# POWER SECTOR CARBON CAPTURE AND STORAGE GRANT CALL

Issued on 21 October 2024

**Energy Market Authority**

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## INTRODUCTION

1. The power sector currently accounts for about 40% of Singapore's primary greenhouse gas emissions. Decarbonising power generation is therefore instrumental in enabling Singapore to achieve net-zero emissions by 2050.

2. In 2019, we announced the Singapore Energy Story, and laid out the plans to decarbonise the power sector and help Singapore achieve its climate commitments while ensuring that our power system remains secure and reliable. Four supply "switches" were identified to transform our fuel mix – Natural Gas (NG), solar, regional power grids, and low-carbon alternatives. To achieve our net-zero emissions target, EMA continues to explore multiple low-carbon alternatives for the power sector, which include Power Sector Carbon Capture and Storage (Power Sector CCS).

3. EMA is exploring two pathways for Power Sector CCS: (a) Post-Combustion Carbon Capture for Natural Gas Combined Cycle Gas Turbines (NG CCGT)[1] and (b) Pre-Combustion Carbon Capture[2] to produce low-carbon hydrogen ($H_2$) for power generation. CCS pathways may offer the advantage of allowing the power sector to leverage existing NG infrastructure while achieving our decarbonisation goals. Further, recent developments have paved the way for EMA to establish a strategy for Power Sector CCS.

4. Firstly, the Government appointed a CCS lead developer (S-Hub, a consortium comprising Shell and ExxonMobil) to study the viability of developing a cross-border CCS project at Jurong Island (JI) involving the onshore aggregation of carbon dioxide ($CO_2$) for storage, liquefaction and export overseas. There could be economies of scale and benefits to be reaped if the power sector taps on the JI CCS project.

5. Secondly, there is renewed interest in several countries to use $CO_2$ capture technologies and some countries have embarked on projects to capture $CO_2$ from CCGTs and $H_2$ Auto-Thermal Reforming (ATR) plants, as provided in Table 1 below. Most of these are in the midst of conducting engineering studies and there are no large-scale Power Sector CCS plants in operation yet. However, the earliest project could be completed by 2025 while the others could be completed by the end of the decade.

6. Based on industry studies, the cost of electricity from CCS technologies could be competitive when compared to other low-carbon alternatives for power generation. Nonetheless, considering the nascency of CCS technology and uncertainties around land-take and cost, EMA would like to conduct a Power Sector CCS Grant Call to

[1] Post-Combustion Carbon Capture for natural gas power plants refers to the installation of an onsite $CO_2$ capture unit to capture $CO_2$ from flue gas produced during the combustion of natural gas in Natural Gas Combined Cycle Gas Turbine (NG CCGT). Post-Combustion Carbon Capture can also be referred to as NG CCGT + CCS.

[2] Pre-Combustion Carbon Capture in this case specifically refers to the installation of an onsite $CO_2$ capture unit to capture $CO_2$ generated during the production of $H_2$ from natural gas in an Auto-Thermal Reforming process (ATR). The $H_2$ would be transported from the ATR plant to a CCGT to be used for power generation. $H_2$ produced from ATR plants can also be referred to as Blue $H_2$. Other means of Blue H2 production, such as via Steam Methane Reforming (SMR) with carbon capture, is not considered due to increased cost associated with carbon capture from SMR's lower concentration and lower pressure $CO_2$ flue gas stream.

further study the feasibility of Power Sector CCS pathways for Singapore, particularly for the onshore portion which includes onsite $CO_2$ capture and transport.

