Agency for Science, Technology and Research
SINGAPORE

LOW-CARBON ENERGY RESEARCH FUNDING INITIATIVE (LCER FI)

FIRST GRANT CALL BRIEFING

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USS IPO, Enterprise, A*STAR
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Overview

Overview – 1 of 2

1. The $49 million Low-Carbon Energy Research Funding Initiative (LCER FI) is a national initiative under RIE 2020, to fund projects in areas such as **Hydrogen and Carbon Capture, Utilisation and Storage (CCUS)**. It aims to develop solutions that support **decarbonisation of Singapore's power and industry sectors.**
2. The first grant call will be launched on **25 Jan 2021**. We invite interested researchers to submit suitable proposals seeking to develop **innovative** and **cost-effective low-carbon hydrogen and CCUS technologies that can deliver carbon abatement for Singapore,** with the intention to be **commercialised/deployed** beyond the project timeline**.**
3. Interested parties are strongly encouraged to form research teams able to **collaborate across organisations in academia (local and international).** They are also **strongly encouraged to work with industry and relevant government agencies** while developing these solutions.

Overview – 2 of 2

4. R&D is one of the key pillars that Singapore is relying on, to **achieve our climate change aspirations of halving emissions from peak to 33MtCO2e by 2050, with a view of achieving net-zero emissions as soon as viable in the second half of the century.** In this regard, the solutions proposed will need to demonstrate scalability at the national-level.

5. The proposed R&D solution funded through LCER FI would also need to take into account Singapore's context (e.g. we are alternative-energy disadvantaged and may not have significant surplus domestic renewables for large-scale green hydrogen production).

LCER FI’s Focus & Desired Outcomes

Focus of Grant Call

Two Thematic Areas:

1) **Hydrogen supply, storage, and downstream uses**
2) **Carbon Capture, Utilisation & Storage (CCUS), focusing on capture for low-concentration CO_2 and utilization of CO_2 to produce aggregates and synthetic fuels/chemicals**

- All proposals are highly encouraged to incorporate **work packages that uses appropriate models, to establish the economic and environmental viability** of the proposed technology. Such work packages include life-cycle assessment (LCA), life-cycle costing (LCC) and techno-economic models.

- That said, we will also consider proposals that develop analytical techno-economic models (e.g. TIMES/MARKAL) able to **compare different CCUS/hydrogen solutions across the entire energy system/economy.**

As a gauge, these are some of LCER FI's desired outcomes for Hydrogen

- Targeted domestic landed cost of low-carbon (green) hydrogen:
  US$5.77/kg (by 2025)

- Enable 100% Hydrogen-fuelled CCGTs to **reach market parity* with conventional Natural Gas CCGTs by 2050**

** Taking into consideration factors including prevailing carbon taxes, oil prices (for Enhanced Oil Recovery (EOR) in the case of blue hydrogen), consumers' willingness to pay a premium for green products (CCU-aggregates/ chemicals/ fuels).*

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…and for CCUS

CCUS (w.r.t. streams that are <15% concentration)

CCS-EOR

- Enable cost-effective enhanced oil recovery - **US$50/tonne (by 2025)**

CO_2 to synthetic fuels/chemicals/polymers:

- No 2025 targets due to nascency of the technologies.

CO_2 to aggregates:

- Aim to eventually reach market parity with imported aggregates
  Interim targets of **<US$55/tonne (by 2025)**

In parallel, **develop and enhance relevant techno-economic models**

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Examples of some potential hydrogen-related technologies

Supply

- Imports: hydrogen regeneration technologies (e.g. ammonia cracking, methylcyclohexane cracking, or other technologies) to reconvert hydrogen from other carrier forms. Other technologies involving shipping/transport and receiving/distribution infrastructure for hydrogen will also be considered.
- Domestic Production: novel technologies (e.g. catalysts) supporting the production of blue and/or green hydrogen.

Storage

- Reducing CAPEX of compressed or liquefied hydrogen technologies.
- Alternative storage technologies (metal hydrides, MOFs, etc.).

