16. marts 2021 

**Ansøgningsskema**

*Indkaldelse af ansøgninger - Projekter til dansk deltagelse i et vigtigt projekt af fælleseuropæisk interesse (IPCEI) for brint. I det følgende gennemgås de fremsatte kriterier samt hvordan de skal udfyldes i dette ansøgningsskema.*

**Baggrund**

Ansøgningsskemaet kan udfyldes på dansk eller engelsk bortset fra resumé/summary, der skal udfyldes på begge sprog.

Ansøgningsskemaet består af følgende afsnit, hvor afsnit 3-7 reflekterer de fem udvælgelseskriterier i henhold til indkaldelsen af ansøgninger.

* Afsnit 1. Generelle oplysninger
* Afsnit 2. Resumé/summary
* Afsnit 3. Udvælgelseskriterie 1: Projektets bidrag til opfyldelse af IPCEI-kriterier
* Afsnit 4. Udvælgelseskriterie 2: Projektets fokus og effekt
* Afsnit 5. Udvælgelseskriterie 3: Projektets budget og finansiering (se budgetskema)
* Afsnit 6. Udvælgelseskriterie 4: Projektets organisering
* Afsnit 7. Udvælgelseskriterie 5: Projektets struktur, realisering og gennemførlighed
* Afsnit 8. Samtykke til deling og behandling af informationer

Alle afsnit skal udfyldes substantielt således, at beskrivelsen kan læses i sammenhæng. Udfyldelsen af ansøgningsskemaet skal holdes så **kort og præcis** som muligt, men skal samtidig være tilstrækkelig informativ til at kunne danne grundlag for en **grundig** evaluering af den samlede ansøgning. Der kan dog herudover henvises til mere uddybende bilag.

# Afsnit 1: Generelle oplysninger

**Stamdata**

Udfyld nedenstående skemaer for at redegøre for projektets stamdata.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Projekttitel** | Green CCU Hub Aalborg | | | | |
| **Projektets beliggenhed** | Rørdalsvej | | | Aalborg | 9220 |
| **Projektets startdato** | 2022 | 04 | 01 |  | |
| **Projektets slutdato** | 2029 | 31 | 12 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Projektdeltagere** | **CVR. nr.** | **Adresse** | **Kontaktperson** | | |
| **Navn** | **Tlf. nr.** | **E-mail** |
| REintegrate | 41860030 | Langerak 15, 9220 Aalborg Øst | Søren K. Kær | 40204795 | Skk@reintegrate.dk |
| European Energy | 18351331 | Gyngemose Parkvej 50, 2860 Søborg | Knud A.Kragh | 42584434 | kak@europeanenergy.dk |
| Blue World Technologies | 39931664 | Lavavej 16, 9220 Aalborg Øst | Mads Friis Jensen | 29707488 | mfj@blue.world |
| [Evt. partnervirksomheds navn] |  |  |  |  |  |
| [Evt. partnervirksomheds navn] |  |  |  |  |  |
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**Placering i værdikæden for brint**

Hvilke dele af værdikæden for brint befinder projektet sig indenfor?

|  |  |
| --- | --- |
| Brintproduktion | Brinttransmission og -distribution |
| Brint og brintbaserede produkter i industrielle applikationer | Brint og brintbaserede produkter i mobilitet |
| Brint og brintbaserede produkter i energisektoren | Brint og brintbaserede produkter til boligapplikationer |
| Andet |  |

# Afsnit 2. Resumé/summary

Beskriv kort projektets formål i et mindre teknisk og tilgængeligt sprog på hhv. dansk og engelsk.

Denne beskrivelse vil blive offentliggjort på Erhvervsstyrelsen hjemmeside, hvis projektet får tilsagn om støtte, og indeholder derfor et begrænset antal ord.

**Resumé på dansk (maks. [350] ord)**

Det ansøgte projekt vil etablere ”Green CCU Hub Aalborg” og derigennem understøtte udviklingen af et brintmarked gennem fremstilling af e-metanol til anvendelse i tung landtransport og skibsfart. Dermed bryder projektet en af de største barrierer for udviklingen og skalering af et brintmarked, nemlig det manglende aftag af ren brint til transport som følge af manglende infrastruktur og køretøjer i perioden frem mod 2030. Projektet omfatter også udvikling og demonstration af brændselscelleteknologi fra Blue World Technologies som muliggør effektiv anvendelse af metanol i den tunge transport på kortere sigt og på længere sigt også i shipping. Projektet vil bidrage væsentligt til CO2 reduktionsmålene i Danmark og Europa frem mod 2030, med en samlet reduktion på 700.000 tons i perioden frem til 2030. Som en direkte konsekvens af dette projekt vil der ske en prisreduktion som muliggør duplikering og skalering i perioden mellem 2025 og 2030 som vil bidrage med yderligere CO2 reduktion på 1.000.000 tons frem mod 2030 inden for transportsektoren.

Aalborg-området er klassificeret som særligt CO2 intensivt og fremgår af EU’s liste over regioner der kvalificerer til støtte fra Just Transition Fund primært på grund af cementproduktionen på Aalborg Portland. Ved den nylige etablering af regionale vækstteams, som skal give input til regionale fyrtårnsprojekter, blev Region Nordjylland udpeget til at fokusere på Carbon Capture and Utilization and Storage (CCUS). Med dette projekt tages det første skridt mod at etablere et anlæg til Carbon Capture and Utilization i Aalborg med støtte fra Aalborg Portland, RenoNord og E.On som mulige CO2 leverandører. REintegrate og European Energy udgør den tekniske og økonomiske rygrad i projektet støttet af Haldor Topsøe på den tekniske side. Med støtte fra Circle K, Mærsk og Bunker One som repræsentanter fra markedet dækker projektet hele værdikæden hvilket underbygger projektets realisme.

**Summary på engelsk (maks. [350] ord)**

The project will establish a Green CCU Hub in Aalborg to support the development of a hydrogen market through the production of e-methanol for transport applications, specifically, heavy-duty and shipping. The use of hydrogen for e-methanol production will overcome one of the most significant barriers for hydrogen market development, the lack of fueling infrastructure and vehicles before 2030. This project develops and demonstrates fuel cell technology from Blue World Technologies to enable efficient use of e-methanol in medium- and heavy-duty transport in the short term and shipping in the longer term. This technology will supplement the use in traditional internal combustion engines. A significant contribution to national and EU CO2 reduction targets of 700.000 tons will result from the project during the 5-year operation towards 2030. Because of the cost reductions achieved by this project, replication, and scaling of the technology between 2025 and 2030 will contribute with another 1.000.000 tons of CO2 reduction in land transport and shipping.

The Aalborg area is classified as specially CO2 intensive and part of the European Just Transition program mainly because of the cement production at Aalborg Portland. When regional growth teams were recently appointed to provide input on national lighthouse projects, Carbon Capture Utilization and Storage (CCUS) was given as the overall theme to the Region North Denmark. With the proposed project, the first step towards the realization of Carbon Capture and Utilization is taken in Aalborg with support from Aalborg Portland, RenoNord and E.On as potential CO2 providers. REintegrate and European Energy form the technical and financial backbone with support from Haldor Topsøe on the technology. With the market side represented by Circle K, Mærsk and Bunker One a complete value chain is established.

# Afsnit 3: Udvælgelseskriterie 1. Projektets bidrag til at opfylde IPCEI-kriterier

I henhold til det overordnede kriterie ”1. Projektets bidrag til at opfylde IPCEI-kriterier” skal det sandsynliggøres, at projektet som delprojekt i et vigtigt projekt af fælleseuropæisk interesse (IPCEI) kan bidrage til at opfylde kriterierne for støtteberettigelse i IPCEI-retningslinjerne[[1]](#footnote-1). Det samlede IPCEI vil bestå af flere delprojekter fra forskellige medlemslande, hvorfor projektet, der ansøges om, ikke skal kunne sikre opfyldelsen af kriterierne alene.

