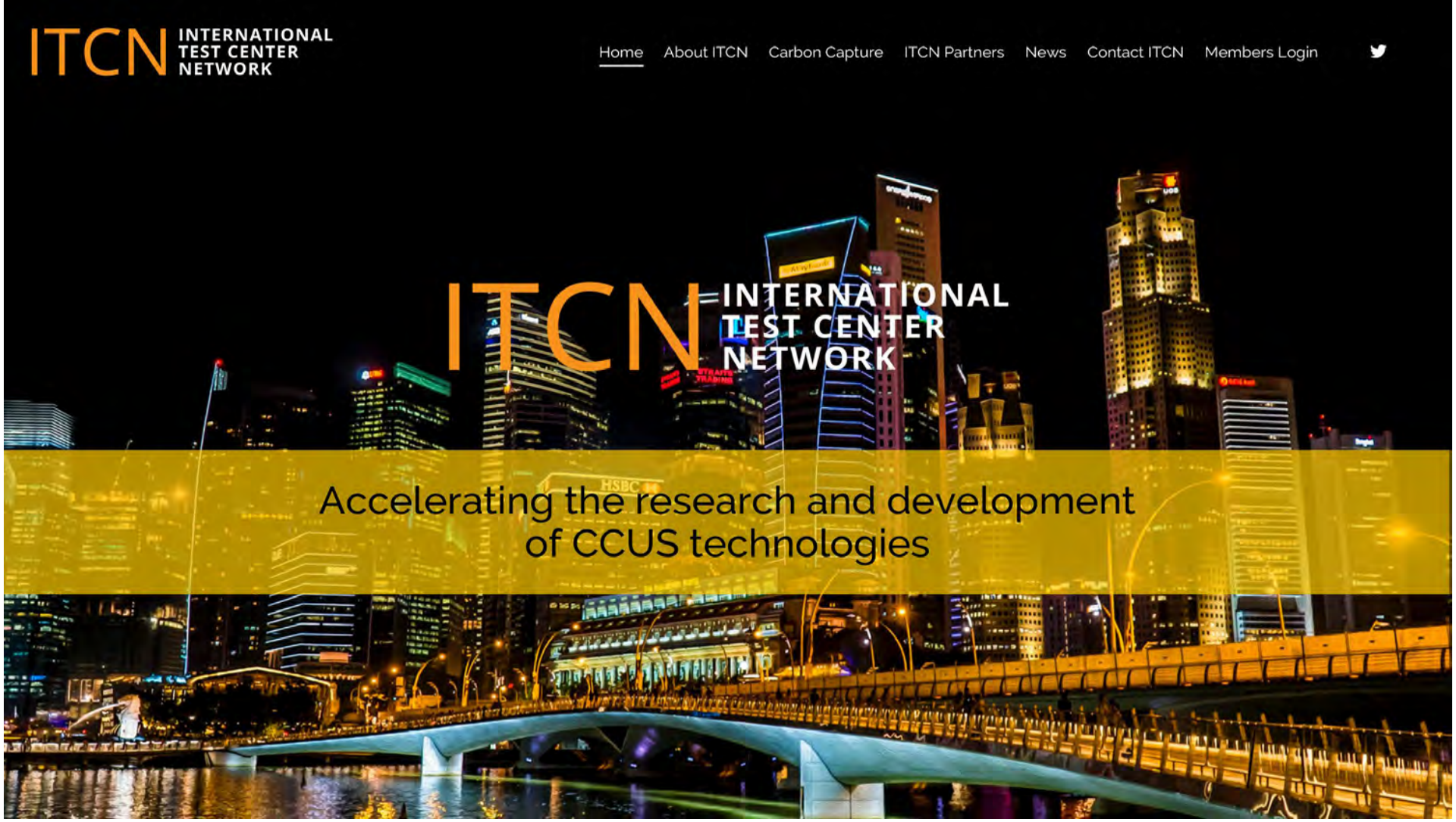


Frank Morton (NCCC)