Downstream uses

- Test-bedding the direct consumption of hydrogen as a blended fuel within existing CCGTs, use of hydrogen for fuel switching in industry processes, or as an integrated process together with CO_2 utilisation pathways.
- Non-conventional uses, such as micro grids which combine hydrogen production using renewable energy, with on-site storage/consumption.

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Beyond technological questions

Consider a **whole-systems thinking approach**

In other words, why should Singapore conduct R&D in this area, given our limited resources.

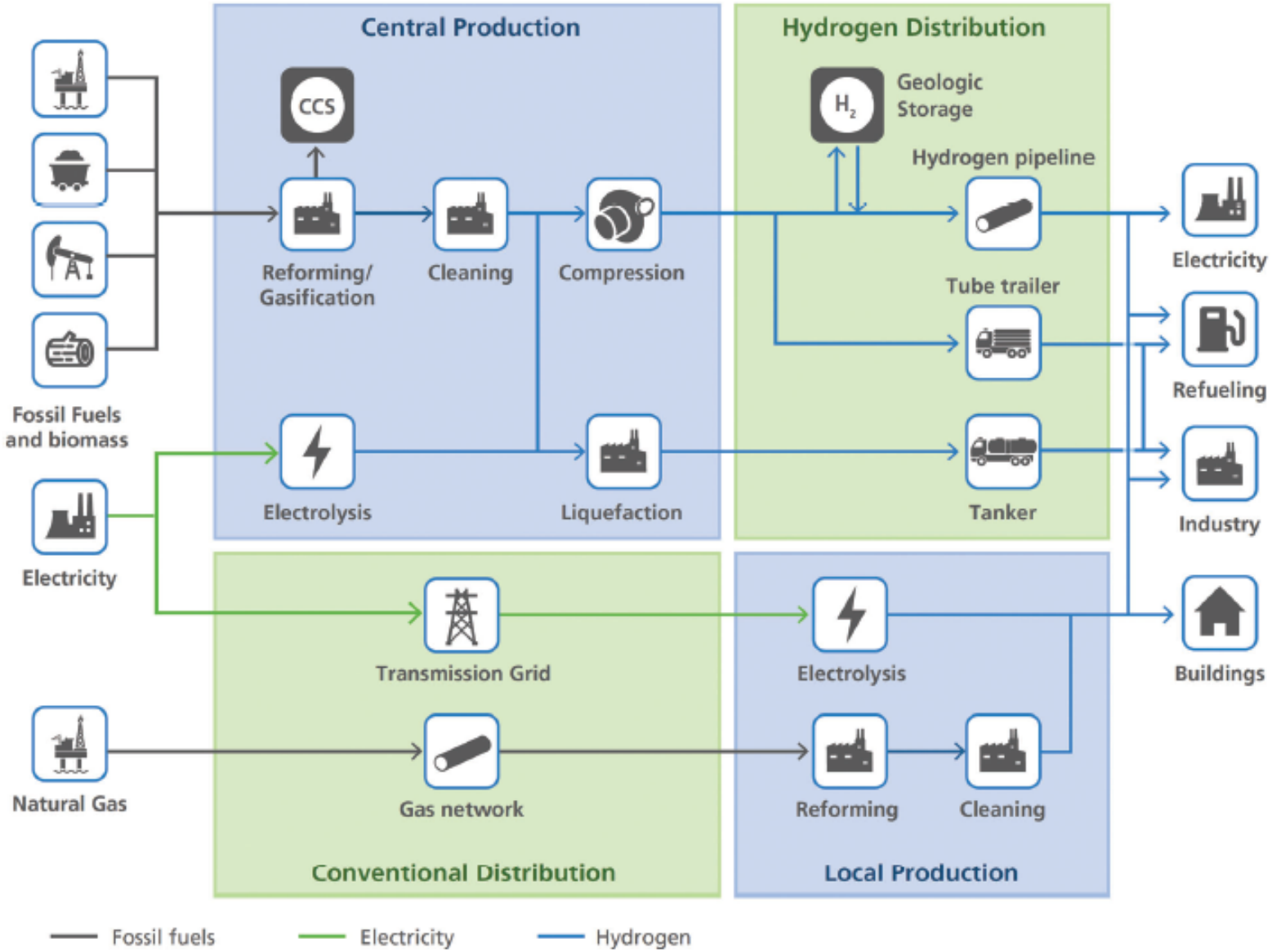

Fig. 14 Hydrogen delivery pathways discussed in this paper. This diagram is simplified and non-exhaustive, and serves to highlight the diversity of options at each stage of the system.

