EXPRESSION OF INTEREST (EOI) TO DEVELOP AN END-TO- END LOW OR ZERO-CARBON AMMONIA POWER GENERATION AND BUNKERING SOLUTION ("PROJECT") IN SINGAPORE

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ENERGY MARKET AUTHORITY
991G Alexandra Road #01-29, #02-29
Singapore 119975
www.ema.gov.sg

MARITIME AND PORT AUTHORITY OF SINGAPORE
460 Alexandra Road mTower #19-00
Singapore 119963
www.mpa.gov.sg

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1. INTRODUCTION

1.1 As a clean fuel that can be used to generate electricity, low or zero-carbon hydrogen has the potential to decarbonise our power grid. Beyond the power sector, low or zero-carbon hydrogen is also a promising decarbonisation pathway for our energy and chemicals, maritime and aviation sector.

1.2 Due to its low energy density, hydrogen gas will need to be liquefied or converted into a hydrogen carrier for transport and storage. Ammonia is currently one of the most technologically-ready hydrogen carriers as it has an established supply chain with multiple end-use pathways.

1.3 Singapore recently launched our National Hydrogen Strategy, where we announced our intention to embark on hydrogen pathfinder projects, beginning with the use of ammonia. To that end, EMA and MPA invite interested parties ("Participant") to submit a proposal ("Proposal") to a **non-binding Expression of Interest** ("**EOI**") to build, own and operate an end-to-end low or zero-carbon ammonia power generation and bunkering solution in Jurong Island, Singapore ("Project").

2. PURPOSE OF EOI

2.1. The EOI will allow EMA, MPA and other relevant agencies ("Government") to assess the feasibility of developing an end-to-end solution for ammonia procurement, import, storage, distribution, and end-use for both power generation and bunkering.

2.2. The Project shall enable the verification, demonstration, and building up of local capabilities in ammonia handling to catalyse the low or zero-carbon ammonia supply chain and the hydrogen transition in Singapore.

2.3. The Project also allows the Government to work closely with industry to develop and refine policies and regulations relating to the safe utilisation of ammonia and hydrogen, the electricity market and grid, and long-term infrastructure planning.

2.4. EMA and MPA will assess the EOI and may launch a Request for Proposal (RFP) based on the returns of the EOI, to implement the project subsequently. Each of EMA and MPA also reserve the right to approach EOI Participant(s) directly after the EOI closes and commence negotiations to award the Project directly without going through an RFP.

3. OVERVIEW OF REQUIREMENTS

3.1 The purpose of the Project is to generate, at the start, a minimum of 50 MW of electricity from imported low or zero-carbon ammonia for an operational period of up to 25 years, and to support ammonia bunkering.

3.1.1 The Project should achieve net-zero carbon emissions by 2050 in line with Singapore's prevailing climate ambition.

3.2 The Participant may propose the power generation pathway, which may include but is not limited to:

3.2.1 The direct combustion of ammonia in Gas Turbines (GT)/ Combined Cycle Gas Turbines (CCGTs) or,

3.2.2 Cracking of ammonia into hydrogen for combustion in hydrogen-compatible GT/CCGTs.

3.3 The Project should be operational by 2027 or soonest possible.

3.3.1 If the minimum starting capacity of 50 MW cannot be reached by 2027 or earlier, the Participant shall define a timeline for the Project to do so.

3.4 The Participant shall also be responsible for the procurement, import, storage, and distribution of low or zero-carbon ammonia, and ammonia-derived hydrogen if applicable. The import terminal and storage facility shall be designed to cater for both power generation and bunkering requirements:

3.4.1 Power generation of minimally 50 MW, with a minimum load factor of 75%.

3.4.2 Storage and jetty designed for at least 0.1 million tons per annum (MTPA) capacity of ammonia bunkering.

3.5 The Participant may propose a phased scale-up plan for the Project beyond the initial deployment in Section 3.4. The Participant should clearly indicate the power generation and bunkering capacity that can be achieved at different stages of the scale-up (and where scale-up is mentioned in this EOI), and the corresponding infrastructure plan and resource needs (including but not limited to land and Government support if any).

3.6 The Project shall conform to all regulatory requirements, including but not limited to, those under the Environmental Protection and Management Act (EPMA), the Environmental Public Health Act (EPHA) and their Regulations.