**Table 1: List of several upcoming Power Sector CCS projects around the world[3]**

| Power Sector CCS Pathway | Company | Location | Stage | Estimated Commercial Operations Date |
|---|---|---|---|---|
| Pre-Combustion Carbon Capture | Linde | Texas, USA | Under Construction | 2025 |
| Pre-Combustion Carbon Capture | Inpex / Air Liquide (Pilot Plant) | Kashiwazaki, Japan | Under Construction | 2025 |
| Post-Combustion Carbon Capture | MHI / KEPCO (Pilot Plant) | Hyogo, Japan | Under Construction | 2026 |
| Post-Combustion Carbon Capture | Calpine (Sutter Energy Center) | California, USA | Under Construction | 2027 |
| Post-Combustion Carbon Capture | British Petroleum / Equinor (Net Zero Teesside) | Teesside, UK | Under Construction | 2027 |
| Pre-Combustion Carbon Capture | Kellas (H2NorthEast) | Teesside, UK | Front-End Engineering Design | 2030 |

## OBJECTIVE OF POWER SECTOR CCS GRANT CALL

7. The objective of the Power Sector CCS Grant Call is to select power generation companies and/or industry partners ("Participants") to co-fund and conduct site-specific feasibility studies[4] for (a) Post-Combustion Carbon Capture and/or (b) Pre-Combustion Carbon Capture. The feasibility studies will allow the industry and EMA to deepen our understanding of the Power Sector CCS pathways, identify infrastructure and site-specific requirements, and obtain better land and cost estimates for different sites.

[3] As of September 2024.

[4] Feasibility studies refer to studies that are conducted before the pre-FEED stage. Feasibility studies should provide AACE Class 4 estimates with a +50/-30% accuracy range.

8. The findings from the feasibility studies would also be a useful base to conduct more detailed preliminary Front End Engineering Design (pre-FEED)[5] and FEED studies in future, in order to support decision-making and development of pilot plants[6]. Depending on the progress and results of these engineering studies, and discussions with the S-Hub consortium for additional $CO_2$ storage capacity, a Power Sector CCS project could commence operations around the mid-2030s.

9. As part of the feasibility studies, proposals for fiscal support to achieve industry-standard return benchmarks and cost optimisation would be welcomed and could be studied further for any potential plants in the future.

## OVERVIEW OF REQUIREMENTS FOR POWER SECTOR CCS GRANT CALL

10. There will only be a maximum of 5 grants awarded across both Power Sector CCS pathways for the feasibility studies.

11. Participants may submit a proposal for (a) Post-Combustion Carbon Capture, (b) Pre-Combustion Carbon Capture, or (c) both. Those who submit proposals for both Post-Combustion and Pre-Combustion pathways will not be viewed more favourably than those who submit a proposal for only one pathway.

12. Participants should state in their proposal the parties involved and their respective roles for the feasibility study. They should also identify the engineering consultant(s) for the feasibility study. The consultant(s) should have some experience and track record in conducting such studies.

13. Only 600 MW H-class CCGTs should be considered for the Post-Combustion and Pre-Combustion Carbon Capture feasibility studies.

14. For cases where the H-class CCGT(s) are planned before 2035, Participants may propose a retrofitting plan or to pre-invest to future proof these CCGTs to be either carbon capture ready and/or ready for integration with ATR + CCS at the onset with a plan to deploy CCS at a later date.

15. The projects should be on Jurong Island and/or Tuas so that they are near the JI CCS aggregation and export facility. This would reduce the complexity of the required $CO_2$ pipeline network.

### (A) Post-Combustion Carbon Capture Feasibility Study

16. The Post-Combustion Carbon Capture feasibility study proposal should follow up from earlier pre-feasibility studies (Refer to Paragraph 24 for more info) to refine the results and should cover the following areas:

a. Provide site-specific Association for the Advancement of Cost Engineering (AACE) Class 4 estimates (+50%/-30%) for the following:

[5] Pre-FEED studies should provide AACE Class 3 estimates with a +30/-20% accuracy range.

