholders based in 99 different countries have been received. They have been taken into account and the original "Orientations" document has been modified accordingly.

The revised version of the "[Orientations towards the first Strategic Plan for Horizon Europe](#)", is now open to receive your views, focusing on a limited number of issues that had not been addressed before. Since the EU added value is the cornerstone of this survey, we particularly welcome views from organisations and networks with a cross border dimension and a mission of advocacy of relevance for research and innovation, (the so-called "umbrella organisations").

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## Section A - About you

\* Are you representing an organisation with members from different countries or a transnational network?

- ☒ yes  
☐ no

If you are representing an organisation or a network mentioned in the question, what is its name?

*1000 character(s) maximum*

ETIP ZEP

Where the headquarter of the organisation or the coordinator of the network is located?

Belgium

If you are responding on behalf of an organisation or a network mentioned in the question, how many members are you representing?

1000 character(s) maximum

20

If you are representing an organisation or a network mentioned in the question, in how many countries your members are based?

1000 character(s) maximum

Global multinational corporations

\* You or your organisation are mainly active/interested in the following areas of Horizon Europe (Please select all that apply):

- ☐ Health (cluster 1)
- ☐ Culture, creativity and inclusive society (cluster 2)
- ☐ Civil security for society (cluster 3)
- ☐ Digital, industry and space (cluster 4)
- ☒ Climate, energy and mobility (cluster 5)
- ☐ Food, bioeconomy, natural resources, agriculture and environment (cluster 6)
- ☐ Widening Participation and Strengthening the European Research Area
- ☐ Pillar I Excellent Science
- ☐ Pillar III Innovative Europe
- ☐ Other

\* Publication privacy settings

The Commission will publish the responses to this public consultation. You can choose whether you would like your details to be made public or to remain anonymous.

- ☐ Anonymous  
Only your type of respondent, country of origin and contribution will be published. All other personal details (name, organisation name and size, transparency register number) will not be published.
- ☒ Your personal details (name, organisation name and size, transparency register number, country of origin) will be published with your contribution.

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## Section B - Questions

Which targeted impacts can be best reached (or only reached) through Horizon Europe? On the other hand, what are the targeted impacts, mentioned in the updated orientations, least likely to benefit from Horizon Europe investments?

1500 character(s) maximum

The largest challenge facing the Europe over the next thirty years will be the transition to climate neutrality. This will involve decarbonising all sectors including power generation, domestic heating and transport. This transformation will have to take place on a short timescale and will require a rate of innovation and development unseen in EU history. To ensure that decarbonisation is achieved at the rate required investment will need to be complementary to the challenge. As such the European Green Deal will be the

targeted impact best served by Horizon Europe.

Secondly, the European Union must strive for a just transition and make sure communities and sectors with a large carbon footprint are supported to a low-carbon future. This is particularly relevant for the Energy Intensive Industries, where decarbonisation will be challenging but offer the opportunity for retention and creation of highly skilled jobs in a low-carbon industry. Therefore, the European Green Deal must be supported by investment in the Economy that Works for People to create a socially just climate neutral economy.

To ensure the objectives of Horizon Europe are met, the Missions should be more explicit on where emissions reductions technologies are situated. Currently the Climate-Neutral and Smart Cities and Adapting to Climate Change do not encompass power and industrial decarbonisation which is a vital goal of the European Green Deal.

Which common challenges between different clusters could reinforce their impacts (e.g. environment and health, green IT...)?

*1500 character(s) maximum*

The European Union must strive for a just transition and make sure communities and sectors with a large carbon footprint are supported to a low-carbon future. This is particularly relevant for the Energy Intensive Industries, where decarbonisation will be challenging but offer the retention and creation of highly skilled jobs in a low-carbon industry. Therefore, the European Green Deal must be supported by investment in the Economy that Works for People to create a socially just climate neutral economy.

Furthermore, the creation of highly skilled low-carbon expertise will ensure the European Union is at the forefront of climate services on a global scale. Creating vast opportunities for Europe in a global decarbonisation market. As such decarbonisation and a stronger Europe in the world are complementary.

Beyond research and innovation, which other measures would be needed at the European level to best achieve the targeted impacts (e.g. innovation deals...)?

*1500 character(s) maximum*

In order to maximise the impact of Horizon Europe funding there must be robust support mechanisms which can take technological innovations from testing and pilot studies to demonstration and eventually commercial deployment. A disconnected support stream will prevent vital technologies from progressing at the rate required to achieve the European climate targets.

The decarbonisation of industry, power and heating will be accelerated by the cross-border construction of infrastructure networks, in particular CO<sub>2</sub> pipeline networks to CO<sub>2</sub> storage facilities and hydrogen networks. The Commission have a vital role in continuing to support the development of these networks through the Connecting Europe Facility, under the next MFF and beyond.

What are your impressions on the co-design process and how can we improve it?

*1500 character(s) maximum*

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## Contact

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## Feedback for DG CLIMA from the CCS Innovation Fund Workshop

This document outlines feedback received from the Innovation Fund Workshop, held on the 6<sup>th</sup> September, 2019 in Oslo, Norway.

Selection criteria	
Degree of Innovation	
<p><i>How can the degree of innovation in comparison to the state-of-the art be best evaluated?</i></p> <p><b>Answer:</b></p> <p>The degree of innovation can be measured for many sectors by considered energy improvements, process integration, environmental impact improvements and smart retrofitting.</p> <p>Specifically, for CCS innovation and state-of-the-art must be considered for the individual parts of the chain:</p> <ul style="list-style-type: none"> <li>• Capture processes (for each separate industrial process therein, e.g. hydrogen production, post/pre combustion power, steel, cement, ammonia production etc.</li> <li>• Transport of CO<sub>2</sub></li> <li>• Storage of CO<sub>2</sub></li> <li>• Cross-chain integration</li> </ul> <p>As <b>CCS technologies cover many sectors, there are many ways which technology improvements can be seen as innovative.</b></p> <p>There must be a balance between innovation and technological certainty. Technologies which have been taken to TRL 7 or above should be considered. Horizon Europe will be a vital mechanism to deliver a pipeline of technologies to the Innovation Fund.</p> <p>It would be helpful for CCS projects to understand what the <b>definition of ‘degree of innovation’</b> is. This will give clarity when applying for innovation funding.</p>	
Project Maturity	
<p><i>Which criteria should be used to evaluate project maturity?</i></p> <ul style="list-style-type: none"> <li>• <i>Business plan, capacity of the promoters behind the project</i></li> <li>• <i>Financial structure (private investors, other public support, strength of commitments)</i></li> <li>• <i>Societal acceptance</i></li> <li>• <i>Legal setup and permitting</i></li> <li>• <i>Stage of project development (concluded feasibility studies, FEED, etc.)</i></li> </ul> <p><b>Answer:</b></p> <p>All of the above have importance.</p> <p>The potential for scalability. The projects ability to enable the at scale deployment of CCS and decarbonisation across one (or several) regions should be considered.</p> <p>The project consortium strength. As above, a strong consortium, with international partners can help realise at scale decarbonisation in several regions. Furthermore, a strong consortium will avoid point-to-point project risks and encourage the development of CCUS related markets.</p>	

The regional decarbonisation options. For some regions CCS may be the most cost-effective means of decarbonisation, in other regions there may be alternative solutions. This geographic decarbonisation potential criteria should be considered.

The group discussed the need for a clear, well defined and easy to communicate **MATURITY ROADMAP**, with the plans, timings, milestones, decisions and key legal/policy milestones. With this, it will be much easier to know and communicate where the project is through every step of the process.

Social acceptance is difficult to measure and more of a result of activity. Rather, an objective **STAKEHOLDER ENGAGEMENT PLAN**, highlighting which measures to take in order to increase acceptance from all stakeholders, including the public (this to be a part of the maturity roadmap).

It is important to, at every stage of the project, measure the project against its effect on the climate and carbon footprint. It is easy to get lost in detail as we saw in the handling of the NER300.

*What are the essential elements that need to be in place for a project to be able to reach financial close within 4 years? Should a completed feasibility study be made a condition for applying for the Innovation Fund?*

**Answer:**

Memorandums of understanding (MoUs) should be in place between consortium partners and projects. This will accelerate knowledge sharing and give investor confidence.

Financial closure conditions within 4 years may be too complex for CCS projects with many gateways to achieve deployment

The legal adoption of a regulatory regime at member state level will be needed for some projects to reach financial close within 4 years.