Kriterierne udgør punkt 11-24 (afsnit 3) i IPCEI-retningslinjerne, og der bedes for hvert punkt redegøres for, hvordan projektet bidrager til at opfylde det enkelte punkt. Der vil særligt blive lagt vægt på bidrag til opfyldelse af punkt 13-19 og 22-24.

Kriterierne kan læses i sin fulde længde inklusiv fodnoter i anneks 1 til ansøgningsskemaet.

Nedenstående skema bedes udfyldt.

|  |  |
| --- | --- |
| **Punkt 13** | [Redegørelse for, hvordan projektet på nuværende tidspunkt eller i den nære fremtid forventes at kunne bidrage til at opfylde kriteriet: ”*13. Kommissionen kan også betragte et »integreret projekt«, dvs. en gruppe individuelle projekter, der indgår i en fælles struktur, en fælles køreplan eller et fælles program, der har samme mål og bygger på en kohærent systemisk tilgang, som støtteberettiget. De enkelte dele af det integrerede projekt kan relatere til forskellige niveauer i forsyningskæden, men skal være komplementære og være en forudsætning for, at det vigtige fælleseuropæiske mål kan opfyldes."*]  The project contributes to the integration criterion by being under the hydrogen umbrella. The project aims to do R&D and FID which will contribute to the IPCEI on hydrogen value chain, there is currently no other competitor working at this scale. There are possible interfaces and synergies to projects focusing on improving electrolyzer efficiency, reducing their cost and integration of electrolyzers into wind turbines aiming for offshore or near-shore applications. |
| **Punkt 14** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: ”*14. Projektet skal på en konkret, klar og identificerbar måde bidrage til et eller flere EU-mål og skal have en væsentlig indflydelse på EU's konkurrencedygtighed, på bæredygtig vækst, på sociale udfordringer eller på værdiskabelsen i hele EU.”*]  The project contributes to a number of goals, including decarbonization, carbon capture technology, renewable energy goals, clean air etc., more details found below. Specifically, it contributes to hydrogen cost reduction through innovation in electrolyzer scale and hydrogen offtake. It also contributes to innovation in zero-emission methanol fuel cell systems for light-duty and heavy-duty vehicles. |
| **Punkt 15** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: ”*15. Projektet skal repræsentere et væsentligt bidrag til EU's mål, f.eks. ved at være af afgørende betydning for Europa 2020-strategien, det europæiske forskningsrum, den europæiske strategi for centrale støtteteknologier, Europas energistrategi, rammen for klima- og energipolitikkerne frem til 2030, den europæiske strategi for energiforsyningssikkerhed, Europas elektronikstrategi, det transeuropæiske transport- og energinet, Unionens flagskibsinitiativer, såsom Innovation i EU, den digitale dagsorden for Europa, et ressourceeffektivt Europa eller den integrerede industripolitik for en globaliseret verden.”*]  The project is of considerable magnitude as it aims to produce 75.000 tons of e-methanol a year, the current comparable plant has an e-methanol production of 4.000, which makes this the most significant project of e-methanol production in Europe(further details on scale are found below). The project will also the World’s largest test and demonstration of methanol fueled fuel cell systems for transport application.  Renewable hydrogen is crucial for overcoming anthropogenic CO2 emissions and the transition to a renewable energy system. Therefore, the European long term decarbonisation strategy (LTS) “A Clean Planet for All” refers to the potential key role of hydrogen, and the LTS scenarios achieving climate neutrality envisage an installed electrolyser capacity ranging between 400 and 511 GW by 2050 in the EU. Additionally, to foster the hydrogen uptake, the European Hydrogen Strategy sets a target for 6 GW installed electrolyser capacity by 2024, and 2x40 GW by 2030.  Hydrogen technologies are identified as a key sector for the EU Covid-19 recovery plans, capable of generating green economic growth and creating jobs. |
| **Punkt 16** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: ”*16. Projektet skal normalt involvere mere end én medlemsstat, og dets fordele må ikke være begrænset til de medlemsstater, der finansierer det, men skal komme en væsentlig del af EU til gode. Fordelene ved projektet skal være klart fastlagt på en konkret og identificerbar måde.”*]  REintegrate is open to collaborating with any other member state, it is planned that the project will be in conjunction with other member states but the specifics will not be worked out until after the matchmaking. Several potential interfaces were identified including electrolyzer optimization, additional end uses of hydrogen, oxygen and e-methanol, activities related to Carbon Capture and Utilization, industrial symbiosis with district heating and development of optimal plant operation strategies considering the existing and future electricity markets. Blue World Technologies is open to discuss deployment of methanol fueled fuel cell trucks in other member states. |
| **Punkt 17** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: ”*17. Fordelene ved projektet må ikke være begrænset til de pågældende virksomheder eller den pågældende sektor, men skal være af bredere relevans og anvendelse for EU's økonomi eller samfund ved hjælp af positive afsmittende virkninger, som er klart defineret på en konkret og identificerbar måde (f.eks. ved at have systemiske virkninger på flere niveauer af værdikæden eller på markeder i forgående eller efterfølgende omsætningsled eller have alternative anvendelsesmuligheder i andre sektorer eller føre til modalskift)*”.]  The indirect way the project will have spillovers will be by creating demand for Green Energy and allowing e-methanol users to purchase a green product. Methanol is used in a number of chemical industries including production of some plastics and these can reduce greenhouse gas footprint by using e-methanol. In a longer term, e-methanol can be further processed to aviation fuels and help decarbonize this sector.  The direct effects on other sectors will be through the project the deliberate spreading of the technical knowledge developed through workshops, projects, conferences and scientific publications. Additionally, REintegrate commits to allow touring of the facilities as far as is possible without constituting a safety hazard. The activities around methanol fuel cell testing will allow the general public to get introduced to the use of renewable methanol in transport. |
| **Punkt 18** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: *”18. Projektet skal indebære samfinansiering fra støttemodtageren”*]  REintegrate’s project will be co-financed by European Energy directly or through equity transferred to REintegrate, the detailed amounts will be included below. Blue World Technologies will co-finance own activities. |
| **Punkt 19** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: ”*19. Projektet skal respektere princippet om udfasning af miljøskadelige subsidier, jf. køreplanen til et ressourceeffektivt Europa og adskillige rådskonklusioner*”.]  Since the project is environmentally friendly, it respects the principle of not funding environmentally harmful subsidies. A strong ESG profile is also essential to obtain a loan from the Green Investment Fund and critical for the future success of REintegrate. |
| **Punkt 22** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: ”*22. Projekter, der indebærer industriel anvendelse, skal gøre det muligt at udvikle et nyt produkt eller en ny tjeneste med højt forsknings- eller innovationsindhold og/eller at indføre en fundamentalt innovativ produktionsproces. Regelmæssige ajourføringer uden en innovativ dimension af eksisterende faciliteter og udvikling af nye versioner af eksisterende produkter kan ikke regnes for vigtige projekter*”]  The project is clearly the First-Industrial-Deployment of an innovative technology in a green field installation to recycle biogenic CO2 and renewable hydrogen into e-methanol. The product, e-methanol, is based on a fundamentally new methanol production route that does not yet have a market and was never demonstrated at this scale. With this project e-methanol production will be innovated to bring it closer to the market and demonstrate its advantages in terms of superior sustainability merits and very important potential to facilitate integration of intermittent renewable energy. The grid integration of an e-methanol production plant was never demonstrated at this scale and can act as a reference for future plants of similar type throughout Europe.  The use of methanol fuel cell systems and the first industrial deployment is fundamentally new and Blue World Technologies is a World. With the current project, the technology will be taken one step closer to the market. |
| **Punkt 23** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet: *”23. Miljø-, energi- eller transportprojekter skal enten være af stor betydning for EU's miljøstrategi, energistrategi, herunder energiforsyningssikkerhed, eller transportstrategi eller bidrage væsentligt til det indre marked, herunder, men ikke begrænset til disse specifikke sektorer”*]  By investing in e-methanol production from Green Energy sources, the project contributes to both environmental sustainability and energy security. Sustainability by reducing emissions, increasing air quality and reducing pollution. Energy security by focusing on Green Energy, which will reduce the EU’s dependence on fossil fuels and other imported goods.  Additionally, by developing this concept, REintegrate expects to lower the barriers to entry into the market, which will allow for a ’Greening’ of the internal market.  The use of methanol fuel cells will allow zero emission transport at high efficiency and secure not only significant CO2 reductions but also elimination of harmful emissions associated with internal combustion engines using fossil fuels. |
| **Punkt 24** | [Redegørelse for, hvordan projektet bidrager til at opfylde kriteriet ”*24. Et projekt skal for at kunne betegnes som et vigtigt projekt have stor kvantitativ eller kvalitativ betydning. Det skal enten være særligt stort i størrelse eller anvendelse og/eller indebære en meget betydelig teknologisk eller finansiel risiko.*”]  The project involves a considerable amount of technological risk due to the numerous moving parts in the value chain. The financial risk involved is especially important since it is unclear what the cost of hydrogen will be in the future and the market is currently almost non-existent, making any forecasts, highly uncertain. De-risking of the technology (technically and economically) is critical for the future deployment of similar plants and will an important stepping stone for the development of hydrogen as an energy carrier in Europe. |
| **Øvrige punkter *(11, 12 og 20)*** | [Redegørelse for, hvordan projektet bidrager til at opfylde de øvrige kriterier i IPCEI-retningslinjernes 3. afsnit, herunder punkt 11, 12 og 20]  REintegrate is open to cooperating with the European Commission to achieve a level of transparency and standards developments that would be expected of the IPCEI. |