[6] Pilot plants refer to the 1st post-combustion carbon capture plant and 1st pre-combustion carbon capture plant in Singapore.

i. Levelised Cost of Electricity (LCOE);
ii. Levelised Cost of $CO_2$ Capture (LCOC);
iii. Levelised Cost of $CO_2$ Avoidance (LCOA);
iv. Capital Expenditures (CAPEX);
v. Operating Expenditures (OPEX);
vi. Land footprint of the Post-Combustion Carbon Capture unit; and
vii. Overall project life cycle $CO_2$ emissions in tonnes $CO_2$/MWh.

b. Assess the technical feasibility of carbon capture for H-class CCGT at a specific site of choice on Jurong Island or Tuas. This should include the following:

i. Availability of land for the Post-Combustion Carbon Capture unit, including the size of the plot space and layout. The unit should be located near the CCGT to reduce the process cost and supporting infrastructure such as pipelines needed to transport the flue gases, and factor in surrounding facilities. Participants are strongly encouraged to utilise their own premises or refer to sites indicated in the Centralised Process, for the Post-Combustion Carbon Capture unit. Participants which do so will be assessed more favourably. If new sites are required for the carbon capture facilities, Participants should consult JTC in advance to determine if there are available sites near the identified H-class CCGTs;

ii. Requirements and availability of utilities (e.g. seawater for cooling, low-pressure steam, electricity) for the Post-Combustion Carbon Capture process and impact on overall power generated by the H-class CCGT, if any. Assume that the steam and electrical utilities needed for Post-Combustion Carbon Capture process are obtained from the CCGT directly (i.e. parasitic load). Any heat and cold integration, if available, to reduce overall energy consumption should also be studied;

iii. Integration of the H-class CCGT and the Post-Combustion Carbon Capture unit including all process and utilities tie-ins;

iv. Determine the optimal $CO_2$ capture unit capacity and $CO_2$ exit stream composition of the Post-Combustion Carbon Capture unit based on the H-class CCGT's operating profile, baseload and peak power generation capacity and S-hub's $CO_2$ pipeline specifications; and

v. Any other areas that should be assessed for the specific site.

c. Provide a timeline for developing a H-class CCGT + CCS project.

d. Identify any regulatory and government support required for the project.

e. All other areas that should be included in the feasibility study to ensure there are no commercial or technical showstoppers for the project.

**(B) Pre-Combustion Carbon Capture Feasibility Study**

17. The Pre-Combustion Carbon Capture feasibility proposal should follow up from earlier pre-feasibility studies (Refer to Paragraph 26 for more info) to refine the results and should cover the following areas:

a. Provide site-specific AACE Class 4 estimates (+50%/-30%) for the following:

   i. LCOE;
   ii. LCOC;
   iii. LCOA;
   iv. Levelised Cost of Hydrogen;
   v. CAPEX;
   vi. OPEX;
   vii. Land footprint of the integrated $H_2$ ATR plant and Pre-Combustion Carbon Capture unit; and
   viii. Overall project life cycle carbon emissions in tonnes $CO_2$/MWh.

b. Assess the technical feasibility of the integrated $H_2$ ATR and Carbon Capture unit at a specific site of choice on Jurong Island or Tuas and supply of $H_2$ to H-class CCGT:

   i. Availability of land for the integrated $H_2$ ATR plant and Pre-Combustion Carbon Capture unit, including the size of the plot space and layout. Participants are strongly encouraged to utilise their own premises, if available, for the ATR plant and Pre-Combustion Carbon Capture unit. Participants which do so will be assessed more favourably. If new sites are required, Participants should consult JTC in advance to determine if there are available sites on Jurong Island;

   ii. Technical integration of the ATR and Carbon Capture unit, and downstream $H_2$ pipeline network from the ATR to the H-class CCGT;

   iii. On-site blending of $H_2$ (starting with minimum 30-vol% $H_2$ and potentially rising up to 100-vol% $H_2$) with NG at the H-class CCGT;

   iv. Determine the optimal $H_2$ production capacity and associated $CO_2$ capture rate and $CO_2$ exit stream composition of the Pre-Combustion Carbon Capture unit based on the ATR plant, CCGT's operating profile and S-hub's $CO_2$ pipeline specifications;

   v. Design for potential expansion of ATR and carbon capture unit capacity and $H_2$-readiness of H-class CCGT for blended H2 power generation starting with 30-vol% $H_2$ and potential expansion to 100-vol% $H_2$; and

   vi. Identification of any required utilities including any opportunities for heat and cold integration to reduce overall energy consumption.

c. Provide a timeline for the project.

d. Identify any regulatory and government support required for the project.

e. All other areas that should be included in the feasibility study to ensure there are no commercial or technical showstoppers for the project.