Figure from: Staffell, I., Scamman, D., Velazquez Abad, A., Balcombe, P., Dodds, P., Ekins, P., Shah, N. and Ward, K., 2019. The role of hydrogen and fuel cells in the global energy system. *Energy & Environmental Science*, 12(2), pp.463-491.

Examples of potential CCUS technologies, focusing on aggregates and synthetic fuels/chemicals

Carbon Capture

Most of Singapore's industry and power carbon emissions have low CO_2 concentration (<15%)

- R&D into capture technologies (e.g. adsorption, absorption, membrane separation, etc.) for low-concentration emissions to increase their technical and economic viability

Carbon Utilisation

- CO_2 to fuels: R&D for innovative conversion technologies and catalysts to increase the EROI (energy returned on energy invested)
- CO_2 to aggregates: R&D in alternative pathways, such as natural minerals and local waste
- Other novel CO_2 utilisation pathways (e.g. valuable carbon as end-products)

Carbon Storage

- Materials that allow long-term storage of CO_2 in local or regional areas (e.g. deep oceanic sediment)

Grant Call Conditions & Eligibility Criteria

Grant Call Conditions

Project Duration: 3 years

Funding Quantum: Up to $4M/project

Mandatory for all proposals:

- Applicants should include a **list of approximately 3 – 5 relevant, independent international peer reviewers** with their personal details (name, designation, institution and contact details), when submitting their proposals.

KPIs

- All proposals should **focus primarily on achieving the LCER FI objectives,** but also aim to achieve research excellence (e.g. citations).
- At the same time, proposals for medium-TRL technologies are highly encouraged to incorporate industry contributions, in cash or in-kind.

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Eligibility Criteria

- All public research institutes (Institute of Higher Learning (IHLs), A*STAR Research Institutes (RIs), and other public sector RIs) are eligible to participate in the call.

- Teams must have **one or more Lead PIs** with at least 70% primary appointment in a public sector research institute (A*STAR RIs, IHLs and other public research institutes), and maintain minimum appointment level for the duration of this award.

- Teams may choose to include multiple research performers as **Co-Investigators (Co-Is)** or **Collaborators,** who are researchers in private companies, in overseas universities, or other local Institutes of Higher Learning (IHLs) and public-funded research entities.

- **Collaborators cannot receive any funding, whether directly or indirectly, from the award.**

- All research work must be done in Singapore, unless approved by the grantor.