For industrial capture projects, a receipt/contract for T&S/Utilisation will be an essential element before financial close.

Feasibility studies should be close to closure or completed for projects to apply for innovation funding. It should not be a requirement that feasibility studies are complete, as it takes time for innovation funding to be granted, in the interim projects will stall, which is costly and may risk a further delay to the project time line as expertise will have to be reassembled.

*What are the key risks and barriers to implementation, respectively pre-conditions for projects to go ahead?*

**Answer:**

**Policy Risk:** At both member state and European level there is a risk that policy frameworks may not be in place in time, or may be changed with adverse effects. A long-term policy will help to mitigate this risk.

**Political Will:** Changes of Governments and political will over the usual political cycle is a risk for innovative projects. Long term signposts from the Commission can help encourage cross-party climate consensus for Innovation Funding target projects.

**Cross-Chain Risk:** if the CCS value chain is separated into CO<sub>2</sub> capture, transport and storage, this increases the interfaces by which there are risks. Many of these have been outlined in detail by previous work for example the CCUS Advisory Group (CAG) report on Investment Frameworks for Development of CCUS in the UK.

**Timing Risk:** There is a timing risk in construction, as part of cross chain risk. The timing of funding mechanisms, and the part-chain project timelines needs to align. If not, this increases the risk of stranded assets or unabated CO<sub>2</sub> emissions. A regional coordinator will be essential here to liaise with projects, other regions, member state governments and the commission to ensure the pipeline of individual projects align across the CCUS chain.

**Funding Timing Risk:** There needs to be clear timelines (and streamlining) between different European (and member state) funding initiatives. Any breaks in funding or overlaps/repetition can stall projects, increasing costs and delaying actual GHG emissions abatement.

**Global Market Prices & Carbon Leakage:** Global market prices must be high enough and stable enough to enable internationally competitive industries have confidence to invest. If these prices fall then carbon leakage to other countries/regions is a real risk.

**Logistics** (CO<sub>2</sub> Transport in the EU ETS, London Protocol, pipeline route/environmental permitting): Clarity on the CO<sub>2</sub> transport logistics will be required before detailed FEED studies can continue. CO<sub>2</sub> shipping in the EU ETS, the London Protocol and construction/environmental permitting are all barriers to project implementation.

**Social Acceptance Risk:** Poor communication to the general public and to politicians is a risk which could stop projects at any stage of deployment. A good **stakeholder engagement plan** will help to mitigate this risk and should be included in IF applications.

#### Relevant Cost Calculation

*What are the key variable factors determining the financial gap?*

**Answer:**

Many of the answers here are covered elsewhere in more detail.

**CO<sub>2</sub> Price:** (see next question)

**Future Policy Landscape:** (see above question on policy risk)

**Future Energy Costs (gas/hydrogen/electricity):** The feedstock and alternative fuels to industrial and power processes which produce CO<sub>2</sub> are a key variable for projects. These costs will vary depending on the member state policies and global market prices.

**Levels of CCS Deployment** (more deployment, more learning, lower costs): (see below question)

**Levels of risk sharing (cross-chain/storage infrastructure):** (See above question)

*What are the financial risks and how best they can be evaluated?*

*Answer:*

**Deployment and Scale-Up:** Deploying CCS will reduce financial risks, and as the industry scales up these risks will reduce.

**Knowledge Sharing:** Knowledge sharing will help to reduce financial risks as projects learn from one another. This is vital in a new industry and will be vital for many technologies which are funded by the innovation fund

**Right Sizing Risk:** There is a balance when building CCS infrastructure (transport and storage) that assets (pipelines, compressor stations, injection facilities etc) need to be correctly sized. Sufficiently large enough to accommodate future volumes of CO<sub>2</sub> in the infrastructure, and not too large as to be considered a 'stranded asset'. Given the scale of CCS required, the latter risk is lower than designing a pipeline too small for the demand. Good industrial coordination and member state/EU support will reduce the financial risk for this specific CCS risk.

**Future CO<sub>2</sub> Price:** Certainty on future CO<sub>2</sub> prices will encourage investment. Lessons learnt from the CO<sub>2</sub> price fall in the NER300 period have been taken on board. Any future trajectories or carbon price floors (introduced by member states) will be strong signals to investors and if sufficiently large will reduce financial risk.

#### Other

*What weights, if any, should be applied to different selection criteria?*

*Answer:*

**Ability to reach 2050 net-zero target.** Projects with long operational lifetimes should be compatible with the long-term climate targets.

**Ability to enable negative emissions.** Negative emissions will play an important role in most 2050 energy and climate scenarios, projects which can maximise emissions reductions should be considered favourably.

**Ability to reduce barriers for future projects.** Some projects, especially early projects, could outline plans to overcome barriers which may be hindering future projects. These barriers may be national (policy, regulation etc), international (business models, investment, liabilities) or regional.

**Knowledge sharing plans,** as discussed in later questions these plans will be important to accelerate development and deployment of CCUS in Europe.

**PCI status already approved.** PCI projects, or those linked to projects with PCI status (and CEF funding) will already have passed through a Commission approval process. These projects should be deployed quicker than 'fresh' projects. This will require an internal collaboration in the Commission and the EIB.

**Replicability/Global Impact** (for CCS and individual sectors). The replicability and global impact of projects could be considered, however many projects will be unique and difficult to fit into a template. The global impact is also difficult to consider aside from the GHG abatement.

## Milestones

*What is the expected timeline to financial close and entry into operation for innovative projects in your sector?*

*Answer:*

We refer to the individual submissions from projects rather than the discussion at the workshop. Obviously, the CCS sector encompasses many sectors and technologies in many industries. Timelines for T&S construction, power station construction or capture facility retrofit for example will be very different.

For industry, the timelines are closely linked to regular maintenance/upgrade windows. This is project specific, but it is paramount that funding decisions are aligned with these windows.

*What are the key milestones before financial close, e.g. feasibility or FEED study, permitting, State-Aid approval, etc. and before full entry into operation, e.g. how long are the construction, testing and commissioning periods?*

*Answer:*

The commission must define what is meant by financial close. It is assumed here that it means the Final Investment Decision (FID). A series of definitions will help projects to submit comparable applications without confusion.

**Contractor selection/ supply chain review.** A review of the contractor and supply chain will have to be undertaken twice for long lead-in time projects. Once when the Pre-FEED and FEED studies are undertaken and once again immediately before the FID is made. For short projects, this isn't an issue, but for longer projects, contractors may change, and supply chain prices/availability may fluctuate in the months/1-2 years between project stages.

### **Safety testing and commissioning**

**Member State Support/Policy/Regulation adoption. EU support announcement.** A key milestone for many large projects will be statements of support from member state governments and the EU. These statements can be in the form of state/EU financial support, policy changes, regulation changes.

**Permits/licenses granted.** For large construction projects building, environmental and operational licenses/permits will have to be granted. Sometimes these processes can be lengthy and subject to unforeseen interventions and delays. For CO2 storage, the granting of both exploration (if determined necessary by member states) and storage permits will be key milestones for store development.

**Contracts in place with project partners,** agreement from stakeholders and signing of MoUs. Securing contractual support from industrial (and government) partners is a vital early gateway for projects.

Financial milestones must align with development milestones (no delays between funding and development e.g. a gap between pre-feed and Feed).

Selection of projects must be a quick process to mitigate delay risk. Any milestones or project gateways which must pass an external process (for example assessment for

Innovation Fund awarding, and due diligence from lenders), must be done swiftly so projects can retain teams and personnel, if left too long, teams are disbanded and personnel relocated.

**An EU 'waiting fund'** which can be allocated to projects whilst they are assessed for further funding to ensure that projects can continue to progress – in some way – into the next phase. This will prevent the above issues of a timing gap between project milestones and the disruption of timelines.

Referring to earlier mentioned maturity roadmap, there should be a **standard package of milestones with room for flexibility**. There may also be new possible milestones such as PCI status, inclusion in the national plans, %-age of the national emissions, negative emissions/BECCS, etc

*How should the grant be optimally disbursed over the project life cycle? To what milestones can/should disbursements be linked?*

*Answer:*

Grants should be linked to project deliverables & gateways. In particular aligned with cash flow gateways (FEED, Financial Close etc)

The grant should also be disbursed so that overall financial risk does not increase over time (aligned with the cost curve of the project)

*What additional milestones would be useful?*

*Answer:*

Declaration of member state backing

Member state regulation/legislation

Testing and proving of storage site (as per the CCS Directive). This is a CCS specific milestone which is defined as an Exploration activity in the CCS Directive, and will be part of a normal process to be granted a storage permit.