## GRANT QUANTUM AND SUPPORT RATE

18. The total amount of EMA grant support is subjected to a maximum cap of S$350,000 or 50% of the cost of the feasibility study, whichever is lower. The S$350,000 number is an indicative figure, and it can be changed at EMA's discretion.

19. All grant disbursements will be made on a reimbursement basis, based on the achievement of appropriate project milestones, submission of relevant invoices, and proof of payment.

## QUALIFYING COSTS

20. Qualifying costs for the feasibility studies include (non-exhaustive):
    a. Technical software; and/or
    b. Professional services (e.g. consultants, site surveys, testing, inspection, and certification approval).

21. Non-qualifying cost items for the feasibility studies include (non-exhaustive):
    a. Internal manpower cost, i.e. salaries and overheads of Participants' staff involved in the feasibility studies;
    b. All cost items that are not used exclusively for the feasibility studies, unless the qualifying cost for that item can be suitably pro-rated;
    c. All cost items that have already been supported by another grant awarded by a Singapore government agency; and
    d. Payments to a related party[7] for professional services.

22. Refer to Annex A for more details on the qualifying costs. All taxes, including but not limited to Singapore Goods and Services Tax and withholding taxes, are excluded**.**

## TIMELINE OF FEASIBILITY STUDIES

23. To qualify for EMA's feasibility grant, the feasibility studies should commence no later than 31 May 2025 and must be completed by 31 January 2026.

[7] A related party is determined with reference to International Accounting Standards 24 – Related Party Disclosures.

## (A) ELIGIBILITY CRITERIA FOR THE POST-COMBUSTION CARBON CAPTURE GRANT CALL

Eligibility Criteria

24. To be eligible for the Post-Combustion Carbon Capture Grant Call, Participants must fulfil all of the following criteria:

a. The power generation company partner must be operating or is bidding to operate a H-class CCGT in Singapore by 2035. A Post-Combustion Carbon Capture pre-feasibility study for H-class CCGTs must have been completed not more than 12 months prior to the submission of this proposal. This could be in the form of an in-house or external pre-feasibility study.

   i. The study should demonstrate its technical feasibility (e.g. technical integration of the Post-Combustion Carbon Capture unit with the CCGT) and economic viability (in comparison to other low-carbon pathways like ammonia and imported $H_2$) for the CCGT to be decarbonised with CCS. The $CO_2$ capture rate must be at least 90%;

   ii. The study should also provide at least AACE Class 5 estimates (+100%/-50%) of the cost and land footprint of the Post-Combustion Carbon Capture unit with the CCGT; and

   iii. The full original pre-feasibility study report must be submitted to EMA as part of the Grant Call's list of submission documents.

b. The H-class CCGT is located on Jurong Island or Tuas to ensure it is located near the JI CCS project.

Evaluation Criteria

25. Participants' Post-Combustion Carbon Capture proposals will be evaluated according to the following criteria:

a. Amount of additional land-take required for the Post-Combustion Carbon Capture unit, including any additional wayleave required for the transport of flue gas from the H-class CCGT to the Post-Combustion Carbon Capture unit (40%).

   i. The land can be located Inside Battery Limits (ISBL) of the H-class CCGT or Outside Battery Limits (OSBL) or a mixture of both; and

   ii. If Participants intend to use land from OSBL, they should obtain JTC's in-principle approval that the land is available before submitting a proposal to EMA. Otherwise, EMA will disregard the OSBL proportion of the land when evaluating the proposal.