3.7 The Project shall conform to all regulatory fire safety requirements, including but not limited to the Fire Safety Act, Fire Code and accepted codes of practice (e.g. NFPA55). Where applicable, the Participant shall propose alternative codes of practice that are fit for purpose today, or propose and partake in their development if none are currently available.

3.8 The Participant shall identify suitable location(s) on Jurong Island for the necessary infrastructure, and construct these infrastructure at the identified site. Participants may propose location(s) that support (i) standalone greenfield facility for the Project, and/or (ii) integrated facility that leverages existing facilities/infrastructure e.g. storage tanks and jetties.

3.8.1 For greenfield sites, Participants shall propose suitable locations where future expansion would be possible.

3.9 The Participant may seek potential off-takers for the ammonia-derived electricity and ammonia bunkering, and state the capacities, duration, and prices of each offtake in the proposals if they have done so. Participants are not required to show firm offtake of ammonia-derived electricity or ammonia bunkering for the purposes of this EOI, but proposals where certainty in the offtake of ammonia-derived electricity or ammonia bunkering will be viewed more favourably.

3.10 The Proposal shall specify any financial, land space and sea space requirement that may be required from the Government for the Project.

3.11 The Participant selected to implement the Project shall provide the Government with financial, technical, and operational information arising from the Project for the full duration of the Project. Amongst others, this may include:

3.11.1 Financial breakdown and projections.

3.11.2 Engineering, technical, and design/ schematics/ drawings, where applicable.

3.11.3 Environment, Health, and Safety (EHS) monitoring, including regular reviews of the adequacy of prevailing EHS regulations, and incident reporting, if any.

3.11.4 Information related to operations and maintenance.

3.11.5 Other information to be mutually agreed by all parties.

4. OPTIONAL SCOPE

4.1 The Participant may, if it so wishes, size the Project to import low or zero-carbon ammonia beyond the volumes stated in Section 3.4. The additional volumes may be used to support additional ammonia bunkering volume or be distributed to industrial off-takers.

4.1.1 If applicable, the Participant shall propose the ownership and operation model for infrastructure for the optional scope.

4.2 The Participant may suggest alternative models to Section 3.4 for putting together the supply chain needed to enable the Project, with clear justification of the benefits of doing so. These may include but are not limited to:

4.2.1 A different procurement model where the Participant is not responsible for procuring the low or zero-carbon ammonia needed.

5. FORM OF EOI

5.1 The Participant shall submit the EOI using the format set out in **Appendix A.**

5.2 The Participant should provide supporting reasons if there are deviations to the requirements set out in this EOI or if it is unable to furnish any of the commercial and technical details in **Appendix A.**

6. ASSESSMENT CRITERIA

6.1 Proposals will be assessed based on:

6.1.1 Quality and strength of Participant's technical and commercial proposals including but not limited to: land and energy efficiency optimisation, project design that allows for potential scale-up in the future, delivery timeline, and Participant's compliance to the requirements of the EOI summarised in Section 3 and detailed in Appendix A.

6.1.2 Support required from the Singapore Government (land, funding, etc.), if any. If Government support is required, Participant shall itemise and detail level of the support with justification.

6.1.3 Levelised Cost of Electricity (LCOE) and Landed Cost of Ammonia (LCOA).

6.1.4 Landed Cost of Hydrogen (LCOH) where applicable.

6.1.5 Robustness and completeness of safety plans, including coarse quantitative risk assessment, identification of health & safety buffer zones, and mitigation plans.

6.1.6 Proven financial strength, experience track record, and capability of the Participant in utility scale power generation, terminal operations, and supply chain development.

6.2 Only proposals submitted before the closing date will be considered.

7. ADMINISTRATIVE DETAILS

7.1 Please submit your EOI in **Microsoft Word** and **PDF** formats via email to:

energy_transformation@ema.gov.sg

7.2 The closing date for submissions is 30 Apr 2023 Singapore time.

7.3 EMA will acknowledge receipt of each submission via email. If you did not receive an acknowledgement of your submission within two business days, please contact Mr Leong Jia Yong (leong_jia_yong@ema.gov.sg) or Ms Ho Wai Ying (ho_wai_ying@ema.gov.sg).

7.4 Each of EMA and MPA reserves the right to share any information submitted by Participants in their EOI. Any part of the submission that is considered by Participants to be confidential should be clearly marked. Each of EMA and MPA reserves the right to aggregate/anonymise the information before sharing on a need-to basis. All EOIs submitted shall be on a non-binding basis and EMA and MPA shall not be bound or under any obligation to accept any proposal submitted.

