MI THINK TANK

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King Abdullah Petroleum Studies and Research Center

The Circular Carbon Economy
From Concept to Realization

Mission Innovation Think Tank Webinar

Welcome and Introduction

Eleanor Webster

Head of Secretariat, Mission Innovation

Department of Energy Security and Net Zero, United Kingdom

Event Discussion and Q&A

- Today's event will use slido for audience Q&A and discussion.
- Discussions questions at the end of the event will be selected from slido
- Join the event and ask your questions through the QR Code on screen , or at slido.com with code: **#CCEThinkTank**

Event Moderator

Brian Efird

Director for Strategic Partnerships

King Abdullah Petroleum Studies and Research Center

slido.com code: **#CCEThinkTank**

Part 1 – The Concept of the Circular Carbon Economy

Adam Sieminski
Senior Advisor to the Board of Trustees,
King Abdullah Petroleum Studies and Research Center

Kees Kwant
Mission Director,
MI Integrated Biorefineries Mission

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Circular Carbon Economy

...from Concept to Realization

Think Tank Webinar

31 January 2024

Mission Innovation & KAPSARC

Adam Sieminski

Senior Advisor to the Board of Trustees
King Abdullah Petroleum Studies and Research Center

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Climate Challenges and Hydrocarbons

Core Idea: A narrow focus on only reducing fossil fuels will result in significant, undesirable socio-economic consequences for both consumers and producers

No practical solutions for hard to abate sectors

- Few cost-efficient emissions reduction solutions for energy-intensive sectors such as aviation, shipping, heavy-duty trucking, cement, metals smelting

Reduced energy access and reliability

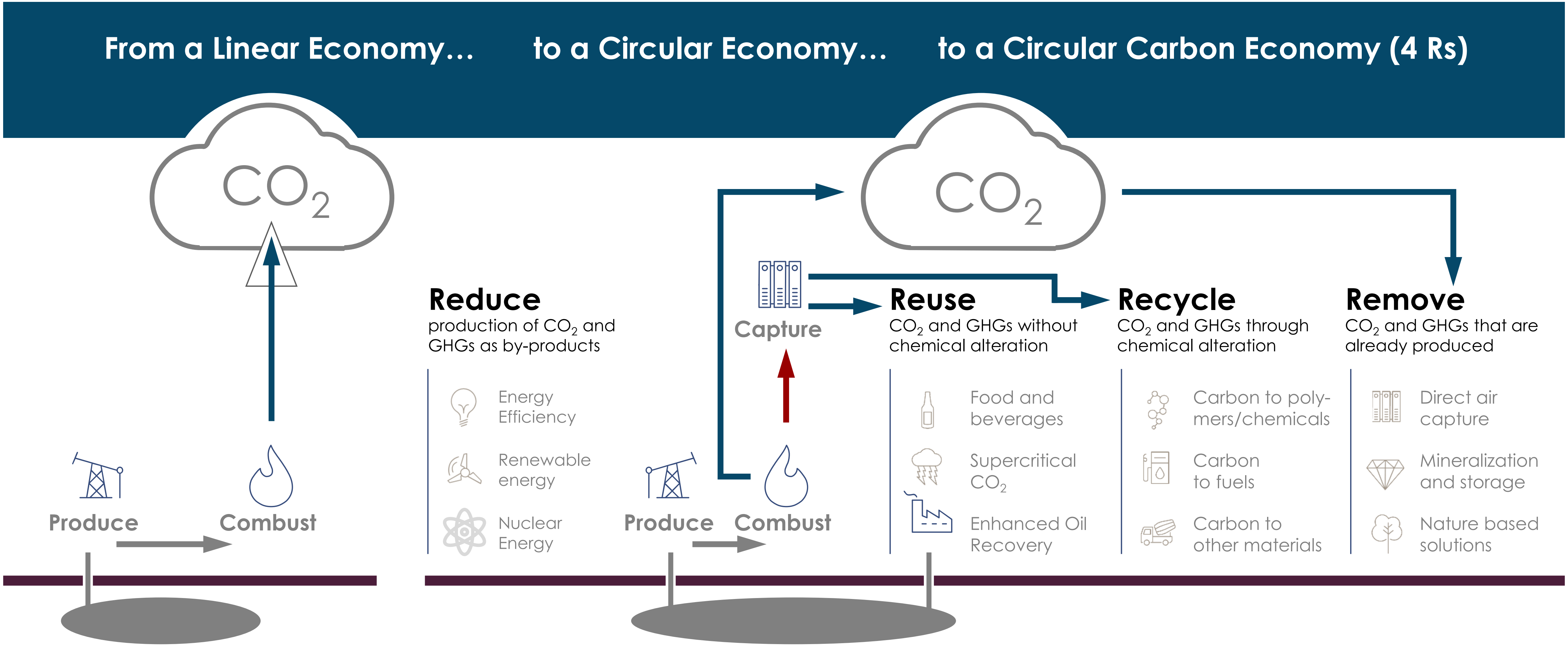
- Major negative impact on consumers access to “affordable, reliable, sustainable, and modern energy for all” – UN Sustainable Development Goal (SDG) 7
- Deterioration of energy availability as a result of depending heavily on intermittent sources

Inefficient utilization of costly existing infrastructure

- Significant cost and time in premature switching to new energy sources
- Inadequate utilization of infrastructure investments already committed

Source: KAPSARC

CCE: Holistic approach, that utilizes all available levers to address CO_2 emissions …while maintaining energy access and economic growth



Source: KAPSARC

CCE Guide – 2020

CCE Framework Adopted by the G20 in November 2020

- **Overview**
- **Reduce: Energy Efficiency**
- **Reuse: Carbon Utilization**
- **4Rs: Hydrogen**
- **Reduce: Nuclear Energy**
- **Reduce: Non-biomass Renewables**
- **Recycle: Bioenergy**
- **Remove: Carbon Capture & Storage and Direct Air Capture**
- **Enabling Policies**
- **2022 Land & Ocean Nature-Based Solutions**

Reduce

Reuse

Recycle

Remove

The circular carbon economy sustainability framework implementation can work in many countries based on each nation's unique circumstances

Technology

- **Prioritize solutions** based on abatement potential, cost, and maturity
- Advance CCE technologies with sustained **R&D and pilot projects**

Policy

- **Provide mechanisms for enabling** deployment of underutilized and new CCE technologies
- Develop **robust measurements, reporting, and verification** systems

Markets

- Establish **carbon hubs** that create a market for carbon leading to innovative products
- Look for ways to make carbon a **value-added** product not an economic burden