      - Participants should engage pipe rack service providers to determine the feasibility of pipeline connection along the service

corridor. If additional wayleave along the service corridor is required, Participants (along with the relevant pipe rack service provider) should consult JTC.

b. Quality of Post-Combustion Carbon Capture feasibility proposal (40%). Refer to Paragraph 16 for more info.

c. Absolute amount of requested EMA funding for the Post-Combustion Carbon Capture feasibility study (20%).

**(B) ELIGIBILITY CRITERIA FOR THE PRE-COMBUSTION CARBON CAPTURE GRANT CALL**

26. To be eligible for the Pre-Combustion Carbon Capture Grant Call, Participants must fulfil all of the following criteria:

Eligibility Criteria

a. The power generation company partner for the feasibility study must be operating a H-class CCGT in Singapore by 2035 that is at least 30-vol% $H_2$-ready. A Pre-Combustion Carbon Capture pre-feasibility study must have been completed not more than 12 months prior to the submission of this proposal. This could be in the form of an in-house or external study.

   i. The study should cover the manufacture of $H_2$ from NG via ATR with carbon capture, and associated $H_2$ pipelines from the ATR plant to the H-class CCGT;

   ii. The study should also provide at least AACE Class 5 estimates (+100%/-50%) of the cost and land footprint for both the integrated ATR and CCS facility, and H-class CCGT; and

   iii. The full original pre-feasibility study report must be submitted to EMA as part of the Grant Call's list of submission documents.

b. ATR plant and H-class CCGT are located on Jurong Island or Tuas to ensure they are located near the JI CCS project.

Evaluation Criteria

27. Participants' Pre-Combustion Carbon Capture proposals will be evaluated according to the following criteria:

a. Amount of additional land-take required for the ATR plant (inclusive of Pre-Combustion Carbon Capture unit), and any additional wayleave required for the transport of $H_2$ from the ATR plant to the H-class CCGT (40%).

   i. The land for the ATR plant can be located ISBL of the H-class CCGT or OSBL or a mixture of both; and

ii. If Participants intend to use land from OSBL, they should obtain JTC's in-principle approval before submitting a proposal to EMA. Otherwise, EMA will disregard the OSBL proportion of the land when evaluating the proposal.

- Participants should engage pipe rack service providers to determine the feasibility of pipeline connection along the service corridor. If additional wayleave along the service corridor is required, the Participants (along with the relevant pipe rack service provider) should consult JTC.

b. Quality of Pre-Combustion Carbon Capture feasibility proposal (40%). Refer to Paragraph 17 for more info.

c. Absolute amount of requested EMA funding for the Pre-combustion Carbon Capture feasibility study (20%).

## APPLICATION

28. EMA invites Participants to submit proposals, using the format set out in **Annex B: Feasibility Project Proposal Template**, on conducting Power Sector CCS feasibility studies for co-funding support. The application window for the Power Sector CCS Grant Call takes immediate effect and proposals should reach EMA by 31 January 2025.

29. EMA will evaluate the proposals based on the Eligibility and Evaluation Criteria as stated earlier. Successful proposals which are accepted and approved by EMA can expect notification by 31 March 2025.

## OFFICIAL POINT OF CONTACT

30. For the purposes of this Power Sector CCS Grant Call, the official Points of Contact ("POC") are:

**Table 2: Official POC from EMA**

| Name | Email Address |
|---|---|
| Bryan Tan | bryan_tan@ema.gov.sg |
| Ho Wai Ying | ho_wai_ying@ema.gov.sg |

31. Participants shall provide its official contact details (as specified in Table 3) for the official POC from EMA (as listed in Table 2). This is to facilitate communications between the POC and EMA, so that any official information or notification regarding the Power Sector CCS Grant Call can be disseminated expediently to the Participants. Should there be any change to the official POC during the Power Sector CCS Grant Call process, there shall be an update to EMA in writing as soon as possible.