## Project development assistance (PDA)

*Will project development assistance (PDA) be useful for projects in the sector? If yes, what types of assistance?*

*Answer:*

Yes

PDA can give assistance for scaling-up, bringing projects towards FEED and provide support for stakeholder management.

PDA can help bridging the gap between interdependent projects, for example a mature T&S system and an immature capture facility.

PDA is important for high CAPEX projects, and funding should be staged in-line with development milestones.



Not too much PDA should be available, or there will be a risk that projects will fast-track to a stage where companies lack the expertise and financial backing to proceed independently.

In the early phases, companies can offer more support. As the projects develop, more assistance will be required from State/EU mechanisms.

PDA should be as broad as possible not to limit good possibilities since there are significant variations and different needs. It should also cover the full value chain, capture, transport and storage, and give the opportunity to start anywhere in the project process.

*Should projects be required to publish the results of any studies done with PDA, if they decide not to apply for Innovation Fund full support or are discontinued?*

*Answer:*

Yes, but not to compromise commercially sensitive data/IPR.

The PDA contract should include a condition to publish certain reports and KPIs (e.g. energy costs for CO2 capture).

It is crucial that there is a possibility to see the progress of the project and learn from the experiences/lessons learned.

It is important to be able to show the European citizen that money is not misused.

If a project proceeds without support, there will be active commercially sensitive data which gives the continuing project a competitive advantage. This data should be kept private.

*Should FEED be financed by PDA or only after successful application for an Innovation Fund award?*

*Answer:*

Yes.

Conflicting opinions:

- There would be merit in co-funding FEED to ensure high-quality content and industry commitment.
- Allow FEED financing upon awarding of IF, this mitigates risk of stranded projects which pass FEED and fail to continue

Preferably funded by PDA – this would allow more projects to complete FEED than the IF can support

### Knowledge-sharing requirements

*What type of technical, economic, project management, regulatory and permitting information will be useful to share with other projects from the sector in order to speed up the uptake of the innovative technologies and to advance the regulatory environment without at the same time compromising the legitimate intellectual property rights, the competitiveness and the first-mover advantage of the companies involved in the projects?*

*Answer:*

**Knowledge sharing can be separated into two categories. A “Hard” and a “Soft” knowledge**

Hard:

- Data (efficiency data, technical data, design plans)
- Reports
- Academic papers
- Permitting, safety and environmental assessments
- Risk assessment and allocation
- List of CCUS experienced contractors/constructors/consultants

Soft:

- Public outreach learning
- Streamlining/project efficiency learning
- Regulation changes/challenges
- Law hurdles
- Government learning (on all of the above)

The inclusion of research institutes in projects should be a positive criterion, particularly those institutes which are linked with Horizon Europe projects. This partnership building will ensure research takes place on real issues and ensure research has real and tangible benefits for CCS projects.

Learnings should be above the standard business practice for CCUS, it is critical to encourage this.

Knowledge sharing of sensitive data could be condensed to core elements such as standardised metrics for efficiencies.

Knowledge sharing should be managed by one specific organisation, ideally with EU funding. The CCUS Projects networks are a good option for this role.

*What types of knowledge-sharing activities should the implementing body organize for projects benefiting from Innovation Fund (and other EU programmes) and for the general public?*

*Answer:*

**Coordination/collaboration with the SET Plan IWG9 and the CCUS project Networks** can help share the knowledge with member states and other projects.

A **key lesson learned template** provided by the EC could ensure that knowledge sharing is easily understood and easily shared between projects, the Commission and the public.

**CCUS Safaris** are an effective way for projects to share information with other projects earlier in the deployment pathway. They are also very useful for international visits, from projects and policy makers alike.

**Communication should be set up to be understandable for “normal people”**. An interesting reference here was the Japanese comic books for children, explaining difficult things in pictures and easy-to-understand text. It is crucial to get public engagement and to pedagogically convey politicians.



**Websites, webinars and workshops** (for the general public, industry and academia). Have all been highlighted as useful. These events (webinars and workshops) could be run independently, however a centralised body which organises these events and coordinates a CCS outreach agenda with all projects would be valuable.

*What should be the form of knowledge sharing tools that would be useful for the market?*

*Answer:*

The CCUS Network could gather and summarize the info using all tools mentioned, especially key learnings and best practice should be shared.

A **key lesson learned template** provided by the EC could ensure that knowledge sharing is easily understood and easily shared between projects, the Commission and the public.

Some stakeholders mentioned that a **brochure or database of key personnel/companies** with an experience of CCS would be valuable for the market to encourage bilateral interaction between the market and CCS players. Other stakeholders disagreed with this idea.

Many of the answers to the previous question are applicable here. Of course, more technical documents particularly focussing on the business models and economics of projects will be very useful for the market.

## Do No Significant Harm Comments on the TEG report on EU Taxonomy

### Response from the Zero Emission Technology and Innovation Platform (ZEP)

October 2019

The Zero Emission Technology and Innovation Platform (ZEP) is the technical adviser to the EU on the deployment of Carbon Capture and Storage (CCS), and Carbon Capture and Utilisation (CCU), a European Technology and Innovation Platform (ETIP) under the Commission's Strategic Energy Technologies Plan (SET-Plan).

### Production of Electricity from Gas

#	Comment	Stakeholder(s)	Evaluation
6	<p><b>"(5) Pollution:</b>            As shown by the EEA, CCS can lead to important increases in emissions of certain pollutants such as NH<sub>3</sub>, NO<sub>x</sub> and PM.</p> <ul style="list-style-type: none"> <li>- Particulate matter (PM) and nitrogen oxide (NO<sub>x</sub>) emissions are expected to increase in line with the amount of the additional fuel consumed if no additional measures to reduce emissions are installed.</li> <li>- Ammonia (NH<sub>3</sub>) is expected to increase significantly (factor 3) due to the degradation of the amine-based solvents used to capture the CO<sub>2</sub>. Mitigation measures specific to these emissions shall be put in place in CCS facilities which enable the GHG emission threshold to be met.</li> </ul> <p>Compliance with the BAT AELs (BREFs) should be required as soon as the Best Available Techniques Conclusion Documents are adopted (rather than after 4 years).</p>	ECOS	Technical Correction – But need to determine BAT and solicit Graeme Sweeney input.
<b>ZEP Response</b>			
	<p>Historically the trace emissions (e.g. NH<sub>3</sub>, NO<sub>x</sub>, PM) from gas fired power plants and gas based industry have decreased with improving BAT and regulation. The introduction of CCS will likely not change this decreasing trend in the long term perspective assuming BAT and regulation keep improving over time. That said, the NH<sub>3</sub> and other active nitrogen emissions may indeed increase if many large amine based post-combustion are constructed in the same period. Regardless, NH<sub>3</sub> emissions can be controlled by technology (e.g. acid wash), and it is expected that such technology is slowly included in BAT and regulation. It must also be noted that if oxyfuel CO<sub>2</sub> capture technology is chosen the NH<sub>3</sub>, NO<sub>x</sub>, PM emissions will be eliminated.</p>		

## Carbon Capture

#	Comment	Stakeholder(s)
1	<p>For the safety of CCS, experiences from Europe and US are relied upon by TEG. IEA lists two projects in Europe, with 1.7 Mtpa capture rate (ref. 1). To put this to perspective, replacing the annual nuclear production in Germany (ref. 2) with 60 % efficient combined cycle gas turbines (emissions ref. 3) results in additional CO2 emissions of 7.8 Mtpa. This is already 4.6-fold the capture rate of the two projects. At the global scale, IEA sustainable development scenarios rely on gigatons of additional CO2 reductions both for CCS and nuclear (ref. 1). This is a rapid scale-up of CCUS deployment up to 76.6 times the current CO2 capture rate by 2040.</p> <p>The TEG report doesn't clearly demonstrate empirical data on the safety of CCS at the required scale. Is there any? Instead, regulatory compliance is relied upon by TEG for the safety of scaling CCS. This is not equal treatment with nuclear where empirical data is demanded on final disposal, and compliance with regulation is not deemed enough.</p> <p>Either requirements on empirical results need to be increased here, or nuclear has to be accepted based on regulatory compliance as well.</p>	Private Individual
<b>ZEP Response</b>		
	<p>The regulation for the geologic storage of carbon dioxide, the 'CCS Directive' (2009/31/EC) outlines in detail the requirements for safe injection and storage site monitoring. This includes a significant monitoring requirement to provide the empirical data that the CO2 storage reservoir is compliant. Furthermore, these CCS Directive also requires the storage site to be monitored for at least 20 years to ensure safe storage.</p> <p>European (including Norway) storage capacity is estimated to be over 134GtCO<sub>2</sub>, which amounts to over 440 years worth of CO2 storage at 300Mtpa CO<sub>2</sub>, which the Commissions 1.5 TECH scenario predicts must be captured and stored in 2050. The storage capacity is orders of magnitude larger than the largest predicted CO2 supply rates, with adherence to the CCS Directive (2009/31/EC), scale up safety will not be an issue.</p>	