# Afsnit 4: Udvælgelseskriterie 2. Projektets fokus og effekt

Der skal redegøres for projektets fokus og effekt i henhold til det overordnede kriterie ”2. Projektets fokus og effekt”. Redegørelsen struktureres efter delkriterierne.

**2.a Projektets fokus på at fremme udviklingen og implementeringen af vedvarende brint, der kan bidrage til at indfri Danmarks og EU’s klimamål for 2030, samt understøtte den langsigtede omstilling til klimaneutralitet i 2050.**

[Redegør for, hvordan projektet via et fokus på at fremme udviklingen og implementering af vedvarende brint kan bidrage til at indfri Danmark og EU’s klimamål for 2030, herunder Danmarks målsætning om 70 pct. drivhusgasreduktion i 2030 samt EU’s 2030-klimamål på mindst 55 pct. drivhusgasreduktion i 2030 og klimaneutralitet i 2050. Dertil skal der redegøres for, hvordan projektet bidrager til at fremme udviklingen af et europæisk brintmarked i henhold til EU’s brintstrategi[[2]](#footnote-2).]

To achieve the very ambitious greenhouse gas reduction targets set in Denmark and Europe a radical transition of the energy system is required with renewable electricity playing a pivotal role. The intermittent nature of solar and wind energy and the fact that full electrification across all sectors is impossible calls for new technologies to enable indirect electrification and seasonal storage of energy. Hydrogen is uniquely positioned as a core component towards solving this challenge via so-called power-to-X (PtX) technology that, as the first step, uses renewable electricity to split water into hydrogen and oxygen. Further processing of hydrogen to e-methanol opens a much larger market than exist for direct use of pure hydrogen in Denmark and simplifies transport and storage of the hydrogen. This market can facilitate hydrogen cost reductions through economy of scale. Carbon capture is another key technology required to achieve deep decarbonization, which is closely linked with the synthesis of carbon containing PtX products such as e-methanol, as it provides the required carbon. Demands for CO2 to synthesize e-methanol creates a market for CO2, in particular biogenic CO2, supporting the deployment of carbon capture technologies and driving innovation and cost reduction in capture technology which will benefit the storage of fossil CO2. The very tight technical and commercial link between PtX and carbon capture via the so-called Carbon Capture and Utilization (CCU) is evident. The Green CCU Hub Aalborg is a very important vehicle to accelerate development of CCU(S). A graphical representation of the Green CCU Hub Aalborg is shown in the figure below.



The Aalborg area was identified as one of the most CO2 intensive regions in Europe primarily due to the cement production at Aalborg Portland emitting more than 2 mio tons of CO2 annually. When the Danish government recently established regional growth teams to identify local lighthouse projects, the Region North Denmark was appointed to focus on CCUS due to the unique local opportunities. With this proposal, the scalable Green CCU Hub Aalborg platform will be established to materialize the visions and potential for the region. The complete value chain join forces to accelerate the deployment of PtX in Denmark from renewable electricity generation (European Energy) and CO2 sources (Aalborg Portland, Reno-Nord and E.On) to e-methanol production (REintegrate, Haldor Topsøe), fuel logistics (Port of Aalborg), and end-users (Mærsk, Circle K, Bunker One, and Blue World Technologies). Blue World Technologies will lead the innovation and first industrial deployment of large-scale methanol fuel cells in heavy-duty transport.

The project contributes substantially both to the 70% Danish Carbon emissions reduction Target and to the 55% percent European Target by installing substantial additional renewable electricity generation capacity and by installing a **120 MW electrolyzer in phase 1** (2024) of the European Hydrogen strategy and creating the foundation for an additional **700 MW in phase 2** of the strategy (2030) partly at the Aalborg site and partly by replication in Denmark and Europe. Hydrogen has a unique ability to bridge the use of electricity to parts of the transport sector that are hard or prohibitively expensive to electrify directly, mainly heavy-duty trucks, shipping and aviation. It is necessary to further process the hydrogen to a liquid fuel, e-methanol, to achieve substantial CO2 reductions already by 2030 through utilization of the existing infrastructure and blending of renewable fuels into fossil. Direct use of hydrogen requires massive investments in infrastructure and an entirely new fleet of heavy-duty fuel cell trucks that will not be available in sufficient quantity to make substantial contributions towards the 2030 target. Methanol fueled ships are available today and new are being built, most recently Mærsk announced the launch of the first methanol fueled container vessel by 2023 (see support letter). E-methanol is considered among the most promising CO2 neutral shipping fuels by shipping companies and fuel brokers, which also reflects in the EU hydrogen strategy. The use of methanol for light- and heavy-duty transport will be demonstrated by Blue World Technologies using their unique fuel cell platform. By the end of the project, they plan to have established a fuel cell production capacity of 750 MW/year in Aalborg.

The Green CCU Hub Aalborg will contribute with a CO2 reduction of 700.000 tons during the 5-year operation period from 2025 to 2030 with the first phase of the project alone through the displacement of fossil fuel in road transport and shipping. In 2028 a four to five-fold increase in production capacity is expected at the Aalborg site and towards 2030 another 3 sites are planned in Denmark and Europe through replication. This expansion is driven by innovation in electrolyzer cost, efficiency improvements, reduced cost of energy, and the development of a more mature hydrogen and e-methanol market. The 2-year operation period of the expanded Aalborg plant between 2028 and 2030 will contribute with an additional CO2 reduction of 1.000.000 tons by displacement of additional fossil fuel. Depending on the development of the green fuels market, the CO2 reduction may partly take place in international shipping.

Irrespective of the end-use sector, the project will help drive the cost of hydrogen past the tipping point mainly through efficiency improvements and scale. Scale is achieved by opening a large new hydrogen market to produce e-methanol.

In addition to CO2 reductions, methanol contributes with very significant reductions in harmful emissions, particularly NOx, SOx, and particles. Methanol is biodegradable eliminating the risk of soil and oceans contamination. E-methanol produced from renewable hydrogen and CO2 has good sustainability merits surpassing biofuels in terms of indirect land use changes, water requirements.

Through synergies with CO2 capture and storage, the Green CCU Hub Aalborg also makes an indirect contribution towards the 70% Danish Carbon emissions reduction Target. The realization of a large CO2 utilization plant creates an offtake opportunity for local industry with ambitious CO2 reduction plans, including Aalborg Portland and Reno-Nord. Building a CCU facility will create the foundation to recycle the biogenic part of their captured CO2 and form an important opportunity to sell CO2 and contribute towards funding the CCS of fossil CO2. This synergy between CCU and CCS is a very important aspect of the Green CCU Hub Aalborg project and the indirect contribution to CO2 reductions from industry can be significant.