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Appendix A

FORM OF EOI

Instructions: Please use this form to submit your EOI and include any supporting documents, justification or key assumptions where applicable.

1. Participant's name, registered business address, contact person's name, designation, email and contact number.

2. Profile of Participant and its partners, if any, in the Project consortium, and details of relevant experience. If the Participant consists of a consortium of companies, the Participant shall also list the key personnel from each company.

3. Most recent 3 years' financial information in respect of the Participant and its partners in the consortium, if any.

4. Technical Details - The Participant shall provide the following details. If the proposal includes plans for scale-up, the participant shall also include the following details for the scale-up phase as separate line items in each section.

    4.1 Production and Supply

        4.1.1 The Participant shall provide details on the supply of low or zero-carbon ammonia for the Project and phased scale-up, where applicable, which include but are not limited to the following:

            4.1.1.1 Source country or countries for ammonia export, including any approvals and permits required.

            4.1.1.2 Details on the low or zero-carbon ammonia production facility including hydrogen and ammonia production technology, electrolyser capacity, daily and annual production output in Tonnes per Day and Tonnes per Annum, renewable energy source and capacity factor.

        4.1.2 If the ammonia production facility is yet to be built/operational, the Participant shall include the facility development timeline detailing the output capacities per year.

4.2 Carbon Intensity of Ammonia Supply

4.2.1 The Participant shall provide information on the emission intensity of the low or zero-carbon ammonia.

4.2.2 The Participant shall provide details on the approach to certify and account for the lifecycle carbon emissions of the ammonia/hydrogen (tonnes of CO_2 equivalent per kg of ammonia/hydrogen) during the Project, including the method or international benchmarks used to certify, measure, report, and verify the carbon intensity, and reference examples used in other jurisdictions. A breakdown across different stages of the value chain may be included (if applicable).

4.3 International Transportation

4.3.1 The Participant shall provide details on the international transport of low or zero-carbon ammonia for the Project which include but are not limited to the following:

4.3.1.1 Export terminal in the source country.

4.3.1.2 Ship operator and shipping route.

4.3.1.3 Duration, frequency, and tonnage of ammonia imports via ship.

4.4 Import/ Bunkering Terminal and Storage

4.4.1 The Participant shall provide details on the conceptual layout for the ammonia import/bunkering terminal and storage facilities.

4.4.2 Jetty. The Participant shall provide details on the specification of the jetty (jetties) needed, including the location, waterfront area, length and number of jetties, draft/ Dead Weight Tonnage (DWT) of ships supported, berthing and unberthing approach of intended ships, and percentage utilisation if jetty (jetties) is shared for other uses.

4.4.2.1 The jetty shall be equipped with facilities to both offload from and discharge to an ammonia bunker vessel and/or ammonia fuelled vessel and/or ammonia carrier.

4.4.2.2 If an existing jetty (jetties) is to be used, the Participant shall provide the location, existing use and specifications, modifications/upgrades that may be required and associated safety and operational considerations.

4.4.3 Storage. The Participant shall provide details on the design of the tanks and major equipment (including safety measures to prevent and mitigate ammonia leakage), number and size (specified in tonnes and cubic metres) of ammonia storage tanks for power generation (required) and bunkering (required) / industry (if applicable), and number of tank turns per year. The Participant shall also provide any other key assumptions in deriving the capacity of storage.

4.4.3.1 For proposals that require unallocated greenfield sites where there are no existing facilities, the Participant shall provide land use details on the potential for future phased scale-up of the import/bunkering terminal and storage facilities to 1 MTPA hydrogen equivalent (i.e. about 5.7 MTPA ammonia equivalent) throughput.

4.4.3.2 For offshore and/or floating storage/power generation options, the Participant shall provide details listed out in sections 4.5, 4.6, 4.7, on liberation, local distribution, and power generation, below.

4.5 Liberation of Hydrogen (if applicable)

4.5.1 The Participant shall provide details on the liberation of hydrogen from ammonia, if the proposed power generation pathway requires the use of hydrogen as a fuel. These include but are not limited to the following:

4.5.1.1 Technology used for ammonia cracking,

4.5.1.2 Number of cracking trains/units,

4.5.1.3 Output capacity of each cracking train/unit,

4.5.1.4 Catalyst used,

4.5.1.5 Yield,

4.5.1.6 Energy requirements and energy efficiency,

4.5.1.7 Details on the design of intermediate tanks and major equipment (including safety measures to prevent and mitigate hydrogen fire).