## Transport of CO2

#	Comment	Stakeholder(s)
1	Do-no-significant harm analysis for eco-systems (6) should ensure that Environmental Impact Assessment (EIA) has been completed in accordance with EU Directives on Environmental Impact Assessment (2014/52/EU) and Strategic Environmental Assessment (2001/42/EC) or other equivalent national provisions or international standards (e.g., IFC Performance Standard) -- whichever is stricter in the case of non-EU countries, prior to significant activities. Impact assessment should confirm compliance with all relevant national and international laws and conventions related to the environment. It should also confirm that the	WWF European Policy Office

	project does not harm ecosystems of high ecological importance, notably nationally and internationally protected areas. In particular such impact assessment should, at the very least, identify, evaluate, and mitigate any potential negative impacts of the designated activities, projects, or assets on Key Biodiversity Areas (KBA) as defined by the UN Convention on Biological Diversity and or UNESCO World Heritage Sites, as recommended by the ISO 14030 standard in the making. Direct or indirect impacts on KBA should be identified using the World Database of Key Biodiversity Areas and related guidance provided by the KBA partnership.	
<b>ZEP Response</b>		
	Pipeline construction and reuse of current gas assets will adhere to the same member state and EU environmental regulation as for current natural gas pipelines. Carbon dioxide transport by pipeline is not currently entrusted to a Transmission System Operator (TSO). In the future, it could be expected that a European coordinator for CO2 pipelines will be established and operate in a similar fashion to the European Network of Transmission System Operators for Gas (ENTSOG).	

## Permanent Sequestration of CO2

#	Comment	Stakeholder(s)
1	Do-no-significant harm analysis for eco-systems (6) should ensure that Environmental Impact Assessment (EIA) has been completed in accordance with EU Directives on Environmental Impact Assessment (2014/52/EU) and Strategic Environmental Assessment (2001/42/EC) or other equivalent national provisions or international standards (e.g., IFC Performance Standard) -- whichever is stricter in the case of non-EU countries, prior to significant activities. Impact assessment should confirm compliance with all relevant national and international laws and conventions related to the environment. It should also confirm that the project does not harm ecosystems of high ecological importance, notably nationally and internationally protected areas. In particular such impact assessment should, at the very least, identify, evaluate, and mitigate any potential negative impacts of the designated activities, projects, or assets on Key Biodiversity Areas (KBA) as defined by the UN Convention on Biological Diversity and or UNESCO World Heritage Sites, as recommended by the ISO 14030 standard in the making. Direct or indirect impacts on KBA should be identified using the World Database of Key Biodiversity Areas and related guidance provided by the KBA partnership.	WWF European Policy Office
<b>ZEP Response</b>		
	The development and operation of geologic storage sites must comply to the 'CCS Directive' (2009/31/EC). Within which are stringent guidelines for the environmentally safe development and operation of CO2 storage site, including the compliance with relevant national and international laws and conventions.	

	<p>The main environmental impacts associated with Sequestration of CO2 are due to:</p> <ul style="list-style-type: none"> <li>• the risk of leakage</li> <li>• The long-term PERFORMANCE of the reservoirs, central issues regarding the monitoring and the interrelation of CO 2 with physical, chemical and geological conditions in the reservoir is still IMMATURE TECHNOLOGY, however the safety of CO2 storage may be assured with the implementation of specific rules and requirements.</li> </ul> <p>CO2 storage in saline aquifers is a mature technology which is in operation world-wide at &gt;5 large-scale CCS projects</p>	Equinor
<b>ZEP Response</b>		
	<p>Clarification of the above marked below in red:</p> <p>The main environmental impacts associated with Sequestration of CO2 are due to:</p> <ul style="list-style-type: none"> <li>• the risk of leakage</li> <li>• Although the LONG-TERM PERFORMANCE of the reservoirs (issues regarding the monitoring and the interrelation of CO2 with physical, chemical and geological conditions) is still IMMATURE TECHNOLOGY, the safety of CO2 storage may be assured with the implementation of specific rules and requirements.</li> </ul> <p>CO2 storage in saline aquifers is a mature technology which is in operation world-wide at &gt;5 large-scale saline aquifer CCS projects</p>	

## ZEP AC61

5<sup>th</sup> December 2019

### **Agenda Item 11.b.: Network Technology update**

*NWT co-chairs: Filip Neele (TNO), Arthur Heberle (Mitsubishi Hitachi Power Systems)*

Network Technology held a meeting on the 28<sup>th</sup> November at the ZEP Offices in Brussels. The network has included the agenda and draft minutes from this meeting. The primary topics of discussion included a new TWG on Hydrogen, a presentation from SINTEF on the Hydrogen for Europe Pre-study and TWG Transport.

The network is aiming to organise more frequent coordination meetings for co-chairs to discuss and provide strategic input to the Network. A draft schedule for 2020 has been drawn up and is being consulted on my co-chairs. This is expected to be finalised in the next week.

### **TWG Collaboration across the CCS chain**

*TWG Co-chairs: Ward Goldthorpe (Sustainable Decisions)/Hallvard Høydaalsvik (Gassnova)*

#### WS1 (storage-related risks):

The CO<sub>2</sub> storage safety report has been reviewed and is ready for use. The Secretariat has addressed and formatted the final comments from TWG members and is ready to be published

#### WS2 (risk sharing in a CCS network):

Since June: further interviews with the case study participants of the ALIGN and ELEGANCY projects to add experiences and recommendations to the outcomes of the two workshops held by the TWG in Brussels;

The additional interviews completed on 26<sup>th</sup> November. The material is being collated to include in interim reports for both the ALIGN and ELEGANCY projects due at the end of November;

After this, the information gained over the course of the TWG will be filtered to determine key themes and recommendations suited to ZEP messaging. This will require a handful of volunteers from the TWG plus assistance from the secretariat.

A ZEP report or information factsheet will be written with assistance from Bellona and the secretariat with a target completion date of March 2020.

### ***TWG CCU and Sink Factor Methodology***

*TWG Chair: Rob van der Meer (Heidelberg Cement)*

There is a need for a simple instrument how to assess the mitigation effect of CCS and CCU: After the introduction of the indicative sink factor approx. 2 years, it was agreed to extend the clarification of this definition.

**The paper to be worked out for the purpose of clarification should address the questions:**

- How much CO<sub>2</sub> will be used?
- How much energy is needed?
- What is the real mitigation effect of CCU technologies?
- What CCU applications should be promoted? i.e. What should be prioritized?
- What legal framework and funding are needed?

**Following those questions, 4 factors were identified:**

- Carbon emission factor (+100% to -100%) depending on emission amount
- Net energy use factor – energy needed to convert CO<sub>2</sub> into new product
- Energy carbon factor – CO<sub>2</sub> required from energy used in conversion process
- Time to implement a certain process

It also will include tables about existing carbon capture technologies and utilisation/storage technologies. The paper will be a short high-level paper identifying key issues for CCU technologies and their mitigation effect from the **TWG expected to be ready by Jan 2020** to be used as reactive paper for the EC to progress projects in 2020/2021 which can demonstrate actual emissions reductions w/o detailed LCA study, i.e. indicative sink factor methodology is intended to be used as a simplified.

### ***TWG Transport***

*TWG Chair: (TBC)*

Since the ToR has been approved, the TWG has established its core responsibilities. The group will write a report which presents an overview of the state-of-the-art along with the important technical, safety, cost and operational challenges that must be overcome to facilitate the timely roll out of pipeline networks as part of CCUS industrial clusters. Onshore, high-pressure CO<sub>2</sub> pipelines may require different regulations in some Member States. The report also considers the harmonisation of such regulations to enable cross border projects.

The network now looks to finalise the topics included in the report. Once members of the group have been established, they will meet (ideally face-to-face) to discuss work stream responsibilities.