**Table 3: Official POC**

| | |
|---|---|
| Name | |
| Designation | |
| Email | |
| Contact Number | |

**SUBMISSION**

32. All proposals must be submitted via email to the EMA POC in Table 3 above. For avoidance of doubt, physical proposal submissions will be disregarded without further reference to the Participants.

## Annex A – Details of the Qualifying Cost Items

| **General Policy** | |
|---|---|
| No cost item should be treated as qualifying unless it has been expressly set out as such in the grant approved and awarded by EMA. The procurement of such cost items must be made according to the formal established and consistently applied policies of the Participants.<br><br>The invoices for all claims must be dated before the completion of the feasibility studies. | |
| **Technical Software** | |
| Qualifying Cost Items | The qualifying costs for technical software refer to the purchase price, lease payments or licensing fees incurred for the period of use of the technical software for the project during the qualifying period. |
| Non-Qualifying Cost Items | Non-supportable items include any financing interest for technical software that is leased. |
| **Professional Services** | |
| Qualifying Cost Items | The qualifying costs for professional services refer to costs incurred for consultancy (including measurement and verification), subcontracting, and testing and certification approval services that are necessary for the project, performed in Singapore by Singapore-based service providers.<br><br>Consultancy costs incurred no more than 3 months prior to the start of the qualifying period, for the purpose of baseline measurement only, may be supported.<br><br>Consultancy costs incurred up to 3 months after the end of the qualifying period, for the purpose of post-study measurement and verification only, may be supported. |
| Non-Qualifying Cost Items | • Entertainment & refreshment<br>• Fines and penalties<br>• Legal fees<br>• Costs incurred in relation to internal/external audit of claims or project milestone achievements<br>• Patent application. This includes patent application, registration, filing, maintenance and other related cost.<br>• Payments to a related party for professional services. |

## Annex B: Feasibility Project Proposal Template

<table>
<tr><td colspan="2">Title</td></tr>
<tr><td colspan="2">Participants should acknowledge and declare that they have met the Eligibility Criteria for Post/Pre-Combustion Carbon Capture, whichever applicable before submitting a proposal.</td></tr>
<tr><td>Project Description</td><td><u>Details of CCGT</u><br>• Specify the technical specifications of the CCGT and/or relevant supporting equipment (including capacity of CCGT and/or equipment, economic lifespan).<br>• Specify the CCGT’s projected usual operating conditions (e.g. average load factor, gross and net heat rate and efficiency on a Higher Heating Value (HHV) basis, amount of fuel used per year, plant emission factor ($tCO_2$/MWh) etc).<br>• Provide location plan, plot space (ha) and plant layout of the CCGT.<br><br><u>Details of the proposed Post/Pre-Combustion Carbon Capture process</u><br><br>(A) For Post-Combustion Carbon Capture Process<br><br>• Provide preliminary technical specifications (e.g. proposed capacity and $CO_2$ capture percentage) of the Post-Combustion Capture unit, cooling water pipelines, flue gas pipelines and $CO_2$ pipelines required.<br>• Provide a preliminary assessment of the energy penalty. Assume that steam and electrical utilities for the carbon capture process will be provided via parasitic load from the CCGT (i.e. the CCGT needs to run at a higher plant load factor).<br>• Propose cooling utility and design for the post combustion capture process. If seawater cooling is used, provide a preliminary assessment on the required amount of seawater as cooling utilities for a CCGT + CCS plant, and whether the site has access to sufficient seawater.<br>• Provide a preliminary assessment of the technical integration feasibility of the CCGT and Post-Combustion Carbon Capture unit.<br>• Specify the CCGT’s projected new operating conditions (e.g. load factor, heat rate and efficiency (gross and net HHV basis), amount of fuel used per year, CCGT’s plant emission factor ($tCO_2$/MWh) for Post-Combustion Carbon Capture process.</td></tr>
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| | |
|---|---|
| | • General process description and block flow diagram of proposed CCGT + Post-Combustion Carbon Capture operation.<br>• Provide preliminary plot layout.<br><br>***(B) For Pre-Combustion Carbon Capture Process***<br><br>• Provide preliminary technical specifications (e.g. proposed capacity and $CO_2$ capture percentage) of the $H_2$ ATR plant, Pre-Combustion Carbon Capture unit, $CO_2$ pipelines and $H_2$ pipelines required.<br>• Specify the CCGT's projected new operating conditions (e.g. load factor, heat rate and efficiency (gross and net HHV basis), amount of fuel used per year, $H_2$ ATR plant's emission factor ($tCO_2$/MWh) for Pre-Combustion Carbon Capture process.<br>• Provide a preliminary assessment of the energy penalty, and whether there is sufficient utilities for the ATR and pre-combustion carbon capture process.<br>• General process description and block flow diagram of proposed Pre-Combustion Carbon Capture operation.<br>• Provide preliminary plot layout. |
| **Projected key cost and land figures for Post / Pre-Combustion Carbon Capture** | **Provide <u>estimated (i) cost and (ii) land required</u> for the Post / Pre-Combustion Carbon Capture process:**<br>• Provide the projected cost (e.g. LCOE / LCOC / LCOA / CAPEX / OPEX) and the calculations behind them.<br>• Identify a site and provide a breakdown of the amount of land required for the Post-Combustion Carbon Capture unit OR $H_2$ ATR production plant + Pre-Combustion Carbon Capture unit and pipelines.<br>• List down all assumptions made in the above computation, including but not limited to:<br>  ○ Estimated fuel cost<br>  ○ Amount of fuel required<br>  ○ Economic lifespan of CCGT and / or $H_2$ ATR plant<br>  ○ CCGT plant load factor<br>  ○ $CO_2$ capture capacity of Post / Pre-Combustion Carbon Capture unit<br>  ○ Utilisation factor of Post / Pre-Combustion Carbon Capture unit<br>  ○ $CO_2$ capture rate<br>  ○ Cost of $CO_2$ liquefaction and transport to $CO_2$ aggregation facilities on Jurong Island. |