M. Pourkashanian (PACT)

J. Gibbins (PACT)

https://itcn-global.org/

ITCN Members

ITCN INTERNATIONAL TEST CENTER NETWORK

Europe

Germany
E.On's Wilhelmshaven power plant

Norway
CO2 Technology Centre Mongstad (TCM)
SINTEF's Tiller facility

United Kingdom
Pilot-Scale Advanced Capture Technology facilities (PACT)

North America

Canada
SaskPower's Shand Power Station

USA
National Carbon Capture Center (NCCC)
University of Kentucky Center for Applied Energy Research
University of North Dakota Energy & Environment Research Center

Asia

China
Huaneng's Clean Energy Research Institute

Japan
Research Institute of Innovative Technology for the Earth

South Korea
KEIR's Hadong and Boryeong test centers

Australasia

Australia
CO2CRC's Otway Research Project
CSIRO's Loy Yang and Tarong test centers
CSIRO's Vales Point pilot plant

ITCN 2019

- Increase the value of public and private CCS research and technology investments through increased sharing of lessons learned and results from parallel activities
- Identify one technical focus area per year and publish summary report
- Continue emphasis on technical and non-technical collaboration
  - Determine more technical areas for collaboration
    - Testing beyond advanced solvents
    - Comparing baselines and campaign results
    - Promoting technology certification and standardization through lessons learned
- Collaborate on partnerships for scale-up of technology and responses to funding opportunities

International Roundtable: Strengthening International Collaboration on CCUS 02/2019 (Washington, DC)

ITCN INTERNATIONAL TEST CENTER NETWORK

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

RITE Research Institute of Innovative Technology for the Earth

SUPPORTED BY: METI Ministry of Economy, Trade and Industry

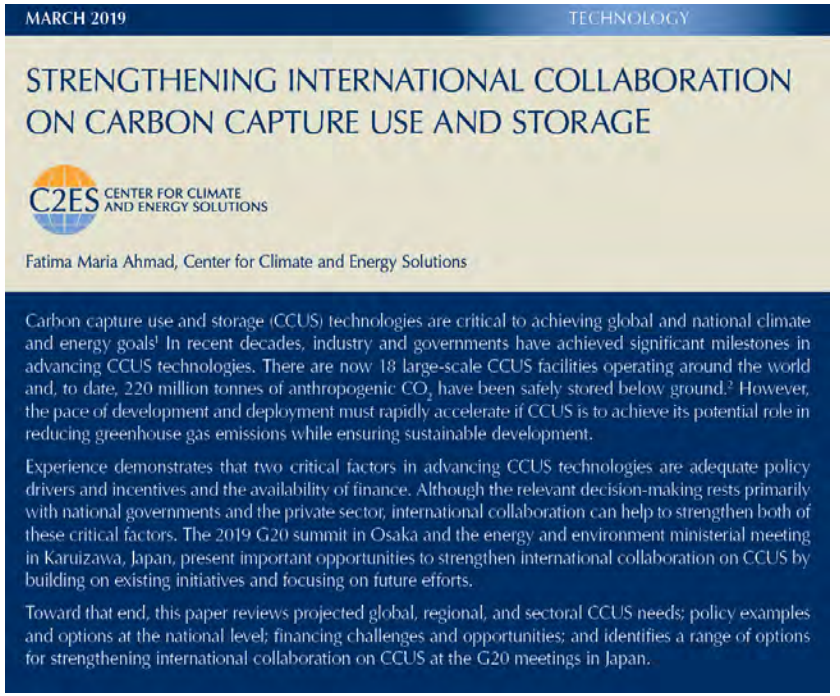
Summary Recommendations

- C2ES and RITE offer a number of recommendations for consideration at the energy and environment Ministerial meeting on June 15-16, 2019, in Karuizawa, Japan, and at the G20 Summit on June 28-29, 2019, in Osaka, Japan. It includes:

- Pledging stronger support for collaborative efforts highlighted in the 2017 Roadmap of the Carbon Sequestration Leadership Forum, including the **International Test Centre Network (ITCN)** and the CO_2 Storage Data Consortium.