Review Process

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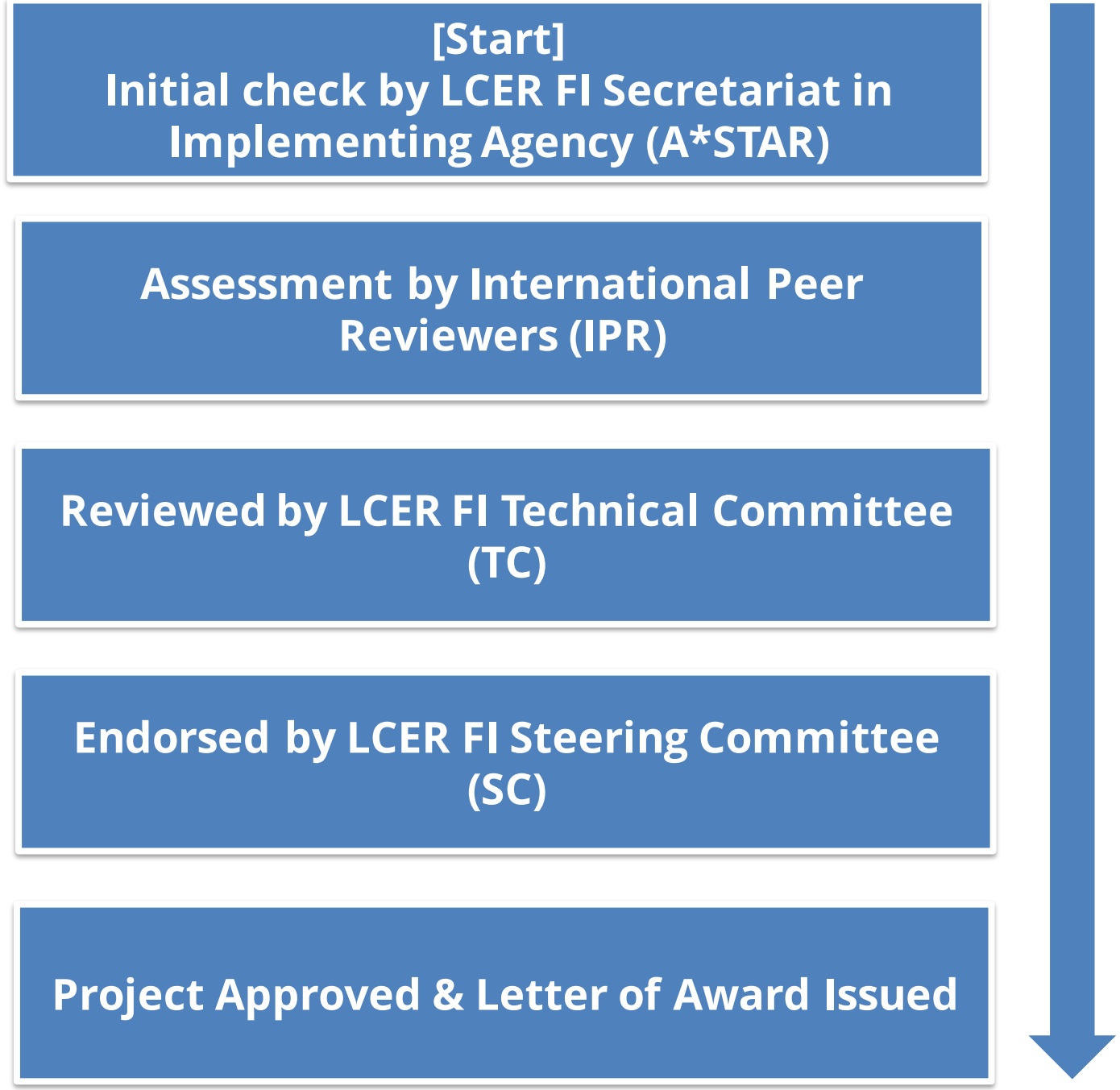
Review Process - at a glance -



Review Process – 3 stages

Proposals will first be evaluated by the IPR and TC using a **quantitative scoring matrix (see next slides)**, before the SC conducts a **qualitative review**.

1. **Review by IPR**

Proposals will be initially reviewed by a **minimum of 3 external reviewers who are experts within** the field of the proposed technology, to ensure excellent science in proposals.

2. **TC Review**

Thereafter, IPR-endorsed proposals will be invited to present to the TC, consisting of relevant technical and policy experts. The TC will then **rank proposals** within each category, based on the designated evaluation criteria. During the assessment/ranking, the proposals each of the two themes will be further **classified into two sub-categories (i.e. low-TRL and med-TRL)**, to allow proposals at similar levels of development to be compared against each other.

3. **Final Review**

Thereafter, the SC will conduct a **qualitative evaluation**, before recommending which projects to fund. While evaluating the proposals, the SC will consider IPR & TC's earlier comments, and ranking. They will also consider the proposal's alignment with Singapore's strategic goals for decarbonisation.