Source: KAPSARC

Thank You

MISSION INNOVATION

Mission Integrated Biorefineries

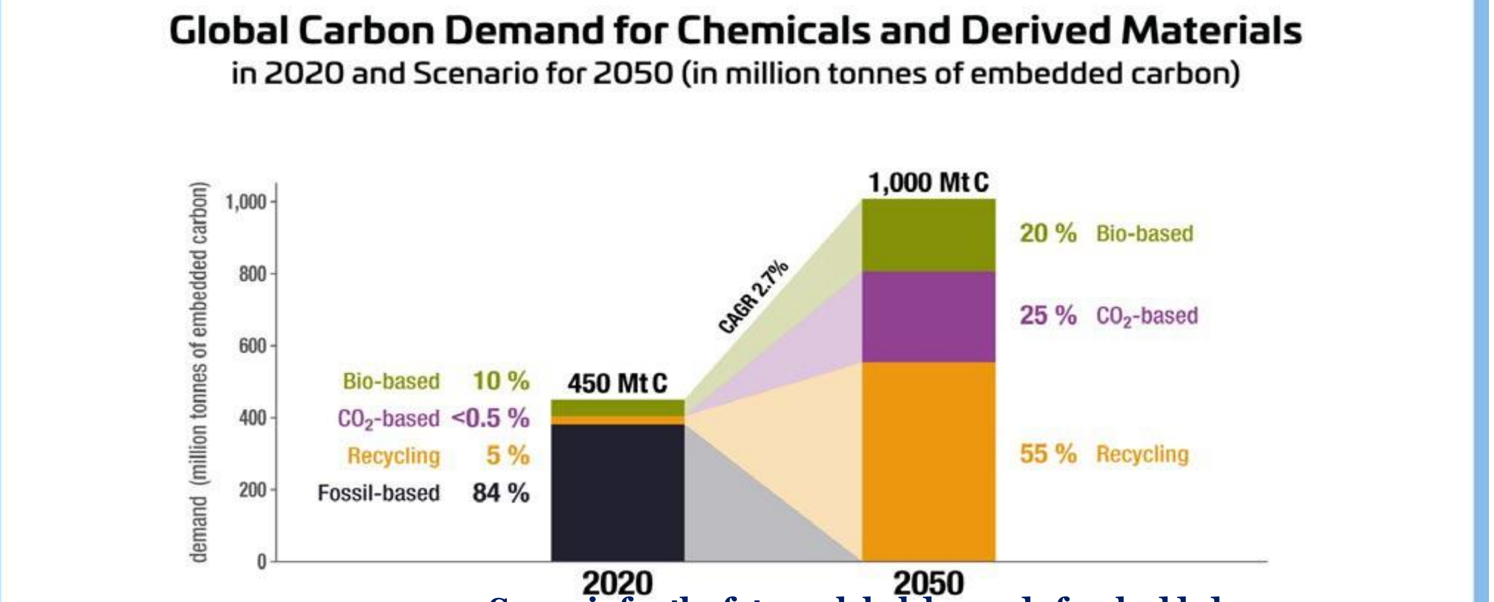
Integrated Biorefineries – Mission Innovation (mission-innovation.net)

Contact, Mission Director: kees.kwant@rvo.nl

Mission Integrated Biorefineries

The tipping point

- *In order to achieve a 100% replacement of fossil resources in 2050, we need a start with an additional 10% replacement by 2030.*
- *All options: Recycling, CCU and bio-based will contribute*
- *Commercialization of biorefineries should be accelerated with a target of 10% of fossil carbon replaced by sustainable bio-carbon*



[Scenario for the future global demand of embedded carbon for chemicals and derived materials in 2050 (nova-Institute 2021)]

Application in hard to electrify sectors

Mission Integrated Biorefineries

Goal:

develop and demonstrate innovative solutions to accelerate the commercialization of integrated biorefineries, with a target of replacing 10% of fossil-based fuels, chemicals and materials with bio-based alternatives by 2030.

Launched in India in 2022

Mission Integrated Biorefineries

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Advancing Work Across Three Pillars

- **1. Research and development:** Promoting research, development, and innovation across the biorefining supply and value chain;
- **2. Pilot scale and demonstration projects:** Advancing pilot-scale demonstration projects for sustainable biorefining technologies;
- **3. Markets policies and Regulations:** Supporting standards and regulatory development in collaboration with industry and leading experts (e.g. LCA and Carbon accounting)

Participating Countries

- India (Mission Co-lead)
- The Netherlands (Mission Co-lead)
- Brazil (Core Member)
- Canada (Core Member)
- United Kingdom (Supporting Member)
- European Commission (Supporting Member)

Mission Integrated Biorefineries

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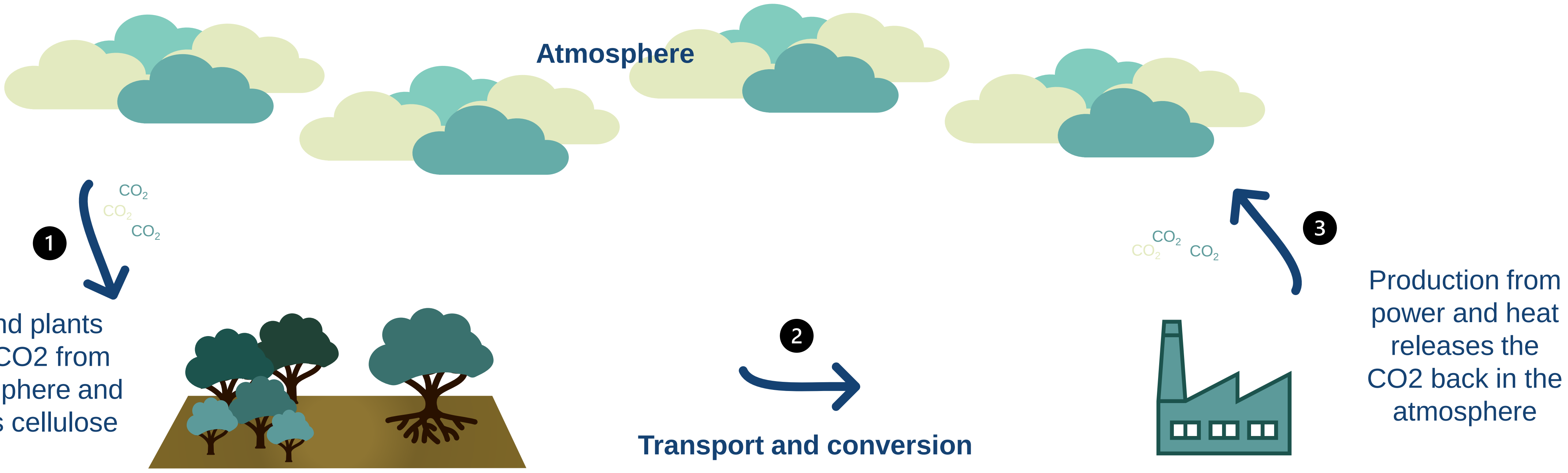
Pillar 3: Market and Policies

7. Sustainability	• Collaboration CEM Biofuture Initiatative workstream 4
8. LCA and Carbon accounting	• Collaboration with UN LCA Initiative • IEA Bioenergy T39/45 • CEM Biofuture initiative