The entire Green CCU Hub Aalborg project is perfectly aligned with the European hydrogen strategy and the development of a European hydrogen market. European Energy is present in major European countries with renewable electricity production capacity and has very ambitious plans to expand its production capacity. The consortium of REintegrate and European Energy will leverage this renewable electricity production capacity for the European expansion of e-methanol production.

**2.b Projektets høje teknologiske modenhed og bidrag til substantiel skalering af PtX-teknologier med henblik på kommerciel anvendelse og markedsbaseret udrulning.**

[Redegør for, hvordan projektet er karakteriseret ved høj teknologisk modenhed. Projekter karakteriseret ved høj teknologisk modenhed defineres som havende et TRL-niveau (Technological Readiness Level) på 7-9[[3]](#footnote-3) ved projektets start.

Dertil skal der redegøres for, hvordan projektet bidrager til substantiel skalering af PtX-teknologier med henblik på kommerciel anvendelse og markedsbaseret udrulning. Beskrivelsen skal anføre, hvordan projektet konkret skalerer PtX-teknologier substantielt, herunder hvilke PtX-teknologier, der er tale om. Samtidig skal det anføres, hvordan projektet fører til kommerciel anvendelse af den konkrete teknologi, og hvordan projektet kan bidrage til udrulning af teknologien på markedsbaserede vilkår.]

When it comes to PtX, particularly the synthesis of e-methanol from CO2 and hydrogen, the technology is still in its infancy. To date only one plant of significant scale was built worldwide, the George Olah plant in Iceland with a production capacity of 4.000 tons/y. Many announcements of large-scale plants were made, the large majority of which are at the power point stage and only very few have reached the final investment decision. REintegrate is a global pioneer in e-methanol in terms of actual production timeline and signed off-take agreements. By 2022, the first plant with a production capacity of 15.000 tons/y of e-methanol will come into operation. This facility will be the largest renewable e-methanol plant world-wide.

European Energy is a rapidly expanding energy company with wind (onshore and offshore) and photovoltaics plants world-wide. European Energy will grid connect 750 MW of renewable electricity generation capacity in 2021 and maintains an annual growth rate of 30-40%. European Energy is capital partner and shareholder in REintegrate, committed to provide the financial backing to complete the project. Together, REintegrate and European Energy have the required foundation to develop PtX facilities not only in Denmark but throughout Europe and beyond making a substantial contribution to greenhouse gas reductions.

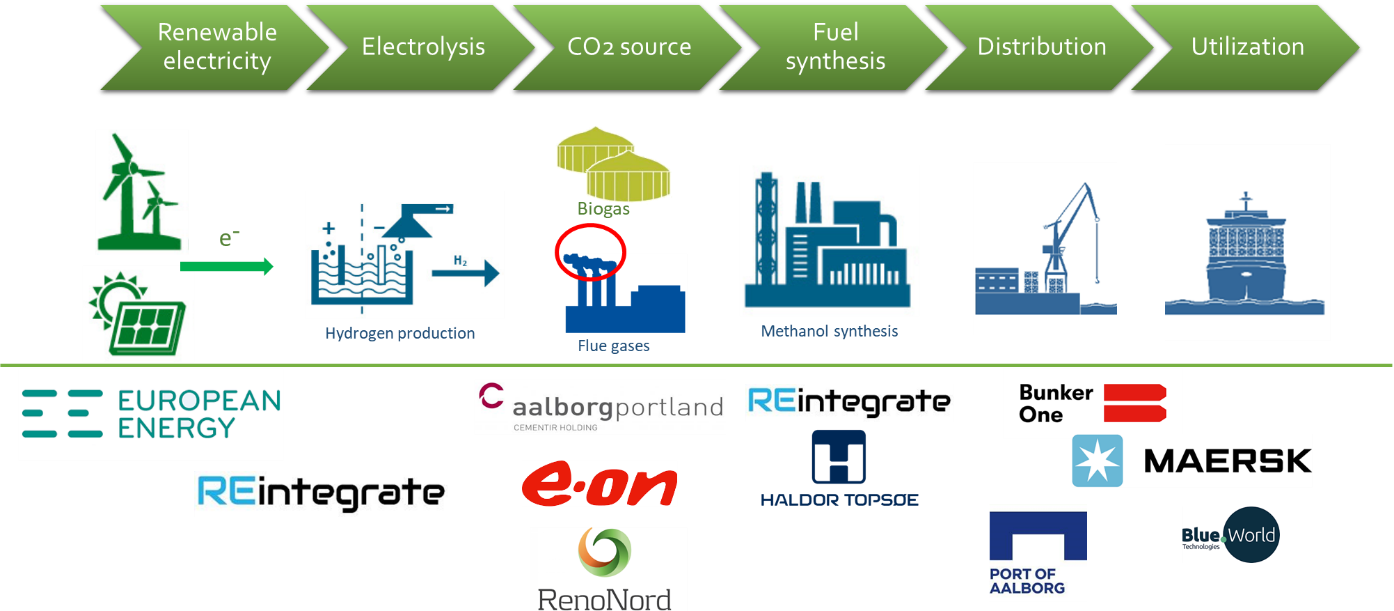
This project is a further development and innovation of the technology developed in the Danish Energy Technology Development and Demonstration Program and the Danish Energy Authorities funded projects “Power2Met” and “Greenlab Skive PtX” focusing on production of renewable e-methanol. These projects have matured the basic Danish e-methanol technology to TRL7-8 based on a 12 MW electrolyzer. With the Green CCU Hub Aalborg project, the technology is taken to the next stage by innovation in efficiency improvement, cost reduction and dynamic operation capability taking it one step closer to commercial deployment at TRL9. Haldor Topsøe will contribute to this with their expertise and experience in methanol synthesis (see support letter). The project will deploy a 120 MW electrolyzer reflecting the current state of the electrolyzer technology. The workplan in Section 7 details concrete development and innovation activities towards this target.

The innovation activities will improve essential Key Performance Indicators (KPI) as summarized in the table below paving the way for massification:

|  |  |  |
| --- | --- | --- |
| **What** | **KPI** | **How** |
| Production capacity | Start: 2,5 ton/hour  End: 12,5 ton/hour | Development of larger plant through innovation activities into improved thermal, chemical and mechanical solutions |
| Efficiency | Start: 10,3 MWh/ton  End: 9,5 MWh/ton | Mainly driven by activities related to the electrolyzer. To a minor extent more efficient balance-of-plant |
| Operation range | Start: 20 – 100% load  End: 10 -100% load | Improvements in system control strategy and critical components (valves, compressors) |
| Total CAPEX | Start: 10,5 M€/ton/hour  End: 9,5 M€/ton/hour | This mainly relates to economies of scale |

Overall, these improvements will reduce the production cost of e-methanol by around 10% compared with 2022 at the same electricity cost and number of operating hours per year.

In this project REintegrate and European Energy will serve two markets for renewable e-methanol: Road transport (Circle K) and shipping (Mærsk and Bunker One). Circle K will mainly use the fuel in Denmark whereas the use in shipping will cover a larger geographical region mainly around the Baltic Sea but also target domestic ferries. The collaboration platform that is established with Mærsk, Circle K and Bunker One is very important for REintegrate to further scale offtake after the Green CCU Hub Aalborg project.



The Green CCU Hub Aalborg will establish a scalable industrial symbiosis with large CO2 emitters (Aalborg Portland, Reno-Nord and E.On) and the district heating to create a sector coupling platform that optimizes total energy efficiency. This first industrial deployment project will be step one in the innovation chain bridging the crucial gap towards commercial operation. Financial de-risking of the investment is another critical aspect of this first industrial deployment that drive the cost of capital down. To mention some of the key risk elements, 1) the installation of an electrolyzer with a capacity of 120 MW goes beyond the current state of the technology and is associated with considerable risks (performance, durability, availability for production), 2) the market for green hydrogen and e-methanol is not yet established and the long-term pricing is uncertain creating considerable financial risk to the project.