Scoring Matrix - IPR

Requirements	Weightage
Novelty and originality of the proposed idea or concept - To what extent does the proposal suggest and explore creative and original concepts? - Are the aims original and innovative? - Does the proposal employ novel approaches or methods? - Is the proposed methodology feasible/viable?	25%
Quality of Science - Did the applicant acknowledge potential problem areas and consider alternatives? - Would the proposal lead to scientific excellence in the proposed field of research?	25%
Competitive / comparative advantage - How competitive is the proposal internationally? - To what extent is the plan for organising and managing the project feasible?	25%
Capability of the research performers to conduct the research - Does the research performer/team possess the necessary capabilities to conduct the research successfully? - Does the PI have the track record to lead and conduct the research successfully?	25%

Scoring Matrix - TC

Requirements	Weightage
Excellent science (novelty and significant improvement from current technologies) and competitiveness at international level - To what extent does the proposal suggest and explore creative and original concepts? - Would the proposal lead to scientific excellence in the proposed field of research?	30%
Strong collaboration across academia and industry - Has the applicant assembled the strongest possible team from within the local ecosystem? - To what extent does the project team collaborate with relevant internationally renowned experts? - Has the applicant secured industry partnerships? Do these partnerships include cash or in-kind contributions?	30%
Well-developed strategy for scale-up - Does the proposal have a well-developed strategy for scale-up, including eventual deployment as a commercially-viable technology?	20%
Consideration of how the proposed technology integrates with our eventual national Hydrogen and CCUS value chain - To what extent is the proposal in-line with Singapore's various announcements on our plans to develop a national hydrogen and/or CCUS value chain?	20%

Sample Proposals

Sample Proposal for CCUS: CO_2 to Fuels (1/2)

Aim:

- Develop better heterogeneous catalysts to convert flue gases and low-concentration CO_2 streams (including from natural gas-fueled power stations) into synthetic fuels.

How does it contribute to CO_2 abatement?

- Key area of focus for Singapore as the power sector is our 2nd largest CO_2 emitter. Within the power sector, natural gas-fuelled plants accounts for majority (~95%) of our fuel mix. Targets to reduce carbon emissions from natural gas power generation.

Why this technology is recommended?

- For supply considerations - there is potential to increase the efficiency of the catalytic reactions (to work at lower concentrations of ~3-4%), and increase the lifespan of the catalyst (i.e. prevent catalytic poisoning). This will allow us to capture low concentration flue gases which we could not previously capture in an economically viable manner.
- From demand considerations – the products cater to the growing interest to use sustainably-sourced fuels for aerospace purposes. Singapore can maintain our thought leadership as a world-class aviation hub, by developing use-cases for such cutting-edge solutions.
- **Include a study to substantiate why this is the best solution to address this problem from a LCA and economic-modelling perspective.**

Sample Proposal for CCUS: CO_2 to Fuels (2/2)

What is required to develop this technology (i.e. the proposed R&D approach)?

- Development of cost effective and robust catalyst with regeneration abilities, system and process modelling and optimization, demonstration of process through a test-bed

Partners

- Research – Carbon capture experts (to increase CO2 concentration from flue gases), Catalyst experts (for the conversion into fuels), Fuels experts (to ensure that the fuels are suitable for aerospace needs)
- Industry - Power station operators, aerospace industry players, back-up generators in large facilities

Key elements of the proposal to address real-world application

- Scale up/commercialisation strategy – tie-ups with aerospace industry players
- Technological validation plan - test-bedding in a suitable industrial plant/facility.

Sample Proposal for Hydrogen: Storage solutions via metal hydride tech (1/2)

Aim:

- Develop a new generation metal hydride-based, cost-effective technological solution for hydrogen storage to cater to on-site production and use of hydrogen

How does it contribute to CO_2 abatement?

- Serves as a potentially effective energy storage solution to allow more surplus renewable energy to be captured/utilised
- Enables decentralised production of carbon-free energy, thereby reducing energy demand for grid electricity powered by natural gas power plants

Why this technology is recommended?

- For supply considerations, compared to compressed hydrogen, the metal hydride storage system is compact and allows safe storage at low pressure. Modular and there is potential for scale-up (already one demonstration project by SP Power, and a few flagship projects in Japan)
- For demand considerations, cost-effective and attractive option for energy consumers demanding higher safety standards, such as residential applications
- **Include a study to substantiate why this is the best solution to address this problem from a LCA and economic-modelling perspective**

Sample Proposal for Hydrogen: Storage solutions via metal hydride tech (2/2)

What is required to develop this technology (i.e. the proposed R&D approach)?