- Organizing side events at the G20 Summit to highlight recent CCUS successes, build stronger understanding of these technologies and their multiple benefits, and identify opportunities for their advancement.

G20 presents an important opportunity to strengthen awareness of the climate and other benefits of CCUS technologies and to initiate new actions by the G20 and by Member countries, building on existing initiatives and partnerships, to advance the development and deployment of these critical technologies.



MARCH 2019 TECHNOLOGY

STRENGTHENING INTERNATIONAL COLLABORATION ON CARBON CAPTURE USE AND STORAGE

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

Fatima Maria Ahmad, Center for Climate and Energy Solutions

Carbon capture use and storage (CCUS) technologies are critical to achieving global and national climate and energy goals[1] In recent decades, industry and governments have achieved significant milestones in advancing CCUS technologies. There are now 18 large-scale CCUS facilities operating around the world and, to date, 220 million tonnes of anthropogenic CO_2 have been safely stored below ground.[2] However, the pace of development and deployment must rapidly accelerate if CCUS is to achieve its potential role in reducing greenhouse gas emissions while ensuring sustainable development.

Experience demonstrates that two critical factors in advancing CCUS technologies are adequate policy drivers and incentives and the availability of finance. Although the relevant decision-making rests primarily with national governments and the private sector, international collaboration can help to strengthen both of these critical factors. The 2019 G20 summit in Osaka and the energy and environment ministerial meeting in Karuizawa, Japan, present important opportunities to strengthen international collaboration on CCUS by building on existing initiatives and focusing on future efforts.

Toward that end, this paper reviews projected global, regional, and sectoral CCUS needs; policy examples and options at the national level; financing challenges and opportunities; and identifies a range of options for strengthening international collaboration on CCUS at the G20 meetings in Japan.

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Current Technologies

- **Solvent Based Capture Technology**
  - Solvent PCC is the only technology that is past TRL 9
  - Challenge is raising the Commercial Readiness Index – to follow
- **Oxy-fuel**
  - Atmospheric pressure technically feasible but appears to be awaiting commercial driver
- **Membranes**
  - Proprietary developments progressing e.g. MTR
- **Solids**
  - Proprietary developments progressing e.g. Inventys

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Next Generation Technologies

- **Supercritical Carbon Dioxide Power Cycle for Stationary Power Generation (s-CO_2)**
  - Heat Exchanger
    - Durability: high temperature metal alloys, advanced materials
    - Thermal Management: high temperature, high pressure, high efficiency and super-compact
  - Fundamental Knowledge Gap on Combustion
    - Chemical Kinetics for combustor development
    - Emission prediction
    - Impact of impurities
- **MCFC-CCUS (Combustion Alternatives)**
  - Possibility to be a game changer: Exxon
    - To increase CO_2 capture rate / module

Commercial Readiness Index (CRI) for PCC needs to be increased by driving sub-systems through the TRLs, based on learning by doing