NWT aim to have the first draft ready for the **AC in March 2020**.

### ***TWG on Hydrogen***

*TWG Co-chairs:*

*(TBC)*

European Zero Emission Technology and Innovation Platform

ZEP Secretariat,  
Carbon Capture and Storage Association  
Offices  
Rue de la Science 14b, 1040 Brussels, Belgium  
[www.zeroemissionsplatform.eu](http://www.zeroemissionsplatform.eu)



Following a request to form a new TWG on Hydrogen, in line with SINTEF and IOGP's Hydrogen for Europe project, the networks next meeting (28<sup>th</sup> November) will focus on the structure and work programme for the new group. The network has reached out to the old TWG on clean hydrogen for wider involvement in the group. The network now asks for approval on a draft ToR (included in pre-reads), and to establish who will take a seat in the group. Once approved the network will aim to set up the group ahead of the next meeting in 2020.

A draft Terms of Reference will be sent out

### ***Other work items***

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#### **NWT CO2 Storage Costs North Sea**

Following recent events in the ERG regarding CO2 transport and storage costs in the North Sea, it has been requested that the network commence work on a literature study which will review transport and storage costs over the past 10 years\*<sup>1</sup>. The aim of the review will be to communicate with ZEP's audience on what we believe are the true costs of transport and storage in the North Sea, to formalise ZEP's position.

#### **Request for work on Climate Positive Solutions (direct air capture)**

There has been a request for the network to produce some work on climate positive solutions, including direct air capture. Ideally, the network will do a review of various options of TRL's of each solution as part of an ongoing conversation with the commission next year. There may also be an opportunity to highlight negative emissions solutions side-by-side.

The network will establish some core experts who can work on the topic of climate positive solutions. The group will put together a brief list of topics and discuss at the next ACEC in January 2020.



# ZEP Network Technology

## DRAFT Meeting Agenda: 28<sup>th</sup> November 2019

ZEP Bruxelles Office  
 Rue de la Science 14b, 1000 Bruxelles, Belgium

11:00 – 16:00 CEST

Item	Lead Presenter	Time
1 <b>Introduction, tour de table, safety notices</b> Updates from ACEC	Co-Chairs	20mins 11:00 - 11:20
2 <b>Policy update</b> <ul style="list-style-type: none"> <li>ZEP and the European Green Deal</li> <li>Update on the SET-Plan IWG9</li> </ul>	Per-Olof Granström	20mins 11:20 – 11:40
3 <b>Hydrogen for Europe</b> <ul style="list-style-type: none"> <li>Presentation from SINTEF - setting the scene for the new TWG on Hydrogen (<i>Pre-read</i>)</li> </ul>	Stefania Gardarsdottir SINTEF	20mins 11:40 – 12:00
4 <b>TWG Hydrogen</b> <ul style="list-style-type: none"> <li>TWG role in Hydrogen for Europe study</li> <li>Potential co-chairs</li> <li>Forward work plan (to be established)</li> <li>Finalisation of ToR Draft</li> </ul>	Co-chairs	40mins 12:00 - 12:40
<i>Lunch</i>		30mins 12:40-13:10
4 <b>TWG Hydrogen Cont.</b>	<i>as above</i>	30 mins 13:10 – 13:40
5 <b>NWT CO2 Storage Costs North Sea</b> <ul style="list-style-type: none"> <li>Request for work on literature review on storage costs</li> <li>Next steps</li> </ul>	Filip Neele	30 mins 13:40 – 14:10
6 <b>TWG Transport</b> <ul style="list-style-type: none"> <li>Report on Transport table of contents</li> <li>Discussion of key topics and possible additions to workstream document sent out at later stage. (<i>Pre-read</i>)</li> </ul>	Haroun Mahgerefteh	30 mins 14:10 – 14:40
7 <b>TWG CCU &amp; Sink Factor Methodology</b> <ul style="list-style-type: none"> <li>Formal updates</li> </ul>	Rob van der Meer	20 mins 14:40- 15:00
8 <b>WS1 and WS2 TWG Collaboration across the CCS chain</b> <ul style="list-style-type: none"> <li>Formal updates</li> </ul>	Ward Goldthorpe (not present)/ Filip Neele	20 mins 15:00-15:20
9 <b>Next steps:</b> <ul style="list-style-type: none"> <li>Chairs' summary</li> <li>NWT 2020 meeting schedule (<i>Pre-read</i>) and forward work</li> </ul>	Co-Chairs	20mins 15:20-15:40

European Zero Emission Technology and Innovation Platform

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 Carbon Capture and Storage Association  
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[www.zeroemissionsplatform.eu](http://www.zeroemissionsplatform.eu)

- AOB



## ZEP Network Technology

### Minutes: Network Technology meeting 28<sup>th</sup> November 2019

#### Attendance

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Arthur	Heberle	Mitsubishi Hitachi Power Systems
Charlie	Garner	ZEP Secretariat
Filip	Neele	TNO (NWT Co-Chair)
Giorgia	Bozzini	ZEP Secretariat
Jorild	Svalestuen	Gassnova
Owain	Tucker	Shell
Per-Olof	Granstrom	ZEP Secretariat
Peter	Zweigel	Equinor
Stefania	Gardardottir	SINTEF

#### Via Teams

Graeme Sweeney (Ardnacragg Energy Services)  
Lauriane Larquey (Shell)  
Haroun Mahgerefteh (UCL)

#### Item 1: Introduction, tour de table, safety notices

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Filip Neele (FN) and Arthur Heberle (AH) introduced the meeting agenda. The agenda was approved.

#### Item 2: Policy update (European issues and SET-Plan IWG9)

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**POG** updated the Network on ZEP's recent policy activities, including the new European Green New Deal (EGD). The new commission from the 1<sup>st</sup> December is heavily determined to fight climate change. CCS will play a large part in the EGD and in the EC scenarios on pathways to 2050. Communication will appear on 11<sup>th</sup> Dec with the EU long-term strategy on 12-13 December. The Multiannual Financial Framework (MFF) 2021-2027 will be very difficult – they are adopting 20-25% for use in tackling climate change. Increased targets for 2030 (-55%) – CBA in 2021. First climate package in March 2020.

**OT** raised discussion on Carbon border tax – how do we handle it and how extensive will it be. **POG** noted there have not been any clear discussions around it. There will be updates to the ETS Directive and the effort sharing regulation. There are no mechanisms for *BECCS* but it has huge potential (negative emissions).

**AH** noted that Chinese companies may contribute significantly to climate change mitigation targets – and queried how much will it affect it? Additionally, **AH** highlighted that many financial institutions have started to withdraw from FFs, which will put a lot of pressure on those industries. For e.g. **POG** noted the 32 PCI's that are linked to gas projects.

The European Parliament has set up own-initiative report – ITRE “A new long-term strategy for Europe's industrial future” S&D. ENVI adopted CCS amendments to COP25 resolution – EP vote on 28<sup>th</sup> Nov.

**SET-Plan:** **POG** noted the next steps for the SET-Plan implementation plan. The next SET-Plan Plenary will take place in April 2020. The new SET-Plan web page has been set up [www.ccussetplan.eu](http://www.ccussetplan.eu).

- **SG** asked whether the Northern Lights projects would be eligible for the targets under the CCUS SET-Plan targets. **POG** explained they would.
- **OT** Will the SET-Plan support Regional Information Gathering funding. **POG** yes - the SET Plan will work on the clusters and to focus on the clusters to gather the respective stakeholders. It will not provide direct funding for salaries, Opex etc

### **Item 3: Hydrogen for Europe Presentation (SINTEF)**

**SG** gave a presentation on the Hydrogen for Europe pre-study on behalf of SINTEF. They are funded by Deloitte and IOGP who have been working closely. The study will quantify the economic benefits of the hydrogen transition across member states. In the study 93-96% capture rates are assumed using ATR's (not SMR's). **OT** noted that we should be careful to assume these capture rates. The pre-study also doesn't account for switching to renewable energy (greening the grid). Potential role for ZEP NWT in the Advisory Group under the Hydrogen for Europe project governance.