4.5.2 The Participant shall provide details on future improvements in technology and the potential for phased scale-up.

4.6 Local Ammonia/Hydrogen Distribution

4.6.1 The Participant shall provide details on the local distribution of ammonia/hydrogen which include but are not limited to the following:

4.6.1.1 Conceptual distribution network (e.g., pipe network) used for the transportation of ammonia and/or hydrogen between import, storage, and end-use applications.

4.6.1.2 Pipe design (diameter, wall thickness, and materials etc.), operating pressure, length, network routing and location.

4.6.1.3 Safety design features to detect and mitigate leak or rupture along pipe network.

4.7 Power Generation

4.7.1 The Participant shall provide details on the conceptual power plant layout including power generation unit, balance of plant, grid connection point, and onsite fuel storage etc.

4.7.2 The Participant shall provide the technical specifications of the power generation unit including but not limited to:

4.7.2.1 Type of ammonia-derived power generation (e.g., direct ammonia combustion or hydrogen combustion after ammonia cracking).

4.7.2.2 Plant configuration (if paired with steam turbine, e.g., 1x1, 2x1 etc.).

4.7.2.3 Plant nameplate capacity (MW) and power (MW) attributed to the ammonia-derived power.

4.7.2.4 Plant capacity factor (operating hours per year),

4.7.2.5 Net energy efficiency (LHV),

4.7.2.6 Power generation unit specifications (e.g., turbine model, capacity, number of turbines considered, new or existing),

4.7.2.7 Capability to provide ancillary services other than baseload power generation, e.g., black start, frequency response etc.

4.7.3 Ancillary equipment in place to manage by-products such as nitrous oxides to meet air emission standards.

4.7.4 If applicable, the Participant should state the percentage volume blend of hydrogen by volume in compatible GT/CCGTs.

4.7.5 The Participant shall provide details on the proposed grid connection point and voltage level for each power generation unit.

4.7.5.1 The estimated fault level contribution from each power generation unit at the point of common coupling shall be within the limits stipulated by the Transmission Licensee (in accordance with section 6.11.4 of the Transmission Code).

4.7.5.2 This requires preliminary consultation with the Transmission Licensee on the feasibility of connecting such power generation unit at a clearly specified connection point.

4.7.5.3 This proposed grid connection feasibility should also account for phased expansion, if any.

4.7.6 The Participant shall ensure that all requirements in the Transmission Code are met; the Participant shall provide justification(s) for areas where there may be deviation(s).

4.7.6.1 The Participant shall provide information on the choice of backup fuel based on the power generation pathway, including performance specifications for Fuel Change Over (FCO), and an estimate on increment in cost and

land requirements to meet the Transmission Code. This shall be provided as a separate line item.

4.8 Industry Usage (If applicable)

4.8.1 If industry usage is included in the Proposal, the Participant shall state the amount of ammonia or derived hydrogen to be used for industry as well as the commercial offtake agreements that may be secured.

4.9 Land and Infrastructure Requirements

4.9.1 The Participant shall provide a breakdown of the land footprint and sea space footprint needed and site layout for the ammonia import/ bunkering terminal, storage and liberation (if applicable) facilities, and power generation facility and any related connecting infrastructure (if applicable).

4.9.2 The Participant shall indicate clearly any additional land or modification to facilities are needed to support activities under the optional scope.

4.9.3 The Participant shall indicate clearly if any of the associated facilities will be built on existing land allocated already or utilise existing facilities, and the additional land locations and requirements (including connecting infrastructure), if required.

4.9.4 The Participant shall indicate, if applicable, opportunities for land use optimisation.

4.9.5 The Participant shall provide all key assumptions for land-take computations.

4.10 Environment, Health, and Safety (EHS)

4.10.1 The Participant shall provide details and standards on the EHS considerations and the corresponding mitigation measures for the Project, which include but are not limited to the following:

4.10.1.1 Indicative Coarse Quantitative Risk Assessment (QRA), performed in accordance with NEA's QRA Technical Guidance, for the ammonia import/bunkering terminal, ammonia/hydrogen distribution network, bunkering

facilities, and power plant including where possible, the anticipated Health and Safety buffer zones imposed by the Project onto surrounding land and sea spaces such as fire/explosion, toxicity, and marine exclusion zones, and the proposed mitigation measures to address the risks.