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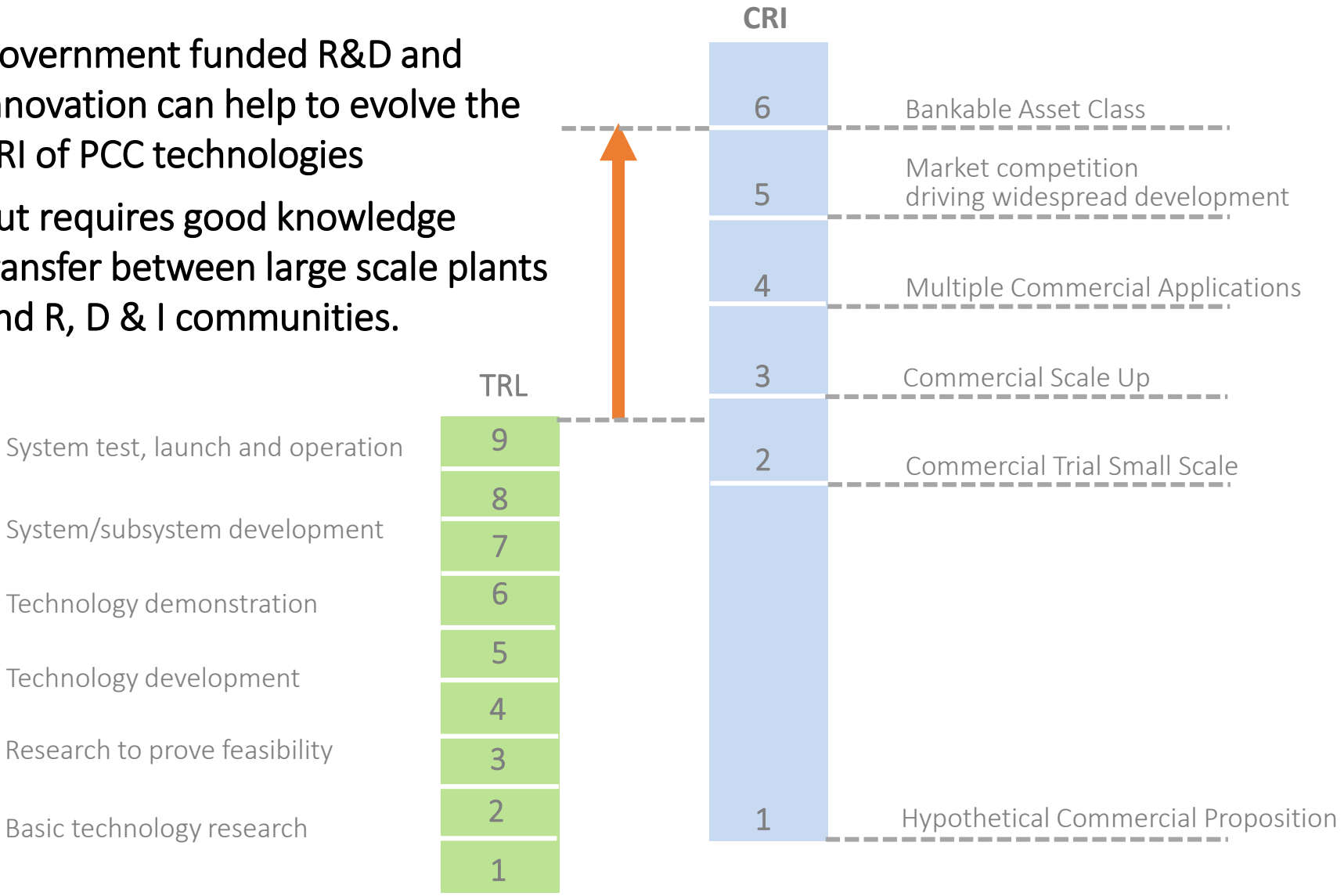
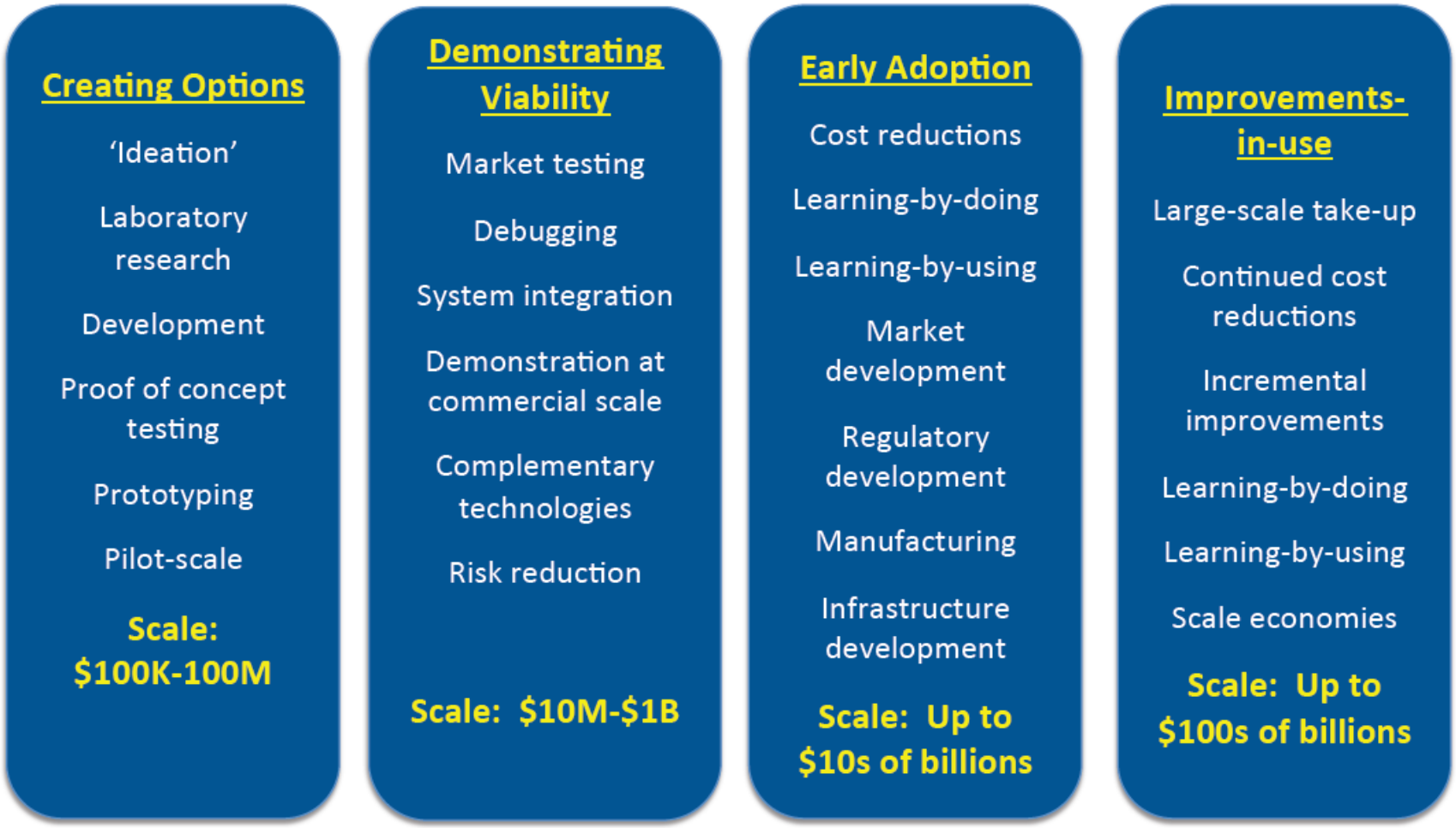
- Government funded R&D and innovation can help to evolve the CRI of PCC technologies
- But requires good knowledge transfer between large scale plants and R, D & I communities.