#### **The key messages are:**

1. What will be hydrogen's strategic role?
  2. What is needed for it to be an effective tool? E.g. in clusters
  3. What is required from policy makers to make this happen?
- **AH** noted the limitation in biogas, highlighting how quickly we need establish renewable energy in the grid alongside energy efficiency. In addition, do we have enough resources, acceptance, equipment, time etc? – proving this might be one of the strongest group of arguments for hydrogens use.
  - **OT** Highly intermittent renewables suffer from high intermittency. Until we have multi-capacity battery storage. **POG** noted we need more extensive support on the narrative around hydrogen. **OT** DOE are funding how to solve the problem of intermittency – society are waking up to this as an issue. **AH** Green hydrogen is energy intensive and requires more extensive infrastructure.
  - **FN** Are you dispensing dedicated renewables in hydrogen, would that slow down decarbonisation efforts? How does greening the grid affect targets? **OT** noted we must highlight the multiple pathways to the solution, with some dilemmas along the way. For example, Orkney hydrogen example. We need to get hydrogen flowing for transformative solutions such as heating. A continuous, confident supply. **POG** also added that Europe should become world leaders in electrolyzers.

For the final study methodology there are 2 power modelling tools to be used.

1. A disaggregated model of Europe on technology resources and sectors to optimise progress to emission targets
2. An e-transport model development by SINTEF – aggregated energy planning model.

These two together with feed into each other what we would like to see but also what is realistic. This will be important in highlighting where we should start.

- **OT** noted the potential of blending hydrogen in gas pipelines – important to reduce costs and that different countries have different blending allowances. **AH** There should be government investment opportunities to research and establish the effectiveness and opportunities around gas blending. A company cannot do it on its own. **FN** noted that many people are opposed to

CCS in the transition are open to a 'slow transition'. **OT** CCS decarbonising at source, hydrogen is decarbonising at customer level. **FN** there was discussion around feeling the transition and we are close to people rejecting the transition. How do you make it painless to the person on the street?

#### ***Item 4: Discussion on the new TWG Hydrogen group***

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Following the hydrogen for Europe presentation, the network discussed the role of the new TWG hydrogen. **POG** gave a short presentation. The group will provide an expert opinion on technologies and policies required to ensure low-carbon hydrogen is accurately represented and considered as a viable technology in the decarbonised future of European Union's energy sector.

##### Potential output includes

- For the Hydrogen for Europe study: on WP1 & 2 and close working relationship with ZEP NWPE for WP3
- ZEP recommendations on
  - On the Hydrogen for Europe Study
  - to DG ENER ahead of and during the Decarbonisation package
  - to DG ENER on the inclusion of low-carbon hydrogen in the forthcoming TEN-E revisions and CEF 2021-2027
- A **report on hydrogen production** (with CCS) capture rates/energy costs – and expected improvements? production with CCS capture rates/ energy costs and expected improvements. What would an idealised cluster look like with clean hydrogen production facilities. *Equinor* particularly interested in being on the advisory board for the TWGH in relation to the H4E project.
- What would an **idealised cluster design** with clean hydrogen production facilities look like?
- **Communication** – follow up with 2017 report Claude Heller (Air Liquide), update on costs of electrolyzers. TO think of arguments why green electricity will not be available until 2030/40/50 – it is not enough. There are not enough companies doing this, and along with intermittent energy supply, and biomass as limited resource, green hydrogen becomes difficult in the near term.

##### Other notes

- **Set priorities on the use of Hydrogen – e.g.** use hydrogen as a kerosene alternative. Blue areas for hydrogen - this an opportunity to restore and support industry through fresh initiatives and bring change to localised economies. The geographical context of hydrogen should be set in the international sphere to recognise international trade opportunities.

##### What next?

- A **draft ToR is being produced ahead of AC61** (pre-read)
- ToR Presented at AC61
- The group will run in line with the Hydrogen for Europe project with co-chairs committing to 12-month intervals.
- At the AC61 we hope look clarify the limits of what the TWG can argue for – ZEP is primarily looking at CCS and not natural gas, so we need to be careful about how we position ourselves. Are there any other reports that we can refocus from the gas community?

#### ***Item 5: NWT CO2 Storage Costs North Sea***

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Requests for work on literature review on NS storage costs. ZEP have communicated the costs of storage via a tweet. We now look to produce a longer communication brief that clarifies storage costs to be largely the same as what they were since the initial ZEP (2011) cost of storage.

Potential to include early projects that are expected to have higher cost reference. We must clarify why there are high figures for storage and offshore transport. **FN** will produce and include recent, independent estimates and early project costs. **The conclusion is that technical cost estimates for mature projects have not changed since 2011.**

Notes include in the review:

- If you oversize infrastructure the initial CAPEX will be high – perhaps high figures have stemmed from these assumptions. E.g. in the US compression infrastructure to support smaller pipelines is expensive and there are considerable OPEX costs.
- New base and entry – fraught with uncertainty at these sites. The second time you inject, the geology is somewhat de-risked so costs are almost certainly less. We need to influence the backbone infrastructure/ founding projects. Expansion of 'founding' projects will be cheaper.

### **Item 6: TWG Transport**

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- **HN** gave a presentation on the new TWG transport, noting the need to increase capture 200-400-fold by 2050 to meet the EC net zero targets. The most practical and economic mode of transportation involves high-pressure pipeline networks; 29billion euros required to reach the 8800km of high-pressure pipeline by 2030.
- **PZ** agrees there is a need for strong commitment to build up the network but notes that the step-change increases in infrastructure required is more accurate in terms of linear increases. **OT** noted that the IEAGHG build out rate for CCS is comparable to the gas build out rate.
- **HN** Pipeline transportation of CO<sub>2</sub> is a well-established technology. However, most of this experience is: primarily restricted to low population density areas and mostly confined to single source to single sink scenarios, except for in the US. It was also mentioned that blended CO<sub>2</sub> transport may be fine in transport but perhaps not in storage.

The TWG will produce a brief report that highlights the main topics around CO<sub>2</sub> transport. As an overarching point, the report should highlight that transport is feasible despite some barriers. We have 10/15 topics we want to say something about 1 page each. One topic could be standardisation. Reach out to other organisations to contribute to each page, 5 or 6 subheadings with stakeholders.

1. Technical and Operational
2. Best practice guidelines for the injection of co2 into highly depleted gas fields
3. Pipeline safety
4. Business models
5. CO<sub>2</sub> marine transport
6. Use of existing natural gas pipelines for co2 transportation
7. Legal and regulatory
8. Case studies: examples of designs of operational systems and of systems designs
9. Onshore transport

**OT** also noted that there may need to be a section which focuses on shipping possibilities (without giving the out the message that it needs to be addressed before the other topics). We will also need to identify if there are any outstanding issues because this is critical if we are going to meet the EC emission targets.

## **Item 7: TWG Updates**

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### **TWG CCU & Sink Factor**

There is a need to clarify the wording around sink factor in addition to other important questions including for example CCU against CCS.

TWG CCU will use a semi-active paper from the commission. The idea is to have an identified method to indicate the mitigation effects. We also have the LCR methodology, but this is not very specific. For instance, there are no rules to account for waste heat or energy displacement – there are many things that are not inside so it's quite difficult to get a level playing field. Comparing this with communicative sink factor will be very difficult.

The report will address

1. Sink factors
2. The energy use factor
3. Estimated time to market

The result is a sink factor that accounts for the energy use factor.

Discussion is ongoing and the report is expected to be ready in **January 2020**.

**OT** mentioned that energy is not equal, particularly in calorific content. Has this been accounted for?

**POG** We drew the line at saying that energy is equal to the report to deal with these unintended consequences – a quick and dirty is necessary

### **Collaboration across the CCS chain**

**WS2** Anyone present who is interested in working with ward on the ZEP report on organisation of the CCS chain. This is expected in March 2020

### **Update from Graeme Sweeney via Microsoft Teams**

The sustainable taxonomy will probably not make it through dialogue under the current commission circumstances. **GS** noted that life cycle analysis is going to become a critical issue. The commission may consider a revisit of REDII – should ISO14067 or the GHG protocol be used to measure lifecycle emissions

Climate positive solutions have become much more of a discussion, with *direct air capture*. It would be helpful if the network would do some work on direct air capture albeit not in-depth technical work. It may be useful to do a review of various options of TRL's of each of them as part of an ongoing conversation with the commission next year. **OT** recommended that this should be put into perspective in the context of other climate positive solutions for example ADM, bioethanol, bio-combustions (BECCS), waste incineration (more challenging from amine perspective) and direct air capture. **GS** lifecycle footprint of biomass will be a critical determinant of the real impacts of stock in the atmosphere. The challenge will always be the timescale for biomass regeneration. In the sus tax, it was very difficult to identify biomass feedstock by 2050. In determining this we should not use REDII for the LCA because they are distributed and not consequential.