- Development of a new metal-hydride material, which has improved reversibility of conversions, with the addition of engineering studies to understand and overcome system-level issues for deployment

Partners

- Research – Metal hydride experts, Mechanical system engineers
- Industry – Electrolyser manufacturers & solar producers
- Users with a large energy demand – Large industrial facilities, office buildings with rooftop solar assets, urban farms (indoor and outdoor), etc.

Key elements of the proposal to address real-world application

- Scale up/commercialisation strategy: tie-ups with users with large energy demand to generate interest and future market demand
- Budget/resourcing – joint investment with electrolyser manufacturers & solar producers

Instructions for Submission of Proposals

LCER FI Grant Call Details

Call opens (for 12 weeks):

- **25 January 2021**
- **Grant call information and relevant documents available at: https://www.a-star.edu.sg/Research/funding-opportunities**

Deadline for Full Proposal Submission:

- **19 April 2021, 0900 (SGT) - revised**

Application only through IGMS:

- Grant call will be **open on the IGMS portal in early February**
- See section on "Application Guidelines". All funded proposals should follow Terms and Conditions for LCER FI (effective from 1 Jan 2020) and NR Fund Guide (effective from 1 Jul 2016)

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Overview of Timeline (Indicative)

FOR ALL APPLICANTS & INTERESTED PARTIES	
Grant Call Opens (for 12 weeks)	25 January 2021
Virtual Briefing for LCER FI: 1 session available (Link to the recorded session would be provided thereafter)	25 January 2021, 1300 – 1400 (SGT)
Apply via Integrated Grant Management System (IGMS)	From early-February
Grant Call Closes (Full Proposal Submission Deadline)	19 April 2021, 0900 (SGT) - revised
FOR SHORTLISTED APPLICANTS ONLY	
Research teams whose proposals were shortlisted will be notified	In the week starting 31 May 2021 (TBC)
Presentation at Technical Committee Review Panel (2 or 3 days)	In the week starting 7 June 2021 (TBC)
FOR SUCCESSFUL AWARDEES ONLY	
In-principal approval	End-June 2021
Letter of Award	Mid-July 2021

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Application Guidelines

- A full proposal shall be submitted electronically through the **Integrated Grant Management System (IGMS) website** (https://researchgrant.gov.sg/).

- E-mail or walk-in applications will not be accepted.

- **Late or incomplete submissions will be disqualified.** Applicants are advised not to submit their application at the last minute in case of technical errors with the IGMS website.

- The following slides outline steps for “Using IGMS” and “Full Proposal Submission”.

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Application Guidelines

Using IGMS:

Key details for first-time users

- Under the landing page,

for CorpPass, click on the "Create Login for PI/ORE/DOR" button

for SingPass, click on "Login with SingPass"

for overseas users without CorpPass/SingPass, click on register

- Ensure all Lead PI/Team PIs **authorise ORCID** before any grant application
- Fill up mandatory fields
- Update user profile

For detailed steps, please refer to:

Help guide for Potential Applicants (also available on the IGMS "Training Guides" page: https://researchgrant.gov.sg/Pages/TrainingGuides.aspx)

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Application Guidelines

Full Proposal Submission

- Login to the system using SingPass or CorpPass or Login for overseas users without CorpPass/Singpass
- Click on “Low-Carbon Energy Research Funding Initiative First Grant Call 2021” under “Open Opportunities” and click “Apply”

For detailed steps, please refer to:

- Quick guide for Potential Applicants; and
- Help guide for Potential Applicants

(also available on the IGMS “Training Guides” page: https://researchgrant.gov.sg/Pages/TrainingGuides.aspx)

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Contact Information

- For general enquiries, please refer to “Annex E - Frequently Asked Questions”.

- If you require further clarification, you may reach us at LCERFI_secretariat@hq.a-star.edu.sg. Please allow up to 3 working days for us to provide a response.