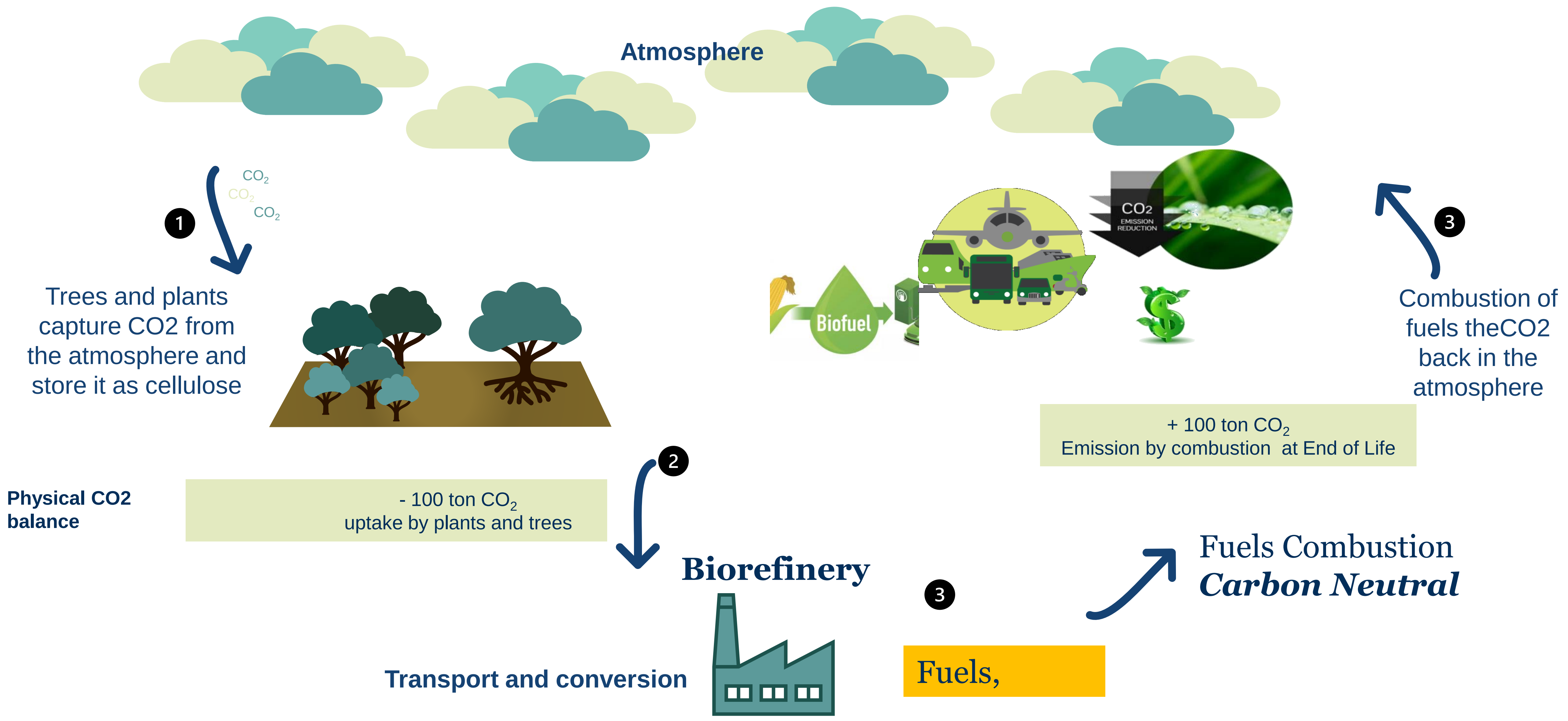
Carbon cyclus bioresources
Conceptual for **energy (electricity and heat)**



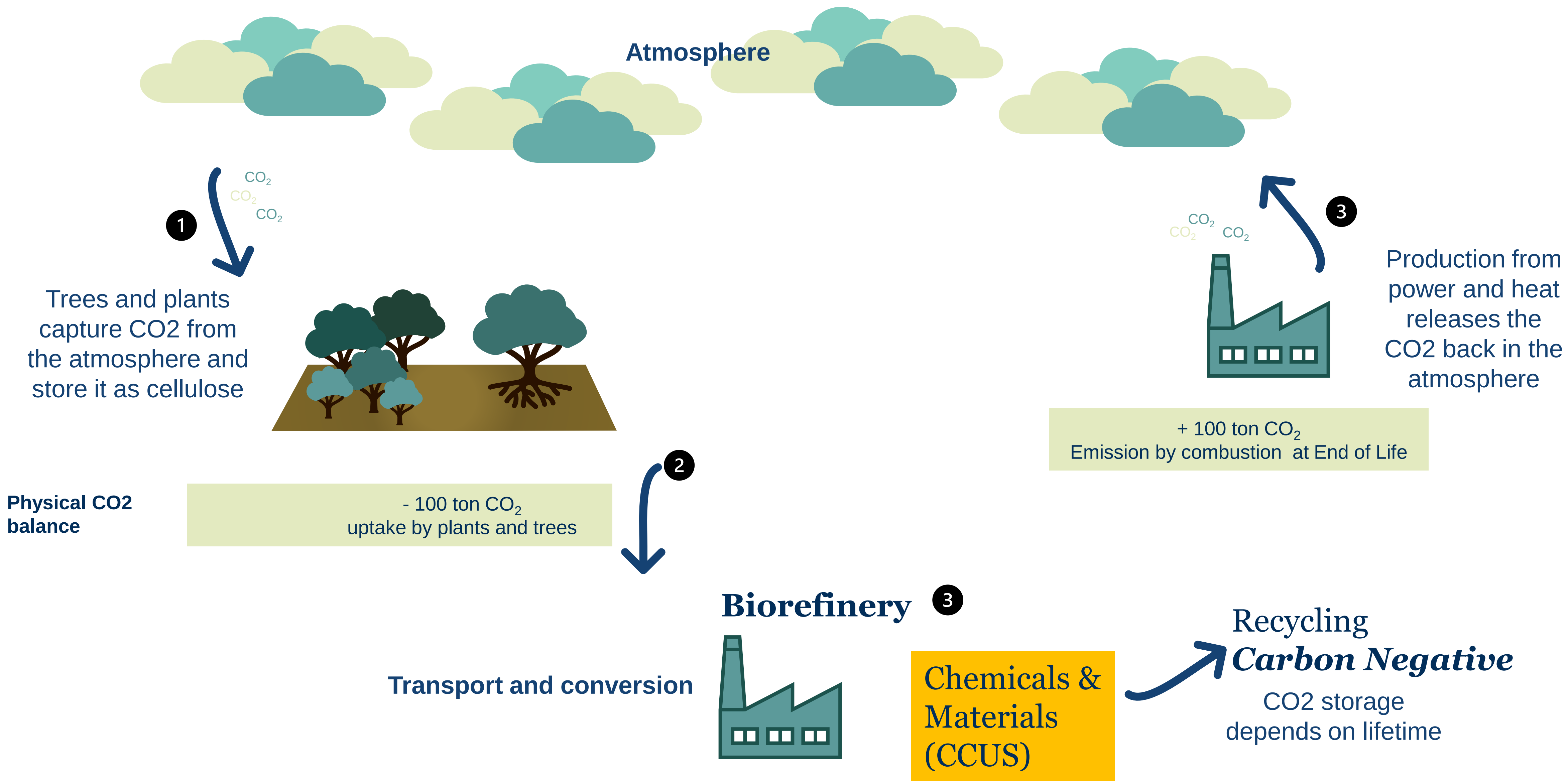
Physical CO2 balance	- 100 ton CO_2 uptake by plants and trees	+ 100 ton CO_2 Emission by combustion of biomass or biofuels
	LULUCF sector	**Energie sector**
Administrative CO2 balans NIR	- 100 ton CO_2 Taken up by plants / trees + 100 ton CO_2 In plants available as biomass	0 ton CO_2

Almost Carbon neutral energy

Carbon cyclus bioresources
Conceptual for **energy as a Fuel (e.g. SAF)**



Carbon cyclus bioresources
Conceptual for materials



Conclusion

- Biobased resources are Carbon Neutral
- Biobased Chemicals may replace fossil chemicals
- Combustion of fossil based materials results in increased CO2 emissions
- Combustion of biobased materials is Carbon neutral
- Circular biobased results in Carbon storage (CCUS)
- More info: IEA Bioenergy, Bio BECCUS Carbon Accounting
- Microsoft Word - IEA Bio BECCUS Carbon accounting. docx.docx (ieabioenergy.com)

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Mission Integrated Biorefineries

THANK YOU

Contact the co-leads:

The Netherlands :

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INTEGRATED BIOREFINERIES MISSION – Mission Innovation (mission-innovation.net)