#### **What next?**

- Establish some experts to produce work on the topic of climate positive solutions. Discussion on costs needs to be included to have context
- Put together a brief list of topics and discuss at the ACEC in Jan 2020
- Maybe include negative emissions solutions side by side



## ***Actions***

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<b>Action</b>		<b>Owner</b>	<b>Timeframe</b>
4	Establish members of the new TWG Hydrogen and co-chairs	Co-chairs	Present ToR at AC61. Formation of group to follow
4	Present draft ToR for TWG Hydrogen at the AC61	FN + AH	December
6	Produce TWG Transport brief report that highlights the main 'topics' around CO <sub>2</sub> transport	NWT	January
6	NWT to send comments via email to establish additional topics/ alterations to the TWG Transport report table of contents	NWT	December
6	NWT to contact Haroun to suggest/ recommend people to attend to topics under the table of contents	NWT	December
6	Set up a meeting with all contributors to coordinate efforts	TWG Transport	Once the ToC is finalised
7	TWG CCU to produce a short paper on ZEP's position regarding LCA	TWG CCU	December
7	TWG to work on direct air capture to review various climate positive solutions. To discuss at next ACEC	NWT	ACEC January



## ZEP Temporary Network Group: CCUS Pipeline Networks

### Background

Carbon Capture, Utilisation and Storage (CCUS) clusters involve the capture of CO<sub>2</sub> from a variety of energy intensive industrial emission sources, followed by its storage or utilisation using a shared CO<sub>2</sub> transportation infrastructure. Overall, it is estimated that CCUS could provide up to 37% of the total CO<sub>2</sub> abatement potential by 2050 (1).

Despite its importance, as of 2019, there are only a few CCUS facilities operating in Europe (2); examples are Sleipner & Snohvit (Norway; Natural Gas Processing), Port Jerome (France: Hydrogen production) and OCAP (CO<sub>2</sub> from industrial sources delivered to greenhouses).

*To meet the European Commission's climate neutral scenarios, CO<sub>2</sub> capture and storage or utilisation capacity needs to increase by between 200 to 400 fold by 2050 (3).*

Currently the majority of operational CCUS clusters are located in the US (4); the largest being the Cortez (24 Mton/yr CO<sub>2</sub> capacity) and the Central Basin (27 Mton/yr CO<sub>2</sub> capacity) CO<sub>2</sub> hubs. These have been developed on an ad-hoc basis, with each hub having its own standards for CO<sub>2</sub> purity, acceptable types of impurities and operating pressure and temperature (5).

In order to accelerate the development of a CO<sub>2</sub> infrastructure in Europe, the EU has recently widened the scope of Projects of Common Interest to include CO<sub>2</sub> transport pipelines, opening the CEF funding (6) scheme to CCUS. Five cross border CO<sub>2</sub> transport networks are currently under consideration for the second Projects of Common Interest (PCI) by the Commission in October 2019 (7).

With a total capacity for handling up to 10 Mton/yr CO<sub>2</sub> by 2030, CO2TransPorts PCI is the largest, intending to develop the infrastructure to facilitate the large-scale capture, transport, utilisation and storage of CO<sub>2</sub> from three of the most important ports for CO<sub>2</sub> capture sites including Ports of Rotterdam, Antwerp and Terneuzen.

In several industrial regions in Europe, the deployment of CO<sub>2</sub> capture is being considered, with plans for CO<sub>2</sub> transport and storage networks being at various levels of development. Table 1 lists these along with their total estimated CO<sub>2</sub> capture potential per annum.

Table 1: Industrial CCUS clusters in Europe

Industrial cluster/region	CO <sub>2</sub> emitted (Mtpa) (8)
Antwerp(BE) (8)	18
Skagerrak/Kattegat (North Sea) (8)	14
North Sea Port (BE) (7)	
Marseille (FR) (8)	35.5
Le Havre (FR) (8)	14.5
Firth of Forth (UK) (8)	7.6
Yorkshire (UK) (8)	60



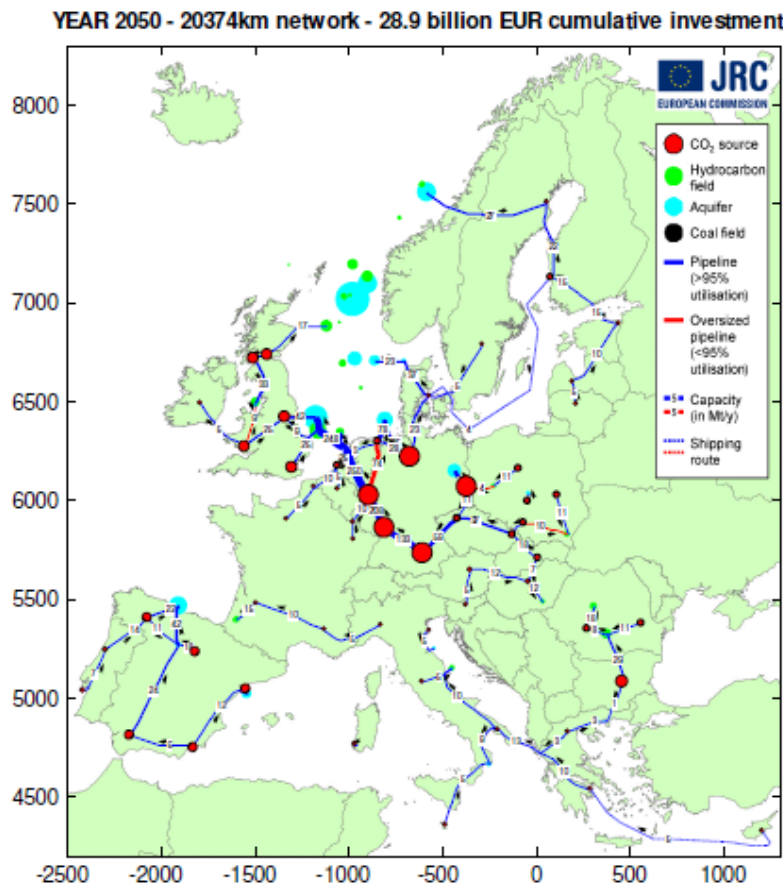
Teesside (UK) (8), (9)	3.1
Grangemouth (UK) (9)	4.3
Rotterdam (NL) (8), (9)	17.5
<b>Humberside (UK) (8)</b>	12.4
North Rhine-Westphalia (GER) (10)	30
Oltenia Region (ROM) (11)	30
Ervia Cork (IE) (12)	4.9

## The Challenge

The large-scale deployment of CCUS clusters in Europe will require the development of appropriate infrastructure capable of transporting hundreds of millions of tonnes of captured CO<sub>2</sub>. In the majority of cases, the most practical and economic mode of transportation involves the use of shared high-pressure pipeline networks, although on occasions, the use of ship transportation, such as that for the Northern Lights CCS project in Norway may also be considered (<https://ccsnorway.com/the-project/transport-storage-equinor-shell-and-total>)

According to CO<sub>2</sub> Network Joint Research Centre report (14), the size of CO<sub>2</sub> pipeline networks in Europe is expected to grow steadily from the current 770 km to 8800 km until 2030, requiring around 9 billion euros of cumulative investment, followed by a step-change increase towards 2050 to over 20,000 km, requiring a total investment of around 29 billion euros. Figure 1 is a schematic of the European CO<sub>2</sub> routing projected for 2050.

***Figure 1: Scenarios identified by the EU's Joint Research Centre for the development of a trans-European CO<sub>2</sub> transport network (9)***



The physical properties of CO<sub>2</sub> differ from those of natural gas, creating some important design and operational challenges. For example, the most practical cost-effective option for transporting CO<sub>2</sub> is in the dense phase or liquid phase, i.e. above 75 bar given the lower pressure drop along the pipeline as compared to the gas phase and the larger 'line pack'. However, this requires pipelines to operate at higher pressures than most existing natural gas pipelines, whilst handling low levels of stream impurities. Water concentrations have to be low to avoid corrosion. Concentrations of non-condensable gases such as N<sub>2</sub> should be low to avoid two-phase flow resulting in compressor/pump malfunction, and also requiring pipeline materials with high fracture toughness. Given that CO<sub>2</sub> is an asphyxiant at concentrations greater than 10% v/v, there are also safety concerns in the unlikely event of an accidental release.

It should be noted that pipeline transportation of CO<sub>2</sub> is a well-established technology. However, most of this experience is confined to sparsely populated areas in the US where 7240 km of CO<sub>2</sub> pipelines have been in operation for almost four decades. These pipelines mostly transport CO<sub>2</sub> from natural sources for enhanced oil recovery.