After the First Industrial Deployment phase (FID) is completed by 2027, it has enabled the second step (not part of this project) that involves expansion to 500 MW of electrolyzer capacity by 2028 and the third step of at least 1 GW by 2035. Sufficient CO2 is available in the CCU Hub to realize this roadmap as carbon capture technologies are matured and deployed. As site expansion progresses to stages 2 and 3, efficiency and cost improvements combined with an expected increase in CO2 taxation will make the technology competitive on commercial terms. Between 2025 and 2030 REintegrate will build, own and operate at least one more production facility based on the Green CCU Hub Aalborg concept in Denmark and another two in Europe creating a very significant spill-over from the Green CCU Hub Aalborg already by 2030. Towards 2050, the roll-out will continue throughout Europe and beyond in close collaboration with end-users such as Mærsk, Bunker One and Circle K.

**2.c Projektets bidrag til at indfri missionen *Grønne brændstoffer til transport og industri (Power-to-x mv.)* i regeringens forskningsstrategi om fremtidens grønne løsninger.**

[Redegør for, hvordan projektet bidrager til at indfri missionen *Grønne brændstoffer til transport og industri (Power-to-x mv)* i regeringens forskningsstrategi om fremtidens grønne løsning. Beskrivelsen af missionen i forskningsstrategien er indsat herunder.[[4]](#footnote-4)]

|  |
| --- |
| **2. Grønne brændstoffer til transport og industri (Power-to-X mv.)**  Uden en målrettet indsats, især inden for tung land-, skibs- og lufttransport samt nogle dele af industrien, vurderes det ikke muligt, at Danmarks energisystem i 2050 er baseret på 100 pct. vedvarende energi.  Der skal udvikles løsninger til at lave nye grønne brændstoffer. Det kan for eksempel ske ved at omdanne strøm fra vedvarende energi til produkter, der kan anvendes til at reducere udledningerne fra dele af transport- og industrisektoren, hvor der ikke eksisterer omkostningseffektive alternativer til fossil energi. Potentialet for CO₂-reduktion fra Power-to-X er stort, da det teoretisk set kan erstatte al fossilt brændstof forudsat, at der er tilstrækkeligt VE-strøm, og eventuelt kulstof, tilgængeligt. Der vurderes at være et langsigtet teknisk reduktionspotentiale på 1,5-7,5 mio. t., heraf 1-4 mio. t. i international skibs- og luftfart (som ikke tæller med i den danske opgørelse af drivhusgasudledninger). Frem mod 2030 vurderes det tekniske indenlandske potentiale at være 0,5-3,5 mio. t. CO₂ (der er overlap med potentialet for CCUS, idet kulstof både kan lagres og anvendes til f.eks. Power-to-X-produkter jf. ovenfor).4  Efterspørgslen efter grøn brint og andre Power-to-X-produkter er ikke tilstrækkelig til, at der er sket en markedsdrevet udbygning, hverken i Danmark eller i udlandet. Det kan skyldes, at der er store omkostninger forbundet med produktionen, så prisen på den grønne brint og andre brintbaserede produkter bliver relativt høj ift. fossile alternativer. Der er behov for en målrettet forskning-, udvikling- og demonstrationsindsats for at bringe disse delteknologer til et niveau af teknologisk modenhed, som muliggør kommerciel anvendelse, ligesom der er behov for at demonstrere, hvordan Power-to-X-systemer kan integreres i det samlede energisystem, f.eks. sammen med varmesektoren.  Danmark kan bygge på en stærk forskningsmæssig tradition inden for især brint og elektrolyse med forskningsmiljøer på flere universiteter. Der er et stort potentiale for en dansk erhvervsmæssig styrkeposition inden for Power-to-X. Erhvervsstyrker inden for grøn energiteknologi, maritime erhverv, transport og logistik, kemikalier mv. giver mulighed for at opbygge partnerskaber, som kan dække hele Power-to-X-værdikæden.  (1)  Potentialet er behæftet med meget høj usikkerhed både i forhold til effekt, dokumentation og udbredelsespotentiale. Der skal derfor tages et markant forbehold i forhold til realiseringen af potentialet. Skønnene kan ikke lægges sammen grundet flere mulige overlap. Der kan ikke sættes lighedstegn mellem igangsættelsen af forskningsmissionerne og realiseringen af reduktionspotentialerne, jf. appendiks i bilag 1. |

The Green CCU Hub Aalborg project will make a substantial contribution towards the mission Green fuels for industry and transport. REintegrate is a first-mover in Denmark and globally with the e-methanol production facility being built in Skive as stated in the support letter from Mærsk. The technology is a spin-out from Aalborg University that is further developed and innovated by REintegrate and built with Danish subcontractors. With the Green CCU Hub Aalborg project, REintegrate and European Energy team up with customers Mærsk (future owner and operator of methanol ships), Bunker One (among the world’s largest fuel brokers for shipping including domestic ferries) and Circle K (gasoline retailer with global presence), and technology provider Haldor Topsøe to take Danish PtX production to the next level and maintain the global first-mover position.

In Green CCU Hub Aalborg REintegrate will leverage the integration potential with the district heating grid to bring down cost and improve total energy efficiency by using waste streams (e.g. waste heat and oxygen) through industry symbiosis. The 120 MW electrolyzer will be grid connected at the transmission system level and use renewable electricity from European Energy’s installations in Denmark. The electrolyzer will take part in the electricity markets and offer balancing capacity to the grid to facilitate integration of additional intermittent renewable electricity generation capacity. All of these are crucial components in the electrification of the energy system through intelligent sector coupling.

**2.d Projektets bidrag til at fremme konkurrencedygtige og omkostningseffektive løsninger indenfor brintområdet.**

[Redegør for hvordan projektet bidrager til at fremme løsninger, der er konkurrencedygtige i forhold til at kunne konkurrere på markedsvilkår og omkostningseffektive i forhold til at levere drivhusgasreduktioner.]

The Green CCU Hub Aalborg project will produce ultra-low CO2 (Greenhouse Gas Reduction of more than 90%) renewable fuels for heavy-duty road transport and shipping. These sectors contribute significantly to CO2 emissions and are not feasible to electrify directly, thus indirect electrification through PtX is a necessity. With the funding requested through this proposal, a cost competitive CO2 reduction option is established for these sectors enabling off-take agreements to be signed on commercial terms.

Further, the e-methanol technology creates a platform to solve one of the key challenges of pure hydrogen, scalability. The use of pure hydrogen for mobility faces critical scalability challenges as the required offtake will not be in place due to a lack of infrastructure and vehicles in sufficient quantity to achieve the required scale until after 2030. When a hydrogen market for direct use in heavy-duty opens around 2030, it will benefit from already existing, cost efficient electrolyzer installations at the Green CCU Hub Aalborg and other facilities in Denmark and Europe deployed based on the same concept. REintegrate intends to use this advantage to supply hydrogen for direct use in transport in addition to e-methanol production.

The Green CCU Hub Aalborg will establish a platform for further technical innovation and cost reduction (PtX plant itself, cost of capital through de-risking of the investment, and cost of renewable electricity) towards 2030 that will bring the cost level to the point where e-methanol can provide cost competitive CO2 reductions compared with other renewable fuels. Introduction of CO2 taxation will contribute further towards closing the cost gap to fossil fuels and open a much larger market for PtX products.

To illustrate, in concrete terms, how the cost will be brought down, a cost breakdown of e-methanol production in 2022 (GreenLab Skive PtX) and 2030 is outlined.

|  |  |  |
| --- | --- | --- |
| **Key assumptions** | **2022** | **2030** |
| Cost of electricity [€/MWh]: | 35 | 30 |
| Electrolyzer efficiency [MWh/ton H2]: | 50 | 48 |
| Electrolyzer CAPEX and OPEX (excl. electricity) [€/ton H2] | 750 | 500 |
| Methanol plant CAPEX and OPEX (excl. H2) [€/ton MeOH] | 160 | 90 |
| **Hydrogen, methanol and CO2 cost** |  |  |
| Cost of hydrogen [€/ton] | 2500 | 1940 |
| Cost hydrogen per ton of methanol (@192 kg H2/ton) [€/ton] | 480 | 372 |
| Cost of CO2 per ton of methanol @1,4 tCO2/ton MeOH | 110 | 90 |
| Cost of methanol (H2 and methanol plant) [€/ton] | 750 | 550 |

With the 2030 targets for hydrogen cost and e-methanol plant CAPEX and OPEX (excl. the H2) of 100 €/ton, the cost is just above 550 €/ton of e-methanol in 2030. For comparison, the cost of fossil methanol is nearly 400 €/ton when it is high. With the expected implementation of CO2 taxation and the general demand for renewable fuels more widespread deployment of E-methanol is secured.