Part 2 – Measuring and Implementing CCE at a National Level

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cce INDEX
Circular Carbon Economy Index
مؤشر الاقتصاد الدائري للكربون

January 31, 2024

Circular Carbon Economy MI Think Tank Event

The Circular Carbon Economy Index

Mari Luomi, Fatih Yilmaz, with Thamir Alshehri, Alaa Alarfaj, Pavithra Shetty and Hind Aldhuwaihi

The circular carbon economy

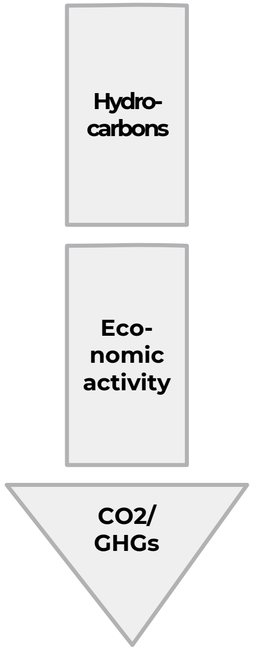
A framework **to support transitions to net-zero emissions** in line with the Paris Agreement's goals.

Builds on the circular economy concept, but focuses on **energy and emissions flows**

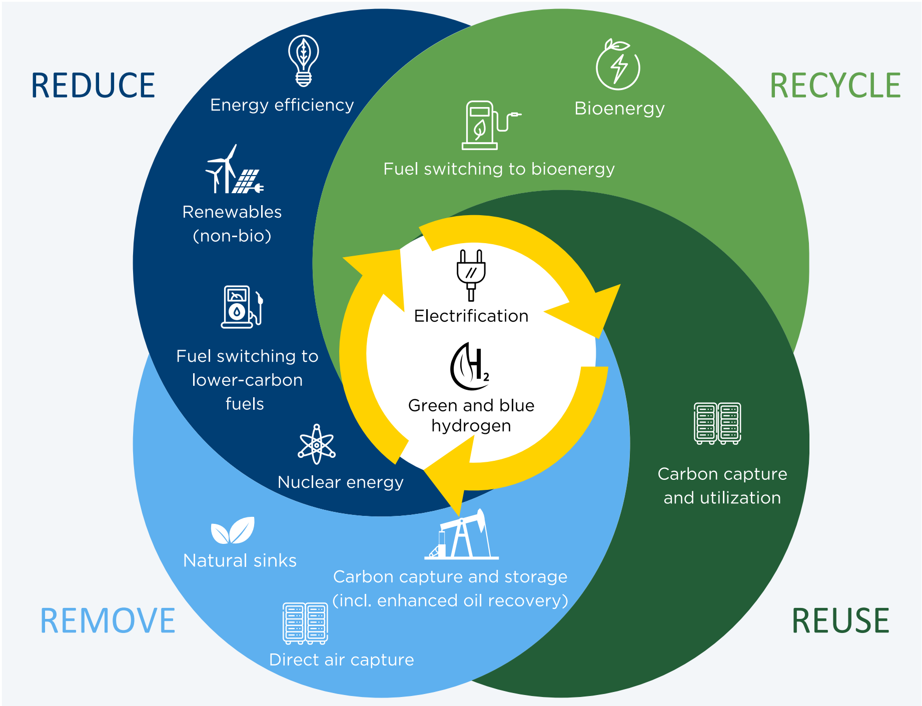
The circular carbon economy (CCE)'s 4 pillars: **reduce, recycle, reuse and remove**

Holistic, technology-neutral approach that enables effective and efficient emissions reductions

Linear economy

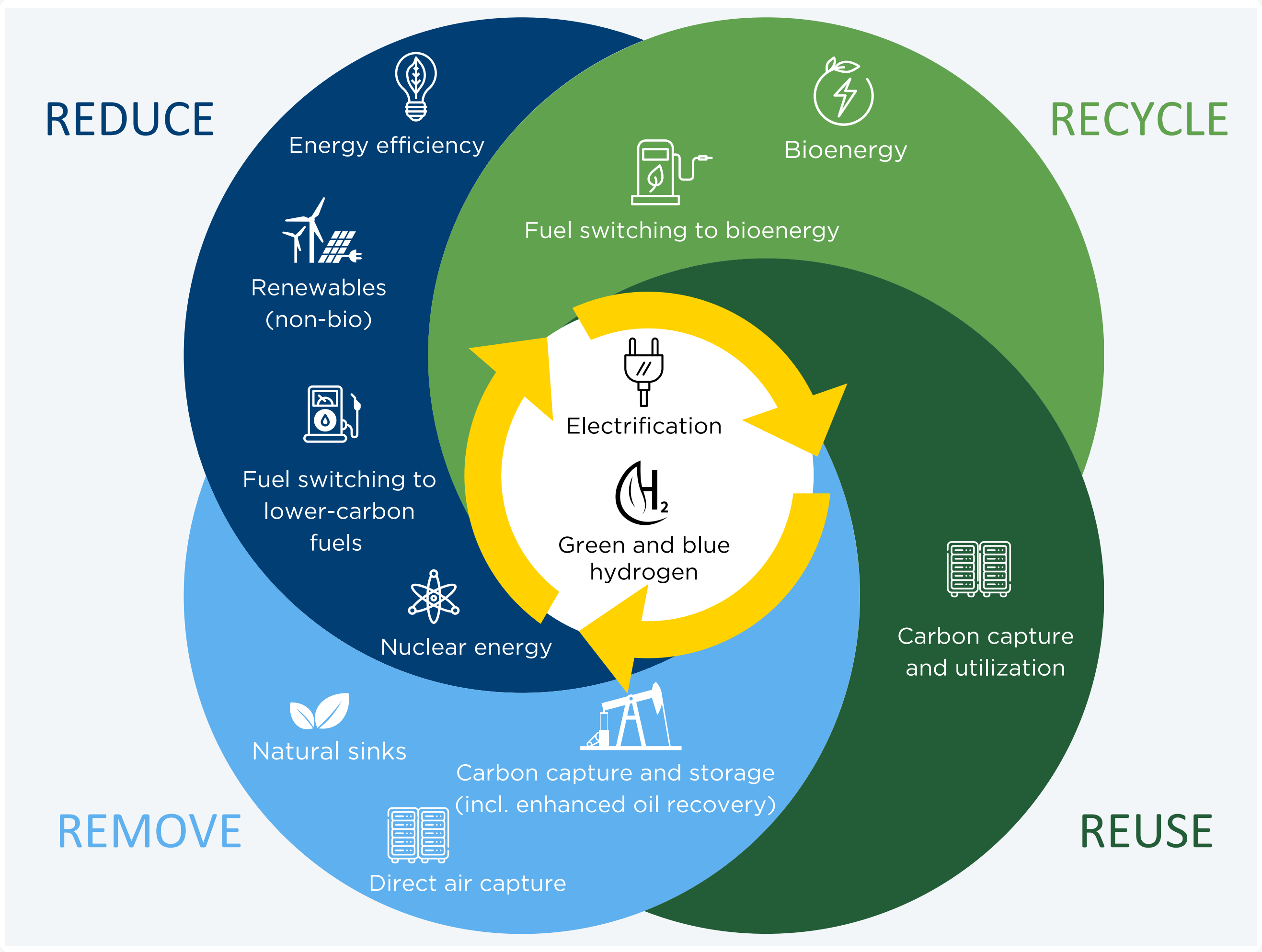


Circular carbon economy



Sources: Williams (ed.) 2020; Luomi, Yilmaz and Alshehri 2021; CCE Index web portal

The circular carbon economy



Using all available technologies and approaches to reach ***net-zero emissions*** *in a cost-effective manner, playing to each country's strengths.*

Sources: Williams (ed.) 2020; Luomi, Yilmaz and Alshehri 2021; CCE Index web portal

The CCE Index

A composite indicator that enables measuring **country performance and potential to progress toward CCEs and net-zero emissions** in diverse contexts. The methodology builds on best practice in index development, with transparency as a leading principle.