4.10.1.2 High level marine risk assessment for jetties, offshore facilities, and marine traffic impact, where applicable.

4.10.1.3 Design specifications for the Project, including basis of safety or references to established latest codes and standards and where applicable, evaluations on why a higher basis of safety was not considered for the project.

4.10.1.4 Relevant codes of practice (including proposed or developed alternative codes of practice that are fit for purpose if none are currently available) that are applicable for the Project but are not limited to fire safety, toxicity and process safety.

4.11 Utility Requirements

4.11.1 The Participant shall provide all utility requirements for the Project, and,

4.11.2 Indicate opportunities for energy optimisation, where applicable.

5. Commercial Details - The Participant shall provide the following details. If the proposal includes plans for scale-up, the participant shall also include the following details for the scale-up phase separately.

5.1 The Participant shall provide the proposed business and operation model for the Project, including commercial partners and the intended off-takers, if any, for ammonia-derived power and bunkering, including the contracting method, such as:

5.1.1 Power Purchase Agreements (PPA) with off-takers. Participants should minimally indicate the industry/sector/company, proposed price of electricity in S$ per megawatt-hour (S$/MWh) and duration of contract.

5.1.2 Selling electricity into the National Electricity Market of Singapore (NEMS).

5.1.3 Terminal use agreement with off-takers (bunker buyers or bunker suppliers). Participants should, to the extent possible, indicate the reload fee (S$/mmbtu) and duration of contract.

5.2 The Participant shall provide the anticipated LCOA in S$ per kilogram of ammonia and if applicable, LCOH in S$ per kilogram of hydrogen to account for ammonia cracking for each year for the duration of the Project, including the calculation and corresponding assumptions.

5.3 The Participant shall provide the LCOE (S$/MWh) for each year for the duration of the Project, including the calculation and corresponding assumptions.

5.4 The Participant shall provide the breakdown of major cost contributors such as Capital Expenses (CAPEX) and Operating Expenses (OPEX) for the Project.

5.4.1 The Participant shall provide the breakdown of the CAPEX and OPEX for Section 3 (Overview of Requirement) and 4 (Optional Scope) as separate line items.

5.4.2 The CAPEX breakdown should minimally include the cost for the following line items for requirements, as per (i) Section 3.4 in the EOI, and separately as per (ii) Section 4.4, 4.5, 4.6, and 4.7 in this Form of EOI for phased scale-up operations:

5.4.2.1 Jetty and topside infrastructure for
a. Unloading of ammonia,
b. Reloading to an ammonia bunker vessel and/or ammonia fuelled vessel and/or ammonia carrier,
c. Storage facilities required for (i) power generation and (ii) bunkering (iii) other purposes (if applicable).

5.4.2.2 Distribution network
a. To enable power generation.
b. To enable marine bunkering.

5.4.2.3 Liberation facilities (if applicable),

5.4.2.4 Power plant,

5.4.3 The OPEX breakdown should minimally include the cost for the following line items:

5.4.3.1 Fuel,

5.4.3.2 Operations & Maintenance (O&M).

5.5 If required, the Participant shall indicate the total fiscal support and normalised amount of fiscal support per MWh of electricity generated required from Government and the corresponding payment schedule.

5.6 The Participant shall provide details on their assessment of the key commercial risks and the corresponding mitigation measures for the Project.

6. The Participant shall provide details on the overall project timeline, management, and risk details. These include but are not limited to the following:

6.1 Project Timeline. Key project tasks and milestones, including but not limited to technical studies, regulatory and permitting approvals.

6.2 Project Management. Engineering, Procurement and Construction (EPC) date and Commercial Operational Date (COD). Phased or future expansion, if any, and associated timeline.

6.3 Project Risk Assessment. Identification of potential show-stoppers that may impact the technical and commercial viability of the Project and their associated mitigation measures, if any.

6.4 Technical and Commercial Non-Compliance. Participant shall state clearly any non-compliance to the technical and commercial requirements stated in the EOI. For all non-compliance, Participant shall explain the extent and reason of the deviation and provide mitigation measures if possible.

6.5 Regulatory Non-Compliance. To state clearly any regulatory requirements or standards that could not be met, or are at risks breaching through the construction and operational lifetime of the project. Participants are to provide the amount of deviation, and explanations for such non-compliance.

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