*CCUS clusters pipeline-networks are significantly more complex presenting a new set of challenges. Such networks take CO<sub>2</sub> from a myriad of sources, which are characterised by varying flow rates, process conditions and compositions. These flows are blended and delivered to one or more, potentially quite different sinks. CO<sub>2</sub> impurities that may be tolerated in the pipeline, may not necessarily be acceptable during storage even if present in relatively small proportions given their long-term cumulative effects (5).*

Several dedicated design standards exist or are under development for CO<sub>2</sub> pipelines:

- Unites States: CFR part 195
- Canada: CSA Z662
- Europe: DNV-RP-J202
- ISO 27913:2016

These standards need to be reviewed in the context of the operation of pipeline networks.

### **Aims and Objectives**

Clearly without viable plans for CO<sub>2</sub> pipeline transportation networks, CCUS industrial clusters will not materialise in Europe.

*Investors are unwilling to invest in a capture plant where there is uncertainty regarding the availability of transport and storage infrastructure; and, conversely, infrastructure investors are unwilling to invest without the certainty that capture plants will emerge.*

This report presents an overview of the state-of-the-art along with the important technical, safety, cost and operational challenges that must be overcome to facilitate the timely roll out of pipeline networks as part of CCUS industrial clusters. Onshore, high-pressure CO<sub>2</sub> pipelines may require different regulations in some Member States. The report also considers the harmonisation of such regulations to enable cross border projects.

While the main focus of the report will be on CO<sub>2</sub> transport by pipeline, ship transportation will also be considered. Working closely with the transport subgroup of EERA CCS, to ensure its credibility and relevance, the report includes contributions from key industry stakeholders, academia, ISO groups, regulatory and policy bodies.

### **Topics**

1. Technical & operational
  - a. Transient flow modelling in multisource CO<sub>2</sub> pipeline networks
  - b. Optimal pipeline network design
  - c. CO<sub>2</sub> purity and quality techno-economic assessment,
  - d. Flow metering & Online CO<sub>2</sub> quality monitoring
  - e. Thermophysical properties for design, approval, and accounting
  - f. Required resilience and flexibility in networks to deal with
    - i. CO<sub>2</sub> supply intermittency and system upsets whilst ensuring safe and economic operation of the pipeline network and the storage site
    - ii. additional CO<sub>2</sub> emitters joining the cluster
2. Best practice guidelines for the injection of CO<sub>2</sub> into highly depleted gas fields
3. Pipeline safety (Haroun to lead; others to contribute)



- a. validated pipeline rupture discharge models capable of handling multiphase multicomponent flows (vapour, liquid, hydrates, dry ice) for both onshore and offshore pipelines
  - b. emergency isolation , blowdown & operational risks due to solid formation
  - c. pipeline corrosion
  - d. fracture propagation
4. Business models
  5. CO<sub>2</sub> Marine transportation (*Norwegian partner, Roland has contacts*)
  6. The viability of the use of existing stock of natural gas pipelines for CO<sub>2</sub> transportation
  7. Legal, regulatory
    - a. London Protocol
    - b. differences in regulations between Member States during cross border CO<sub>2</sub> pipeline transport
  8. Case studies: examples of designs of operational systems and of system designs
    - a. Snohvit: one-on-one pipeline, high-pressure aquifer
    - b. Northern Lights: ships and pipeline
    - c. NorthSeaPorts / Porthos
    - d. ACORN
    - e. ERVIA: long offshore pipeline to depleted field at very low pressure (*ERVIA*)
    - f. Germany: ECRIA
  9. Onshore transport, truck and rail (*Can we include a brief section on this?*)

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ZEP memorandum **“The cost of subsurface storage of CO<sub>2</sub>”**

December 2019

Message: the technical cost of offshore transport and storage of CO<sub>2</sub> is in the range of € 10-20 /tonne (and this has not changed since about 2010)

***CO<sub>2</sub> capture and storage: an essential greenhouse gas emission reduction technology***

CO<sub>2</sub> capture and storage (CCS) is an essential element of the portfolio of technologies and measures that will be needed to meet the Paris agreement’s greenhouse gas emission reduction targets [REF IPCC, AR5 report]. The new EU Commission has the ambition of an net zero emission Europe by 2050, the ‘Green Deal’ [REF].

[REF to recent report that compares emission reduction technologies and that shows that CCS is one of the lower-cost measures]

***Projects of Common Interest***

Following the opening of the Projects of Common Interest programme to CO<sub>2</sub> transport networks, five CO<sub>2</sub> PCIs are currently active in northwest Europe [REF PCI list]. These are currently designing the first elements of a large-scale CO<sub>2</sub> transport and storage infrastructure that will open up the vast storage capacity of the North Sea and Irish Sea to the countries bordering this offshore area, as well as the countries in their hinterland. The PCIs are developing infrastructure that will be able to transport and store several million tonnes of CO<sub>2</sub> on a yearly basis, delivering a significant contribution to industrial emission reduction.

***Cost of storage***

In 2011, the Zero Emission Platform (ZEP) published an analysis of the technical cost of CCS transport and storage [ZEP,2011]. The cost of storage was estimated to lie in the range of € 2-20 /tonne. Onshore storage sites have a cost that is typically at the lower end of this range, while generally more expensive offshore storage is at the higher end of the range. Using large-capacity storage sites will generally result in lower cost of storage. The ZEP cost estimates apply to a mature, post-demonstration CO<sub>2</sub> storage industry. During the early phases of developing CO<sub>2</sub> storage industry, storage cost is expected to be higher.

Since 2011, the focus of large-scale transport and storage has shifted to offshore storage sites. The ZEP 2011 cost estimates for offshore storage were in the range of € 4 – 20 /tonne. Offshore transport by pipeline was estimated at € 3.4 – 9.3 /tonne, depending on flow rate, for a distance of 180 km. These cost estimates exclude the cost of compression.

Updated cost estimates of transport and storage have been published recently. In the UK, a detailed analysis of five offshore sites resulted in reliable cost estimates [Costain PBD, 2016]. The estimated (technical) unit costs for offshore transport and storage lie in the range of £ 11 – 18 /tonne (approximately € 13 – 20 /tonne). Generally, higher costs were derived for saline aquifers, which require new wells and platforms. Site-specific cost estimates were derived for five offshore UK sites, including two depleted fields and three saline aquifers.



In The Netherlands, a roadmap for the development of CCS from 2010 [EBN-Gasunie, 2010] was updated in 2017 [EBN-Gasunie, 2017], resulting in a high-level estimate of the cost of transport to and storage in offshore depleted fields in the Dutch sector of the North Sea. Estimated unit technical cost of storage are in the range of € 2-10 /tonne, which were in line with the cost estimates published in 2010 [EBN-Gasunie, 2010]. The cost of transport by pipeline are in the range of € 1-2 /tonne, while compression adds about € 9 /tonne. All these cost estimates assume post-demonstration, full-scale deployment of CO<sub>2</sub> capture, transport and storage.

In Norway, the feasibility study for the full-chain CCS project [Gassnova, 2016] estimated a *total* chain cost for capture at three different industrial sources, transport via ship and pipeline to a single offshore storage site to be about 140 €/tonne CO<sub>2</sub>. This cost figure is for first-of-a-kind capture of relatively small amounts of CO<sub>2</sub> at each industrial site, and includes a pipeline with surplus transport capacity. From this figure it should therefore be expected that the per-tonne cost in a post-development CCS chain would be well below 100 €. The cost for the transport and storage part of the chain, normally believed to be less than half the total cost, should therefore be well below 50 €/tonne. ... Could write something about the estimated cost for the exploration well that will, if successful, be converted to an injection well. This is anticipated to cost less than 535 million NOK (about 60 million Euro at current exchange rates).

... (to be added, if possible)

### **Conclusion**

As large-scale CCS transport and storage infrastructure is being designed, with first injection planned in the mid 2020's, CCS remains one of the more cost-effective greenhouse gas emission reduction technologies, offering the possibility of deep emission cuts, not only for energy-intensive industries, but also for other sources of CO<sub>2</sub> emissions [REF to a recent report]. The technical cost of storing CO<sub>2</sub> in offshore storage reservoirs in the post-demonstration phase is expected to lie in the range € 2 – 20 /tonne; adding transport and compression cost will bring this in the range € 12 – 30 /tonne.

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