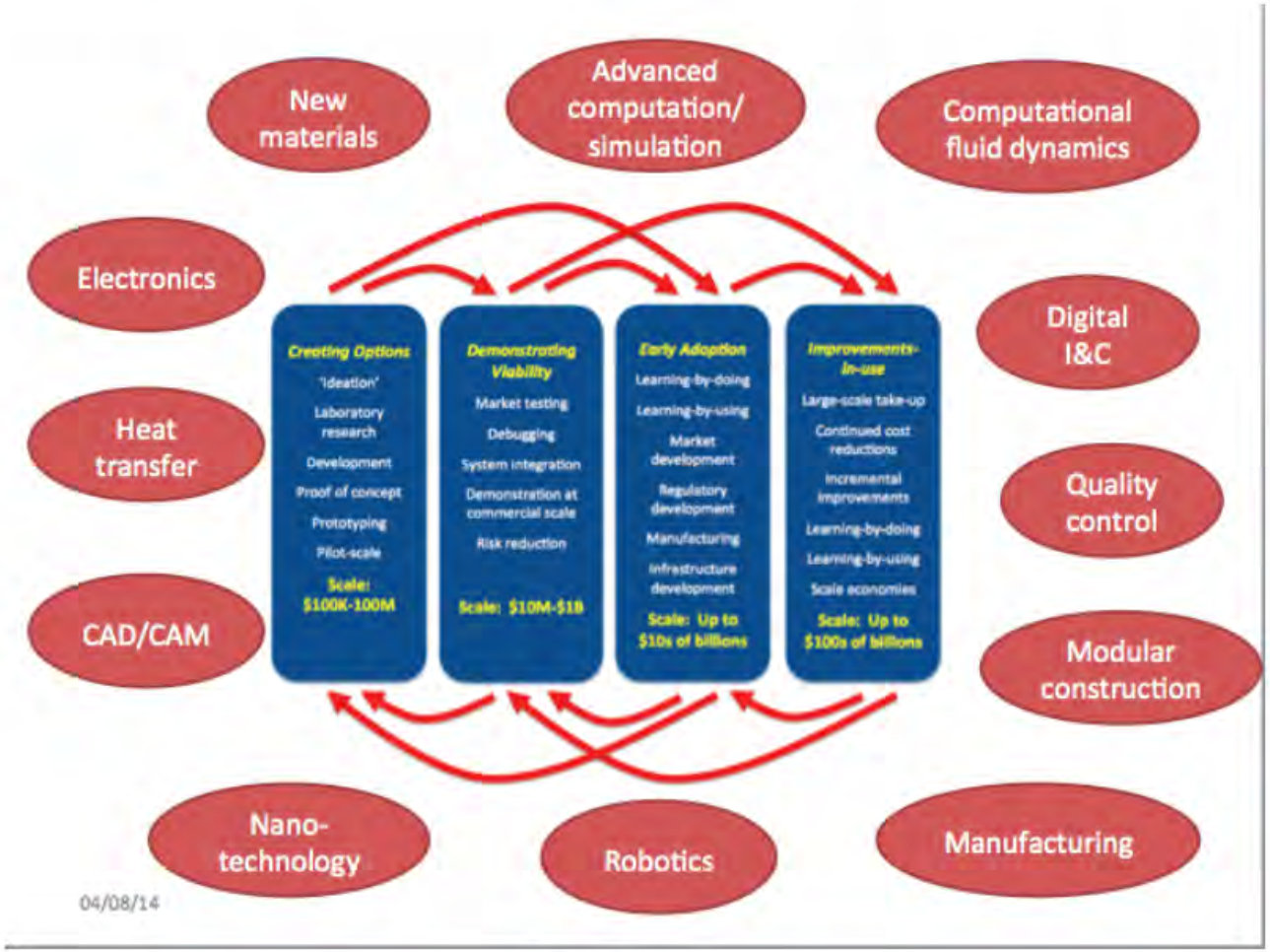
From Bruce Adderley, Jeremy Carey, Jon Gibbins, Mathieu Lucquiaud and Richard Smith, "Post-Combustion Carbon Dioxide Capture Cost Reduction to 2030 and beyond", Faraday Discussion on CCS, July 2016. http://pubs.rsc.org/en/Content/ArticleLanding/2016/FD/c6fd00046k#!divAbstract