Efficient and cost-competitive downstream usage of the produced e-methanol is demonstrated by deploying a fleet of fuel cell electric medium- to heavy-duty vehicles (TRL7-8). The vehicles are demonstrated by local fleet owners (refuse collection trucks, distribution of groceries and other goods etc.) and initial refueling infrastructure is deployed to sustain the early market demand. At the port of Aalborg, Blue World Technologies is ramping up for mass-manufacturing of high-temperature PEM fuel cell (HT-PEPMFC) technology with a yearly capacity of 750MW. The combination of HT-PEMFC and e-methanol offers core advantages over pure electric medium- to heavy-duty vehicles, which are faced with technological challenges related to reduced payload and driving range. Among others, this solution enables:

* **Fast refueling** of liquid methanol (similar to diesel) using the existing infrastructure.
* **Zero harmful emissions** as dangerous emissions like NOx and SOx are eliminated.
* **Superior driving range and flexibility** similar to fossil fuel vehicles (above 1000km).
* **High fuel efficiency** at 45% compared to <30% of ICE vehicles.
* **Competitive total cost of ownership** when powered by renewable methanol.

Moreover, when compared with fossil diesel heavy-duty vehicles, the use of e-methanol reduces the well-to-wheel CO2 emissions with up to 99% and is classified by EU as clean and zero-emission drivetrain solution.

**2.e Projektet nytte efter støtteperiodens ophør.**

[Redegør for nyttiggørelsen af projektet efter støtteperiodens ophør, herunder forventninger til, hvorvidt og hvordan projektet vil kunne fortsætte på markedsbaserede vilkår.]

REintegrate intends to continue to operate the plant after the public support period as several factors point towards a viable business case can be established provided that the critical financial support to form the foundation is granted.

* The site can be further developed to increase production capacity and improve economic feasibility through scale.
* The electrolyzer will require an overhaul after 8-10 years where efficiency improvements in core technology will benefit the continued operation (more hydrogen is produced per MWh of electricity consumed).
* Continued cost reduction of renewable electricity will bring down production cost and improve cost competitiveness of the plant.
* An increasing revenue is expected from the electric grid balancing market.
* Implementation of CO2 taxation will support a price premium over fossil fuels and a growing market for renewable fuels.

From close contact with large end-users of e-methanol, REintegrate is confident that there will be a market for the produced fuel after the project period.

In addition, the plant will be a central part of replicating the technology to other sites across Denmark and the EU once all parts of the value chain have been optimized through the First Industrial Deployment phase.

Blue World Technologies will use the project as a platform to demonstrate methanol fuel cell technology in large scale paving the way for market deployment.

# Afsnit 5: Udvælgelseskriterie 3. Projektets budget og finansiering

Der skal redegøres for projektets budget og finansiering i henhold til det overordnede kriterie ”3. Projektets budget og finansiering”.

[Redegør for følgende:

* Projektets budget i overordnede tal i tillæg til et udfyldt og vedlagt budgetskema. Angiv forudsætninger for alle centrale budgetposter og beskriv dertil den samlede plan for finansiering af projektet, herunder en vurdering af, at planen er realiserbar.

The project budget for the PtX part was established based on the combined experience from REintegrate (e-methanol plant in GreenLab Skive), European Energy (large EPC projects) and Haldor Topsøe (large methanol plants). Blue World Technologies established the budget for the fuel cell part. In the table below, the budget lines from Annex 2 are provided adding up to the total investment of MDKK 1159.

|  |  |  |
| --- | --- | --- |
| **Annex 2 reference** | **Detailed cost description** | **MDKK** |
| a) | VVM permit preparation | 1 |
|  | Construction permit | 1 |
|  | Basic Engineering assistance | 10 |
|  | REintegrate internal hours incl. overheads | 25 |
|  | Fuel cell innovation and optimization for heavy-duty | 35 |
|  |  |  |
| b) | Vehicles for demonstration of methanol fuel cells | 10 |
|  |  |  |
| c) | Construction of building to host electrolyzer | 50 |
|  | Construction of well-fare building and control room | 5 |
|  | Methanol storage tanks (10.000 m3) | 50 |
|  | Electrical transformer and grid connection | 50 |
|  | CO2 storage tanks on site | 20 |
|  | Civil work and infrastructure | 25 |
|  | Methanol fueling infrastructure | 5 |
|  |  |  |
| g) | CAPEX electrolyzer (alkaline) | 450 |
|  | CAPEX methanol plant (Haldor Topsøe estimate) | 425 |
|  |  |  |
|  | **Total project cost** | **1159** |
|  | **Net income during project period (2022-2029)** | **115** |
|  | **Requested support** | **522** |

With the established total investment of DKK 1159 mio., a 20-year operating budget shows that public support of 522 MDKK is required to ensure a WACC of 8% which REintegrate, European Energy and Blue World Technologies consider viable given the technical and economic risks. A relatively high public support rate is requested since a larger market must be opened through reduced cost of the e-methanol. Secondly, the electrolyzer will be grid connected and electricity grid tariffs must be paid adding considerably to the cost of electricity compared to a behind-the-meter setup. A revenue may be generated from grid balancing services, but this is very uncertain and a conservative estimate was used in the operating budget.

REintegrate and European Energy already have close links to financial institutions including the Danish Green Investment Fund that will finance part of the REintegrate Skive plant. During the negotiations around the financing of the Skive plant, the Danish Green Investment Fund has given very positive indications concerning the financing of future projects. REintegrate and European Energy consider the following financing budget realistic for the Green CCU Hub Aalborg project:

|  |  |
| --- | --- |
| **Financing source** | **MDKK** |
| Public support under IPCEI | 522 |
| Danish Green Investment Fund (loan) | 306 |
| Equity from Blue World Technology towards their part of the budget | 25 |
| Equity from European Energy via REintegrate | 306 |
| **Total** | **1159** |

For comparison, the DKK 306 mio. equity investment outlined above will only represent just around 6% of the planned European Energy investment of DKK 5.000 mio. in 2021. European Energy has the financial strength to realize the Green CCU Hub Aalborg project with REintegrate as well as the expansion plans outlined in this proposal provided public funding is granted to make the innovation possible that is required to reduce cost and financial risk associated with this First Industrial Deployment.

As a remark, REintegrate has proposed to the newly established Growth Team for Region North Denmark to provide financial support towards maturing the Green CCU Hub Aalborg project. Specifically, the proposal is to kick-start the basic engineering and permitting phases as part of the CCUS theme set for the Region North Denmark. This will accelerate the timeline by approximately 6-9 months. Since this funding was not yet granted, this proposal covers the full investment toward the realization.

European Energy is committed to provide the capital required to close the financing need between the requested public support and the total CAPEX as well as the bridge financing during the construction period. The required capital will be as loan, and equity directed through REintegrate as new capital. A letter from CEO Knud Erik Andersen of European Energy confirming this commitment is enclosed with the application.

# Afsnit 6: Udvælgelseskriterie 4. Projektets organisering

Der skal redegøres for projektets budget og finansiering i henhold til det overordnede kriterie ”4. Projektets organisering”.

[Redegør for følgende:

* Ansøgers faglige, organisatoriske og finansielle styrke med henblik på at sikre den nødvendige robusthed ved gennemførelsen af det ansøgte projekt som delprojekt i et IPCEI.