THE CCE INDEX AIMS TO:

- Promote understanding of the CCE concept
- Create a common language around CCE metrics
- Enable data-driven policy and planning discussions in various contexts

THE CCE INDEX FOCUSES ON ANSWERING THE FOLLOWING QUESTIONS:

- How are countries **engaging with diverse climate change mitigation** options and technologies in terms of **depth and diversity**?
- How are countries **positioned to accelerate progress toward circular carbon economies**?
- How do **different countries compare to each other** on their current CCE performance and CCE transition potential?

... WITH THE AIM OF SPARKING FURTHER CONVERSATION ON THESE TOPICS.

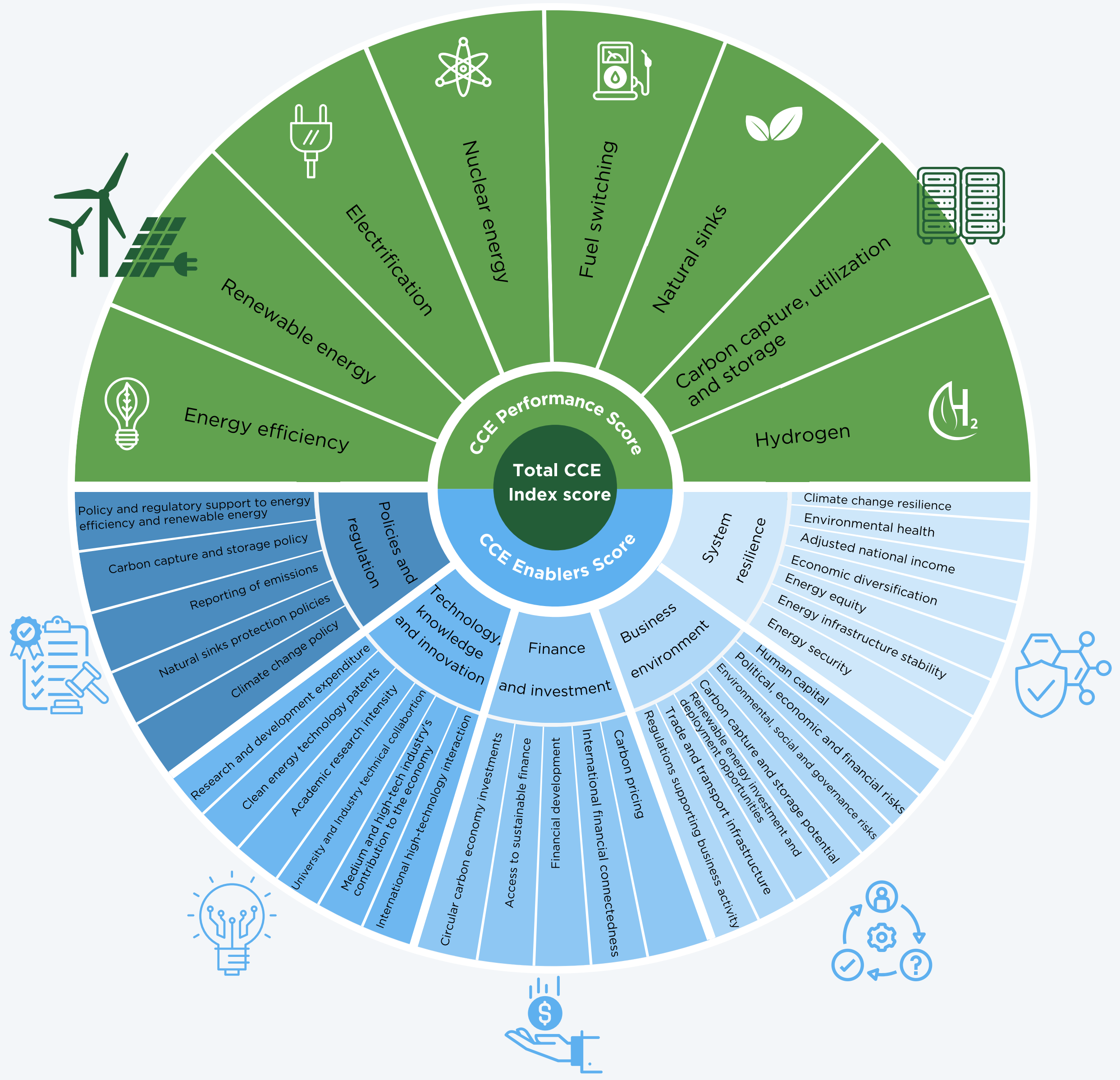
2023 CCE Index indicator framework

CCE Performance:

- How are countries engaging with diverse climate change mitigation options and technologies in terms of depth and diversity?

CCE Enablers:

- How are countries positioned to accelerate progress toward circular carbon economies?



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Source: CCE Index web portal: https://cceindex.kapsarc.org/

cce INDEX

2023 CCE Index Oil Producers Lens indicator framework

CCE Performance:

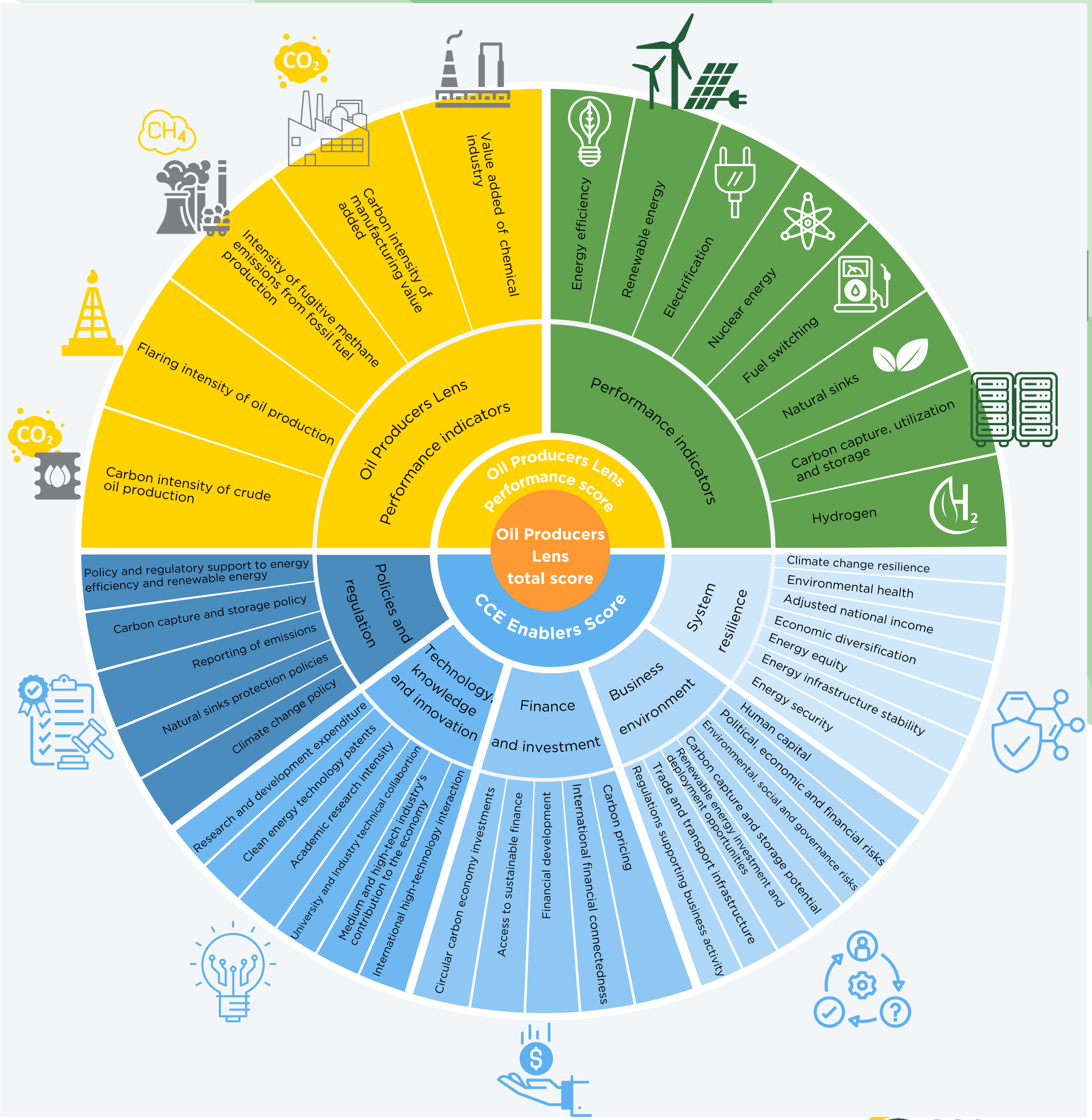
- How are countries engaging with diverse climate change mitigation options and technologies in terms of depth and diversity?