Four stages of energy innovation



From: R.K. Lester, *Regionalizing Energy Technology Demonstrations*, MIT Carbon Sequestration Forum 16, Cambridge, MA, November 12-13, 2014

Basic research is important at every stage of the innovation process (as is the take-up of knowledge from other sectors)



From: R.K. Lester, *Regionalizing Energy Technology Demonstrations*, MIT Carbon Sequestration Forum 16, Cambridge, MA, November 12-13, 2014

Open-technology / open-access post-combustion capture is a key enabler for international partnership

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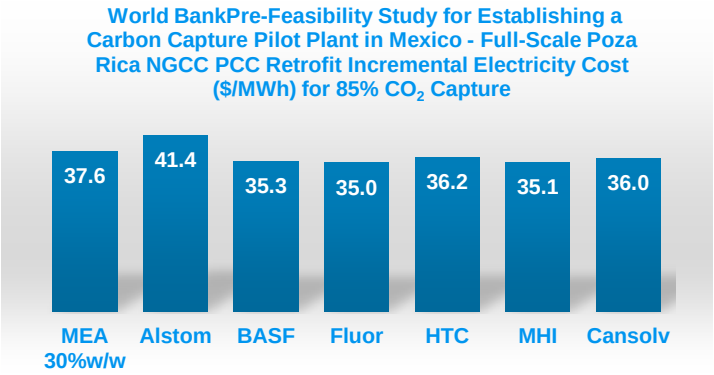
- Open-technology – owner has full control of the technology, including multiple solvents
- Open-access – uses generic, non-proprietary solvent
- Enables international knowledge exchange and strong commercial competition to reduce costs at all stages – feasibility, FEED, EPC, commissioning and operation
- Enhanced value for government expenditure on deployment and RD&I
- Increases rate at which the field of solvent PCC technologies will improve:
  - OT / OA PCC hardware is a fast track to deploy multiple innovations, including through in-service upgrading
  - Can try out new solvents etc. without building a new plant for every one!
  - Plus critical information exchange, in both directions, with Mission Innovation and pilot testing e.g. ITCN, ACT - Accelerating CCS Technologies*
- Relative costs for OT / OA indicated by World Bank+ study
- Proprietary PCC technologies gave similar cost, only marginally better than 1st generation generic 30% w/w MEA.



* www.act-ccs.eu + https://www.gob.mx/sener/en/documentos/pre-feasibility-study-for-establishing-a-carbon-capture-pilot-plant-in-mexico?lang=en

International CCUS Collaboration - Knowledge exchange for CCS deployment

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Open technology/open access activities, with feedback to ITCN, include:

http://www.co2crc.com.au/wp-content/uploads/2018/10/Retrofitting_Australian_Power_Station_with_PCC.pdf

- CO2CRC, Bechtel and UKCCSRC open access retrofit study to a full 2GW brown coal power station site, 2017-2018

- ITCN workshop on 2nd generation open access solvents in Hong Kong, June 2018
- Workshop on open access solvents at GHGT14 in Melbourne
- Workshop on practical aspects of PCC retrofit to coal and gas plants based on open access information, April 2019 in Sheffield; practitioners from China, Ireland, South Africa, Thailand, US, Norway, NL, UK
- Collaboration with Guangdong CCUS Centre in 2019-2020 on 50t/day pilot testing plus their open technology deployment plans.

International post-combustion capture retrofit workshop held in Sheffield, 9-12 April 2019

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PACT / University of Sheffield (UK)
Bechtel (US)
TNO (NL)
Test Centre Mongstad (Norway)
Universities of Edinburgh and Leeds (UK)
GDCCUS (China)
Ervia (Ireland)
SANEDI (South Africa)
CMU & EGAT (Thailand)
Gassnova – OA FEED study

https://ukccsrc.ac.uk/news-events/news/international-post-combustion-capture-retrofit-workshop