The project will be managed jointly by REintegrate and European Energy. REintegrate is currently expanding the organization to execute the first PtX project in GreenLab Skive and to develop a project pipeline in Europe. Already by the end of 2021 REintegrate will have a team of 10 people focusing entirely on growing the PtX business and in 2022 another 6-8 employees will join. With European Energy as a strong capital partner and key investor in REintegrate they provide the required backing with legal support, financing experts and very strong business development skills hence fully capable to complete the state aid process. In practice, REintegrate operates as a fully integrated daughter company in the European Energy group.

* At ansøger har de nødvendige juridiske og økonomiske kompetencer til at gennemføre statsstøtteprocessen.
* De deltagende ressourcepersoners kompetencer, herunder projektledelseskompetence og de eventuelt medvirkende virksomheders relevante erfaringsområder.

Søren Knudsen Kær will be the overall project manager from REintegrate. Søren has deep technical insight and strong experience in project management related to new energy technologies. Lars Udby will support Søren on the business and economics. Lars was responsible for the first large-scale electrolyzer installation in Denmark, HyBalance, with a total budget exceeding DKK 100 mio. The technical management of the plant construction will be headed by Karsten H. Møller from REintegrate. Karsten has 30 years of experience from construction of large complex process plants. Most recently Karsten successfully managed the reconstruction of Avista Oil in Kalundborg and the large-scale heat pump installation in Farum both with budgets well beyond DKK 100 mio.

From European Energy Head of Innovation Knud Abildgaard Kragh will contribute to the overall project management from the European Energy side. Knud will be supported by specialists in legal matters, electricity trading and financing from the European Energy organization counting more than 200 employees.

The core project organization outlined above will be supported by an advisory panel with members from the companies that provided support letters to the application. This will ensure direct access to specialist covering the full value chain and ensure, not only successful execution of the Green CCU Hub Aalborg project, but also further expansion to other sites.

* At der deltager flere led i værdikæden af relevante aktører for at medvirke til at sikre gennemførelsen af det ansøgte projekt i henhold til dets formål og for at medvirke til at fremme udbredelse af tilsvarende teknologiløsninger efter projektets afslutning.]

Port of Aalborg will engage in the work with their strong experience in fuel logistics and will make the required land available to build the Green CCU Hub Aalborg facilities. This is fully aligned with Port of Aalborg’s strategic plans as shown by their letter of support for the project.

Haldor Topsøe will participate with their strong experience in methanol plants and to bring in experience from related e-methanol activities in general.

Aalborg Portland, Reno-Nord and E.On will work with REintegrate and European Energy on the supply of CO2 for the e-methanol production. In the short term biogas CO2 will be liquefied and trucked to the facility pending the installation of carbon capture plants at Aalborg Portland and Reno-Nord. The collaboration with Aalborg Portland can form the basis for similar technologies being installed at other cement factories in the Cementir Group. Reno-Nord is a typical Danish waste incineration plant, and their experience from the Green CCU Hub Aalborg can be replicated at other Danish waste incineration plants. E.On represents several large biogas plants in Denmark and with more than 100.000 tons of biogas CO2 available already today.

On the offtake side, Green CCU Hub Aalborg works with leading companies in shipping, Mærsk and Bunker One, as well as in road transport with Circle K being one of the world’s largest gasoline retailers. Together, these partners provide a solid link to end-users and are fully capable of ensuring the required offtake to scale the hydrogen value chain in Denmark and beyond. With their letters of support and Circle K’s already existing offtake agreements with REintegrate they show their strong commitment and interest to with REintegrate.

# Afsnit 7: Udvælgelseskriterie 5. Projektets struktur, realisering og gennemførlighed

Der skal redegøres for projektets budget og finansiering i henhold til det overordnede kriterie ”5. Projektets struktur, realisering og gennemførlighed”.

[Redegør for projektets tidsplan, herunder tidsplan for indhentning af nødvendige tilladelser og lokale plangrundlag. Gennemførelsen af projektet bedes beskrives i form af arbejdspakker med et passende antal relevante milepæle.

Dertil skal der redegøres for, at projektet kan gennemføres indenfor de gældende rammebetingelser og lovgivning for køb og salg af el og energi, energiaftaler mv. eller inden for vedtagne eller forventede, men endnu ikke implementerede ændringer heraf. I tillæg hertil skal der redegøres for, at projektet kan opnå de nødvendige fysiske etableringstilladelser som bygge- og miljøgodkendelser mv. indenfor en rimelig tidshorisont.

Der skal redegøres for, at projektet ikke vil blive gennemført i den ansøgte version – enten slet ikke eller i en betydeligt svækket version, hvis der ikke opnås støtte. Det skal anføres, hvorledes tilskud til det ansøgte projekt vil øge indsatsens omfang, udstrækning, tempo set i forhold til en situation, hvor der ikke opnås støtte.

*Endelig skal det anføres, hvordan projektets resultater bliver opsamlet og offentligt formidlet med den nødvendige impact. Der skal redegøres for, hvem projektets resultater vil blive formidlet til, hvordan resultaterne vil blive formidlet (kommunikationsplatforme, besøgstjeneste mv.) samt hvordan resultater undervejs vil blive opsamlet og bearbejdet, herunder der vil være eventuelle undtagelser i formidlingen som følge af IPR-spørgsmål eller lign. (fortrolige oplysninger).]*

The Green CCU Hub Aalborg project is divided into several work package to efficiently structure and manage the execution. Overall, the plan follows the experience REintegrate developed in the GreenLab Skive PtX project. The timeline is provided as months after project kick-off, for example M10 means 10 months after starting the project.

**Work package 1: Site planning and conceptual engineering (M1-M6)**

This work package will develop the site plan including interfaces to the electricity grid, the district heating grid, the CO2 supply and storage, fuel storage and handling, wastewater treatment.

Innovation and development will be carried out to improve efficiency, integrate with district heating, improve dynamic operation capability (grid balancing) and secure scalability of the complete solution.

Efficiency improvements are tightly linked to the electrolyzer. REintegrate will work closely with selected potential electrolyzer suppliers to ensure the required improvement is achieved. The balance-of-plant of the e-methanol synthesis plant will be improved through innovation into thermal heat integration of the processes, development of a more advanced synthesis reactor to enable the required capacity increase and to improve conversion efficiency of CO2 and hydrogen to e-methanol. A more efficient two-column distillation system will be developed to reduce the heat demand compared to the currently used design.

Improvements in dynamic operation capability is achieved through innovations in plant controls. REintegrate developed experience in this field through the pilot plant commissioned in 2020 and further refined the control in the engineering phase of the 2,5 ton//hour plant that will start operation in 2022. In the proposed project REintegrate will include novel design details to extend the operation range down to 10% from currently 20% of full load. When the plant follows electricity production from renewable sources this will allow more operation hours during the year and improve grid balancing capabilities.

Complete overall facility design calculations including all production capacity numbers and front-end engineering design. Finish conceptual 3D illustrations to be used for the construction permit application. Consolidation of CAPEX and OPEX budgets as well as the overall business case.

Milestones:

Site plan completed (M3)

Conceptual engineering completed (M6)

Consolidated CAPEX and OPEX budgets (M6)

**Work package 2: Permitting (M1-M18)**

Preparation of all official documents required for the construction permit application and the VVM approval. Submission of the documents and dialog with the authorities during the processing of the applications.

REintegrate has proposed work package 1 and 2 to the regional growth teams in Region North Denmark as it is perfectly aligned with the focus of their work being CCUS (see [Regionale vækstteams skal skabe vækst og arbejdspladser i hele Danmark (em.dk)](https://em.dk/nyhedsarkiv/2021/marts/regionale-vaekstteams-skal-skabe-vaekst-og-arbejdspladser-i-hele-danmark/)). If funding is granted to start the work, it will accelerate the timeline to production start.

Milestones:

VVM application submitted (M6)

VVM approved and construction permit obtained (M18)

**Work package 3: Detailed engineering and procurement (M6-M18)**

REintegrate will engage with a consulting engineering to complete detailed engineering of the Green CCU Hub Aalborg e-methanol facility based on the innovations from work package 1. The work will establish the complete technical foundation to produce the required tender documents for procurement and construction of the production plant. This includes complete bill of materials, pipe design with required stress analyses, detailed design of reactors and separator vessels, the control system, and the final detailed 3D computer model.