CCE Enablers:

- How are countries positioned to accelerate progress toward circular carbon economies?

Oil Producers Lens:

- How is major oil and gas producers' industrial performance (& business environments) aligning with the CCE?



Source: CCE Index web portal: https://cceindex.kapsarc.org/

Country coverage

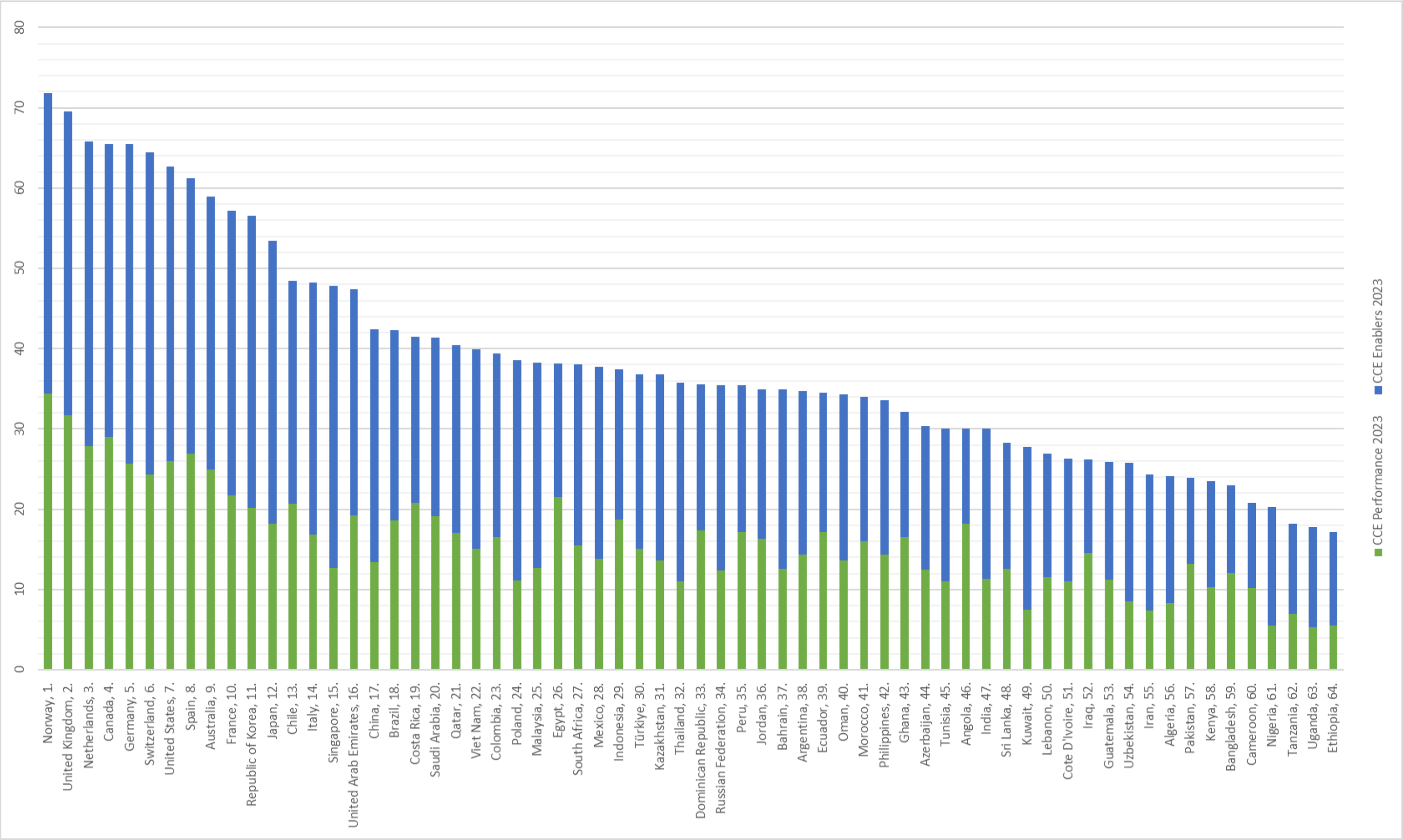
90% of the global GDP and CO_2 emissions –
64 countries (2023)

Country inclusion criteria:

- At least 1 million population
- Largest economies from each World Bank region
- Top-30 oil and gas producers
- Arab League member countries
- 80% or more of indicators values available

Source: CCE Index web portal: https://cceindex.kapsarc.org/

2023 CCE Index scores (total)



Top-5 countries:

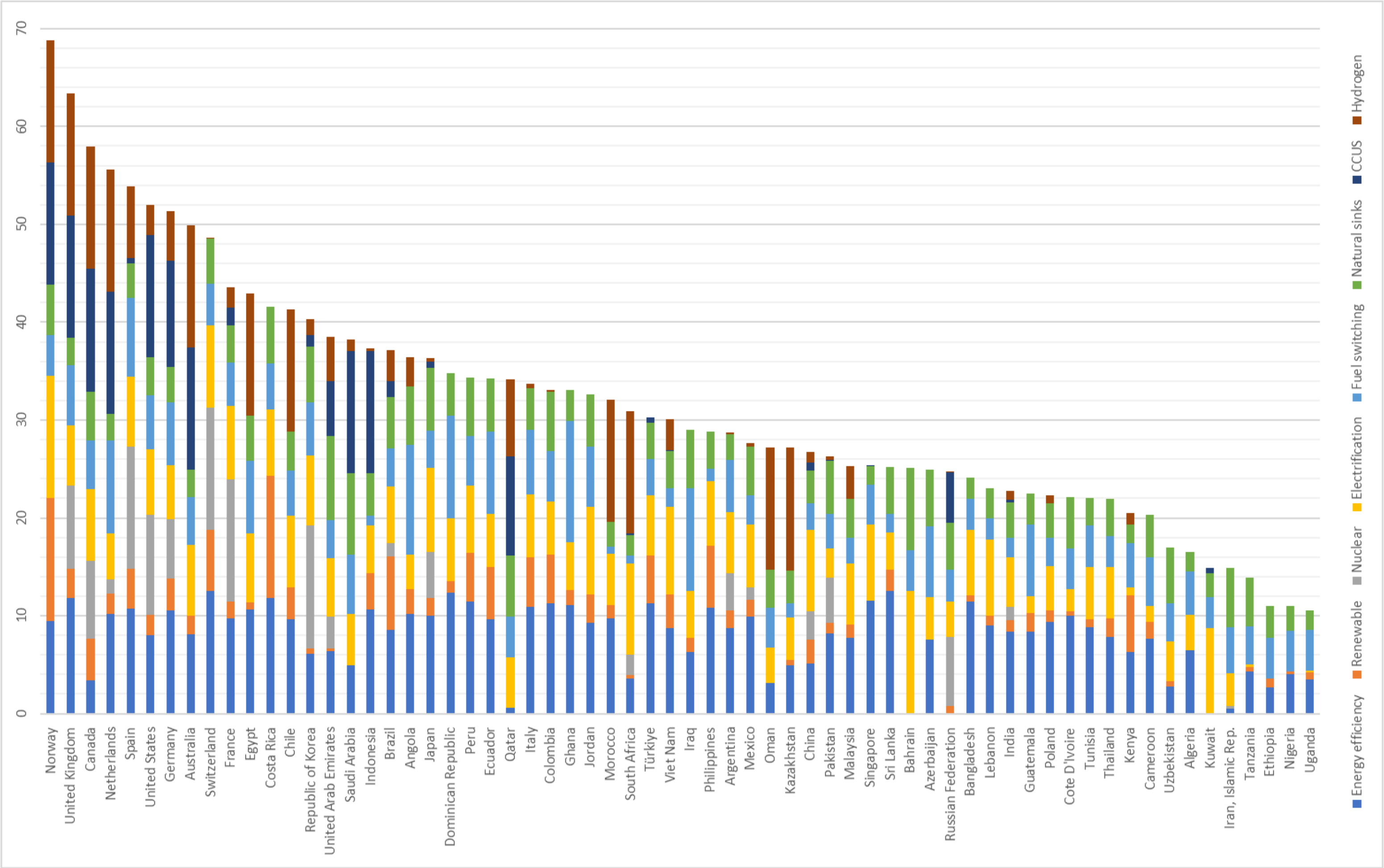
Norway, UK, Netherlands, Canada, Germany

Bottom-5 countries:

Cameroon, Nigeria, Tanzania, Uganda, Ethiopia

Source: Luomi, Yilmaz and Alshehri 2023.

2023 CCE Performance scores (total)



Top-5 countries:

Norway, UK, Canada, Netherlands, Spain

Bottom-5 countries:

Iran, Tanzania, Ethiopia, Nigeria, Uganda

Source: Luomi, Yilmaz and Alshehri 2023.

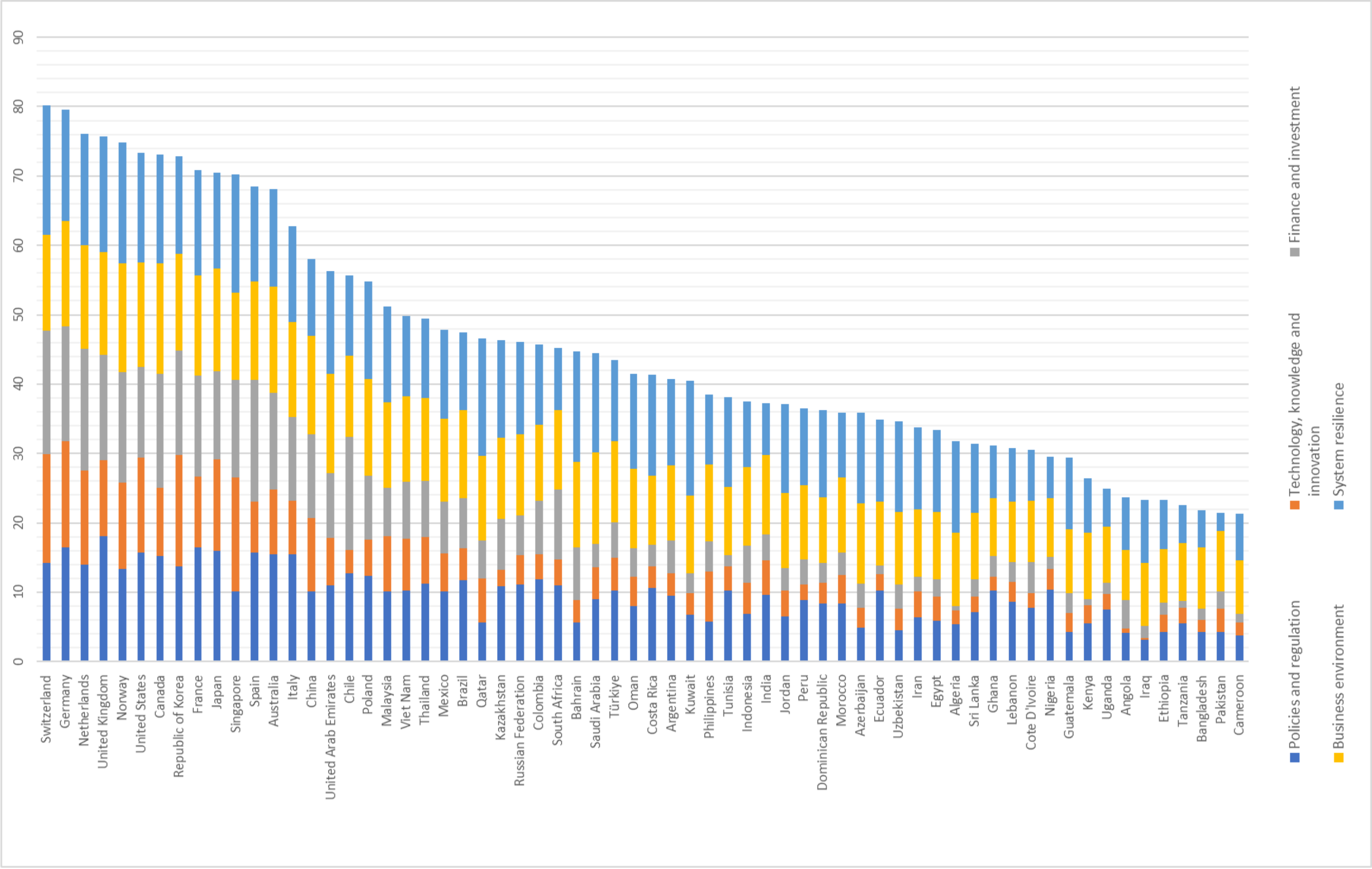
2023 CCE Enablers scores (total)

Top-5 countries:

Switzerland, Germany, UK, Norway, US

Bottom-5 countries:

Ethiopia, Tanzania, Bangladesh, Pakistan, Cameroon



Source: Luomi, Yilmaz and Alshehri 2023.