| | |
|---|---|
| | |
| **Project Timeline and Milestones** | **Provide <u>timeline of the key milestones</u> of the feasibility study and project including but not limited to the following:**<br>• Feasibility study commencement date<br>• Feasibility study completion date and submission of Final Report |
| **Feasibility Study Costs** | **Provide detailed cost breakdown of the following including supporting quotations for all cost components:**<br>• Technical software<br>• Professional services (including details of professional's designation, experiences, manhours and unit costs) |
| **Risk Assessment and Mitigation Plan** | Provide detailed project risk assessment and mitigation plans for CCGT + Post-Combustion Carbon Capture OR $H_2$ ATR plant + Pre-Combustion Carbon Capture unit + CCGT breakdown. |
| **Feasibility Project Leader / Point-of Contact** | Provide contact details of Project Leader / Point-of Contact managing the feasibility study. |
| **Feasibility Study Consultant** | Provide details of the identified engineering consultant for the feasibility study. |
| **Feasibility Study Participants** | If applicable, provide list of feasibility study participants (i.e. power generation companies and/or industry partners) and roles. |
| **Summary of Feasibility Study Proposal** | **Provide a summary of the proposed feasibility study using the template provided in the Appendix to Annex B.** |

**Appendix to Annex B – Summary of Feasibility Study Proposal**

*This section should not exceed 2 pages, with the prescribed format (i.e. font in black) to be strictly adhered to. Font in red italics (including this heading) are to be deleted and replaced with the necessary information.*