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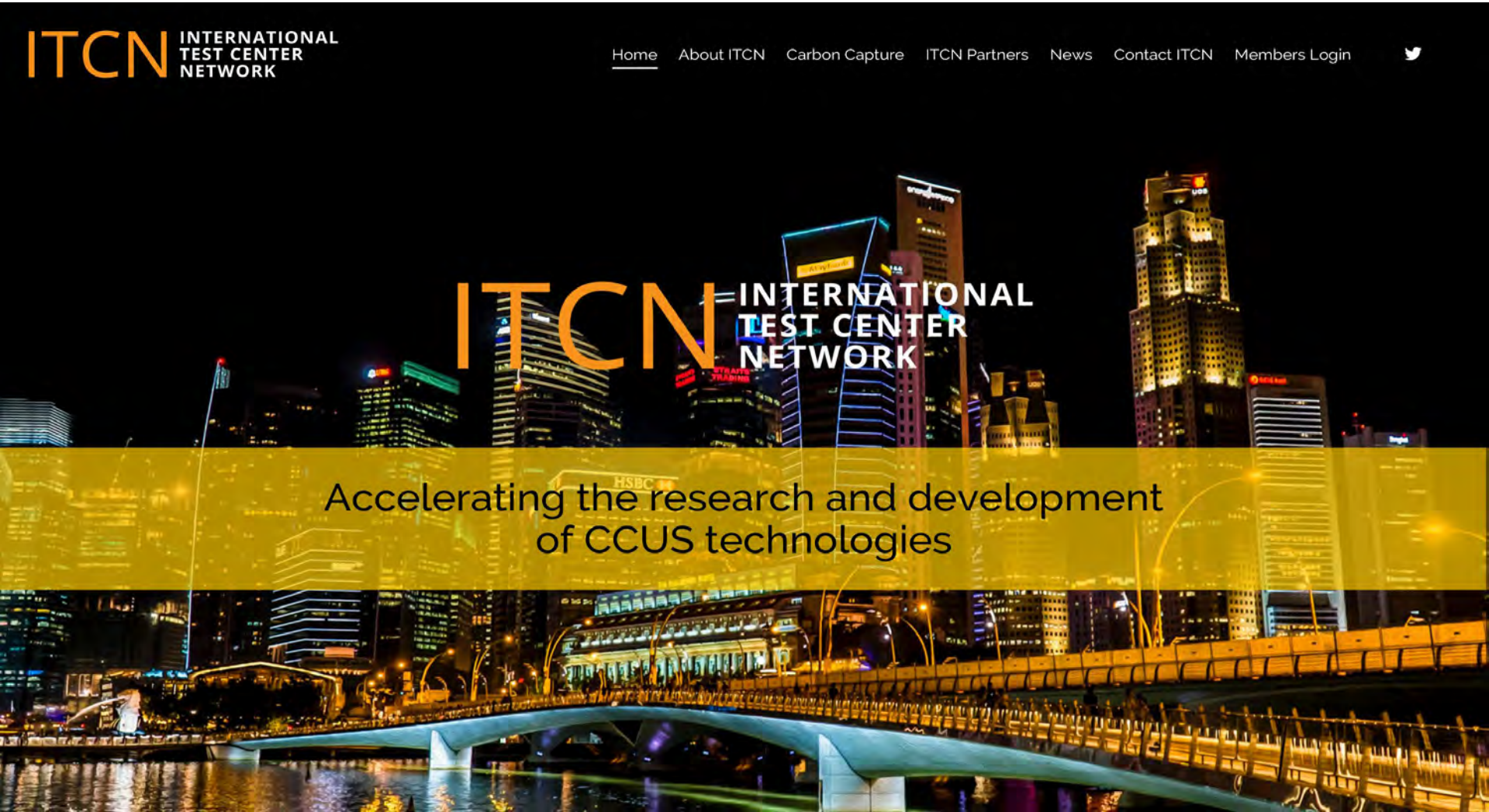
ITCN-2018-2020

- Expansion of international membership
- Partnership and collaboration
- New data archive (www.itcn-global.org) and Open Access Data
- Facilities expansion including, sCO2 reactor, BECCS + WtE, next generation capture technology and CCUS as a part of integrated smart energy system (TRL 3-6)



For additional information: Please download our factsheets for the description of ITCN facilities.

https://itcn-global.org/itcn-factsheets/