An open tender process will be held including dialog with potential suppliers, contract negotiations and signing of final supplier contracts.

Milestones:

Detailed engineering completed (M12)

Complete tender material prepared (M15)

All major subcontractor agreements signed (M18)

**Work package 4: Construction and commissioning (M12-M36)**

This work package is focused on the site civil and electrical work required for site preparation, preparation of electrical installations towards the transmission grid, required installations for the connection to the district heating grid, construction of fuel storage and handling infrastructure, construction of CO2 handling and storage infrastructure.

Factory prefabrication of the complete e-methanol synthesis plant will be carried out by subcontractors closely monitored by the REintegrate project manager and engineering team. The procurement and/or production of long lead items including the electrolyzer will be initiated in due time to meet the deadline for site installation.

Site installation of all equipment including the e-methanol synthesis plant, the electrolyzer, final approval and line walk of the complete facility. Commissioning of the entire plant and production ramp-up.

Milestones:

Site preparations completed (M24)

Factory prefabrication completed (M30)

Site installations completed (M34)

Production ramp-up completed (M36)

**Work package 5: Operation (M36-M60)**

This work package covers the first 2 years of production with the required fine tuning of the production plant. This work also covers the first years of fuel supply to the early adopters of e-methanol and secures the required technical and financial support to enable the end-use cases.

Milestones:

First delivery of e-methanol to end-user (M36)

End of financial support period (M60)

**Work package 6 – FC vehicle development, integration, and validation (M1 – M48)**

This WP focusses on further development and optimization of BWT’s methanol-powered fuel cell platform for medium- to heavy-duty application (light commercial vehicles, heavy-duty trucks / busses, and maritime application). Power demands for road mobility varies between 25 kW to 100 kW and between 200 kW to multiple MW for marine application. Based on BWT’s automotive blueprint (TRL7), a modular HT-PEMFC platform is developed and demonstrated (TRL7-8) in a fleet of medium- to heavy-duty vehicles during the CCU Hub Aalborg project. Tasks included in the WP are:

* Optimization of the core HT-PEMFC technology (MEA, bipolar plates, methanol reformer and BoP) to ensure high performance and durability (Extended lifetime ~20,000 hours)
* Design and development of a dedicated modular HT-PEMFC range-extender platform (based on the automotive blueprint developed by BWT), with focus on optimal hybridization and operation between vehicle, batteries, and FC.
* Iterative development, integration, and demonstration of the developed range-extender solution to increase the maturity level towards TLR8-9 for the different heavy-duty applications (trucks, van, maritime, busses etc.).

Milestones:

Heavy-duty fuel cell range-extender platform developed and validated (M30)

Vehicle integration and validation completed (M48)

**Work package 7 – Infrastructure deployment and vehicle operation (M40 – M60)**

The produced methanol is distributed to end-users through the existing infrastructure used by fossil fuels (tanker trucks). For refueling purposes, the necessary refueling infrastructure supporting early market demands will be deployed. The vehicles with HT-PEMFC range-extenders are certified for on-road usage and commercially demonstrated by selected end-user during a period of 12 months.

Milestones:

Refueling infrastructure deployment (M48)

Vehicle demonstration (M60)

**Work package 8: Management and dissemination (M1-M60)**

This work package concerns the project management activities including the financial and technical reporting towards the funding body.

Dissemination activities will be carried out under this work package including quarterly update of a dedicated project website hosted and managed by REintegrate. The website will communicate all non-confidential aspects of the project to ensure the obtained knowledge is made available to stakeholders across Europe.

REintegrate will work with other stakeholders and networks to disseminate the project results to as broad an audience as possible. GreenLab is planning to establish an innovation and visitor center at their site in GreenLab Skive. A dedicated area in the building will be allocated to showcase recent photos and descriptions of the Green CCU Hub Aalborg plant. REintegrate will host interns from Aalborg University and other Danish universities to allow the students to get hands-on experience with all aspects of the PtX value chain.

Re-integrate commits to undertake the following dissemination actions of non-IP protected results from the IPCEI on Hydrogen:

* Share results with the scientific & technological community through conferences/workshops
* Share results with the scientific & technological community through publications
* Share results with the scientific & technological community through the participation in large European research projects (e.g. Horizon Europe)
* Share Results with the scientific & technological community through R&D collaborations with universities and public research organizations
* Share results with the scientific & technological community through actions in industry associations
* Set up/ Participate in courses & training
* Set up/Participate in apprenticeship programs

Milestones:

Project website established (M3)

Project communication plan developed (M6)

Planned dissemination activities completed (M60)

Without the requested financial support, it is not economically viable to establish the Green CCU Hub Aalborg. At this scale, the economic risk is too large for the project to be realized on commercial terms alone. Although the participating end-users are ready to cover part of the cost premium over fossil fuels, the cost of the produced green fuel will be too high to secure offtake agreements and make the project bankable. In addition, being the first industrial deployment at this scale entails a significant technical risk that is too high to be covered by the companies alone. Consequently, without the requested support, the project will not be realized in the described form resulting in a significantly slower deployment of PtX in Denmark. REintegrate estimates that the requested funding will leverage a deployment of 500-1000 MW of electrolyzer capacity before 2030. Without public cost share, the deployment will be much less, on the order of 100-150 MW before 2030.

On the regulatory side, the realization of the Green CCU Hub Aalborg project does not presume any special conditions in terms of the existing regulations related to the energy market and the transport of electricity in the public transmission grid. As mentioned in the budget section, paying electricity transport tariffs to the grid puts a significant burden on the project economics and hence a relatively large public cost share is requested.

On the permitting side, REintegrate has experience from the GreenLab Skive PtX and based hereon no critical issues are foreseen with the proposed plant in Aalborg. Port of Aalborg support this viewpoint as owner of the planned construction site and with their experience from construction and operation of the large fuel infrastructure facilities at Port of Aalborg. To ensure a smooth permitting phase, REintegrate and European Energy will engage with a consulting engineer company. Altogether, the permitting phase is expected to take a maximum of 18 months including the preparation of documents.

# Afsnit 8: Samtykke til behandling og deling af informationer

De indsendte informationer vil håndteres i overensstemmelse med databeskyttelsesforordningen, og den udarbejdede samtykkeerklæring i anneks 3, der uddyber ansøgers rettigheder for informationsdeling.

[Du bedes her angive, om du vil give dit samtykke til, 1) at dine oplyste kontaktoplysninger mv. behandles af Erhvervsstyrelsen (JA/NEJ) JA

og 2) om du vil give samtykke til, at oplysningerne deles med Kommissionen og andre danske myndigheder virksomheder (JA/NEJ)] JA

Læs mere om samtykket og dine rettigheder i Anneks 3 om samtykkeerklæring.

1. Meddelelse nr. 2014/C 188/02 om kriterier for analysen af, hvorvidt statsstøtte til fremme af gennemførelsen af vigtige projekter af fælleseuropæisk interesse er forenelig med det indre marked Meddelelsens anvendelse er forlænget til den 31. december 2021 i henhold til Europa-Kommissionens meddelelse nr. 2020/C 224/02. [↑](#footnote-ref-1)
2. Meddelelse fra Kommissionen ”En strategi for brint med henblik på et klimaneutralt Europa” ([Link](https://eur-lex.europa.eu/legal-content/DA/TXT/PDF/?uri=CELEX:52020DC0301&from=DA)) [↑](#footnote-ref-2)
3. Læs her for nærmere definition fra Europa-Kommissionen: <https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf> [↑](#footnote-ref-3)
4. Fremtidens grønne løsninger - Strategi for investeringer i grøn forskning, teknologi og innovation, s. 21 ([Link](https://ufm.dk/publikationer/2020/filer/1-fremtidens-gronne-losninger-strategi-for-investeringer-i-gron.pdf)) [↑](#footnote-ref-4)