| |
|---|
| **Participant(s) should acknowledge and declare that they have met the Eligibility Criteria for Post/Pre-Combustion Carbon Capture, whichever applicable before submitting a proposal.**<br><br>**Name of Participant(s): *X***<br>**Unique Entity Number: *X***<br>**Date of Proposal Submission: *X*** |
| **Feasibility Study Description**<br>• *X*<br><br>*Please provide a brief summary (in point form and not more than 200 words) of the proposed feasibility study proposal.* |
| **Feasibility Study Timeline and Milestones**<br>• Qualifying Period: *Commencement date* to *End date* (*X* months)<br>• Payment Milestone 1 (*X*%): *Estimated date* (*description of milestone*)<br>• Payment Milestone 2 (*X*%): *Estimated date* (*description of milestone*)<br>• Payment Milestone *X* (*X*%): *Estimated date* (*description of milestone*)<br><br>*Please add more milestones as necessary, up to a maximum of 4 milestones. X% refers to the percentage of total grant tied to that payment milestone.* |
| **Projected key cost and land figures including key assumptions for Post/Pre-Combustion Carbon Capture (all figures should be in SGD)**<br><br>NG price is assumed to be $ XX / MMBTU (Refer to Vesting Contract)<br><br>• Projected LCOE for Post/Pre-Combustion Carbon Capture = $ X / MWh<br>• Projected LCOC for Post/Pre-Combustion Carbon Capture = $ X / tonne $CO_2$ captured<br>• Projected LCOA for Post/Pre-Combustion Carbon Capture = $ X / tonne $CO_2$ avoided<br>• Key assumptions<br><br>(For Post-Combustion Carbon Capture)<br>• Projected CAPEX of Post-Combustion Carbon Capture unit = $ XX<br>• Projected OPEX of Post-Combustion Carbon Capture unit = $ XX<br>• Projected optimal $CO_2$ capture capacity of Post-Combustion Carbon Capture unit = X MTPA $CO_2$, including any fluctuations with CCGT utilisation rate and future plan for expansion in capacity (if any)<br>• Projected utilisation factor of Post-Combustion Carbon Capture unit = X%<br>• Projected $CO_2$ capture rate = X%<br>• Projected overall carbon intensity of CCGT + CCS = X tonnes $CO_2$ / MWh |

- Projected amount of land required and site(s) identified for Post-Combustion Carbon Capture unit and CCGT = X ha (CCGT) + Y ha (Post-Combustion Carbon Capture unit) + any wayleave and additional land / seafront space for utilities
- Key assumptions

(For Pre-Combustion Carbon Capture)
- Projected CAPEX of $H_2$ ATR plant (inclusive of Pre-Combustion Carbon Capture unit) = $ XX
- Projected OPEX of $H_2$ ATR plant (inclusive of Pre-Combustion Carbon Capture unit) = $ XX
- Projected optimal $CO_2$ capture capacity of Pre-Combustion Carbon Capture unit = X MTPA $CO_2$
- Projected utilisation factor of Pre-Combustion Carbon Capture unit = X%
- Projected $CO_2$ capture rate = X%
- Projected overall carbon intensity of $H_2$ produced from ATR + Pre-Combustion Carbon Capture = X tonnes $CO_2$ / MWh
- Projected amount of land required and site(s) identified for $H_2$ ATR plant (inclusive of Pre-Combustion Carbon Capture unit) and CCGT = X ha (CCGT) + Y ha ($H_2$ ATR plant) + Z ha (Pre-Combustion Carbon Capture unit) + any wayleave and additional land / seafront space for utilities
- Key assumptions

**Cost breakdown of feasibility study**
- Technical software: $*X*
- Professional services: $*X*
- Total: $*X*
- Absolute amount of requested EMA funding for the feasibility study: $*X*

**Risk Assessment and Mitigation Plan**
- *X*

*Please provide a brief summary (in point form and not more than 100 words) of the project risk assessment and mitigation plans for CCGT + Post-Combustion Carbon Capture unit breakdown OR $H_2$ ATR plant + Pre-Combustion Carbon Capture unit + CCGT breakdown.*

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**Total projected $tCO_2e$ abated throughout the lifespan of the Post/Pre-Combustion Carbon Capture Unit**
- *X* $tCO_2e$ = *Projected annual carbon abatement × remaining economic lifespan of CCGT*
- Key assumptions