- For any queries on the use of IGMS or technical issues please contact the IGMS helpdesk at:

  Tel No : (65) 6556 8807 or (65) 6556 6971

  E mail : helpdesk@researchgrant.gov.sg

LCER FI Secretariat

- Mr. Desmond Chua
- Mr. Benjamin Sim

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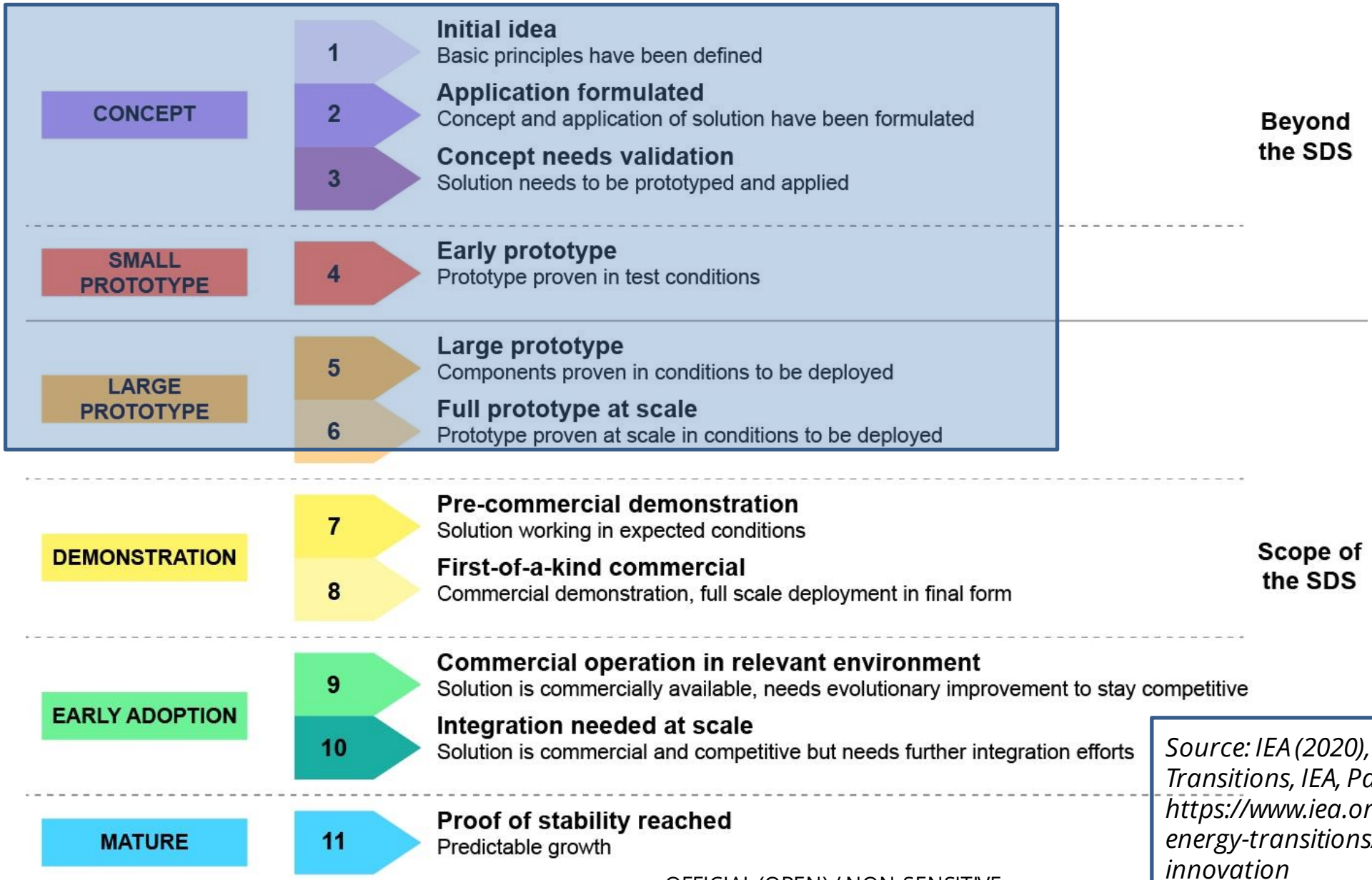
Thank you.

Annex A – Technological Readiness Scale applied by the IEA



Source: IEA (2020), CCUS in Clean Energy Transitions, IEA, Paris https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-technology-innovation

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THANK YOU

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