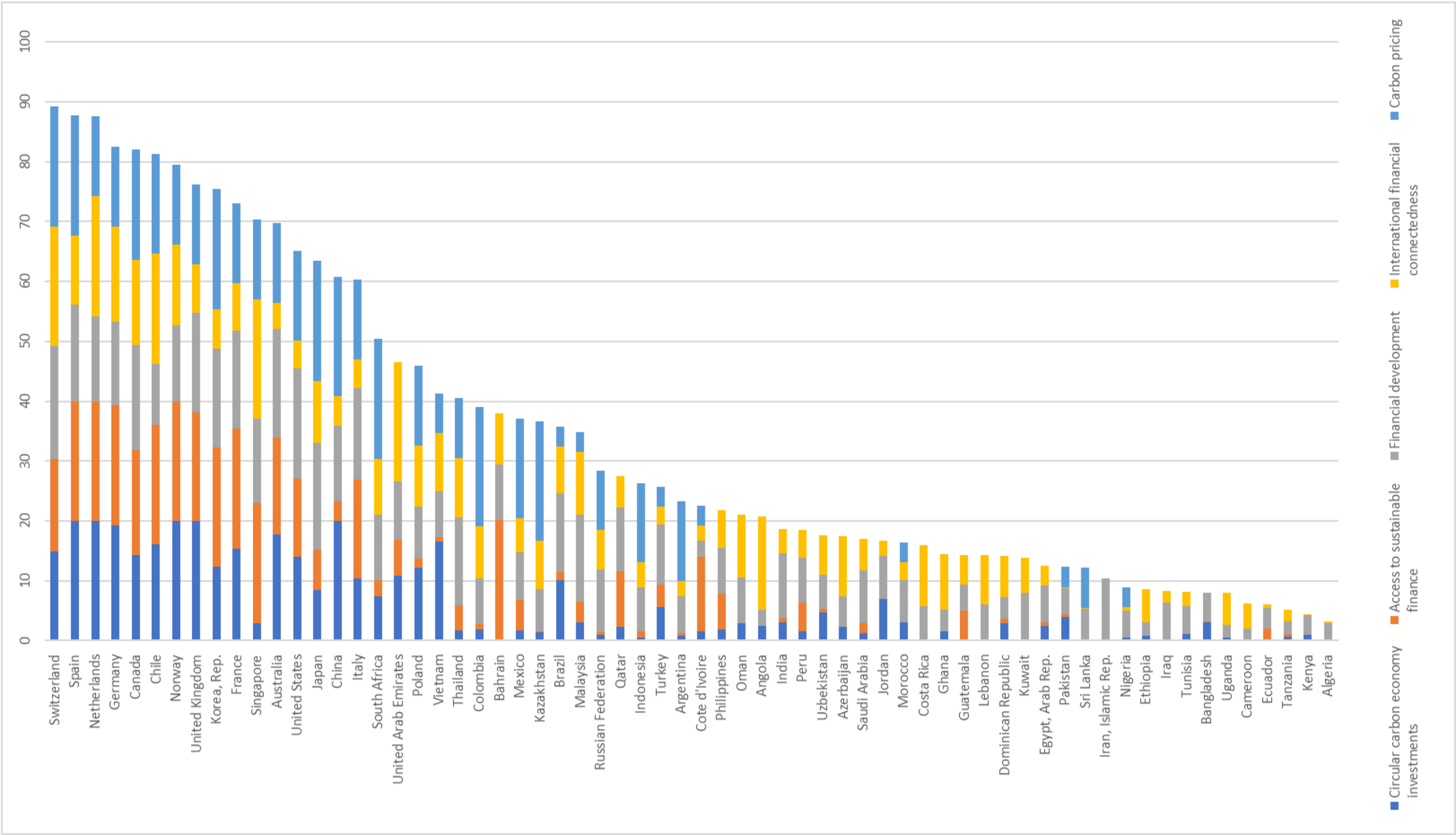
2023 CCE Enablers scores –
Finance and investment

Top-5 countries:

Switzerland, Spain, Netherlands, Germany, Canada

Bottom-5 countries:

Cameroon, Ecuador, Tanzania, Kenya, Algeria



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Source: Luomi, Yilmaz and Alshehri 2023.

CCE INDEX

CCE Index methodology and analysis

All underlying data and indicator descriptions are available via the CCE Index web portal, along with KAPSARC research papers describing the Index methodology, analyzing the 2021 and 2022 results, and presenting more detailed case studies of Saudi Arabia and the GCC countries.

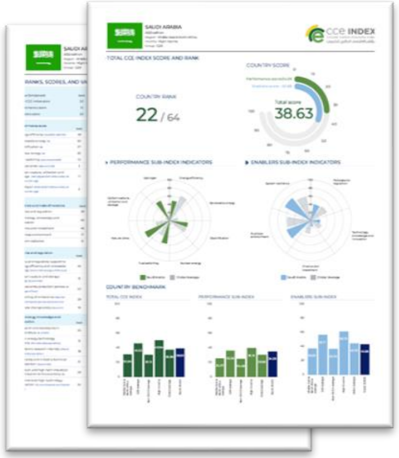
The 2023 edition of the CCE Index was launched at the UN Climate Change Conference in Dubai (COP 28).

Further country and regional case studies are under development/scoping.

CCE Index downloads

CCE Index project page

The CCE Index web tool



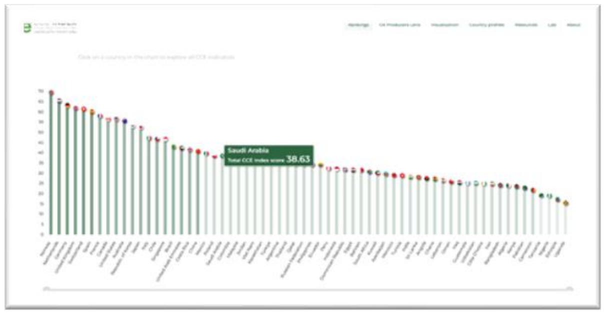
Portal features:

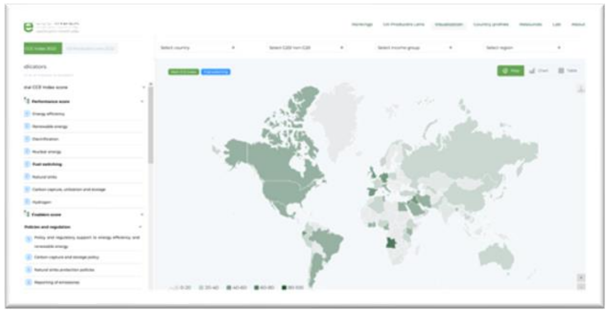
- Complete CCE Index results for **64 countries**, including top-30 oil and gas producers
- **Visual** displays of the CCE Index results
- Options for country **comparisons**, including in key reference groups (major economies, income, region)
- **Additional indicators** and scores for 28 oil and gas producers
- **Country profiles** and **scorecards**
- **Resources**: methodology, underlying data and research

The portal has also a section for advanced users, **the CCE Index Lab**, with **two simulator tools** and **two analysis tools**:

Indicator weights: Allows for changing the weight of one or more indicator and observe the impact on country scores and rankings.

Indicator values: Enables toggling indicator values for an individual country and observe the impact on the country's score and rank.





Country comparisons: Allows comparing a country to other countries covered by the CCE Index.

Group comparisons: Allows comparing a country to different groups, including based on region and income, and to the CCE Index country averages.

TO BE A LEADING ADVISORY THINK TANK IN ENERGY ECONOMICS AND SUSTAINABILITY.

The 2023 Circular Carbon Economy Index

Additional slides

CCE Index methodology

01

Conceptual framework development (and country selection)

- Identifying targets of measurement (temporary) and concepts > quantitative indicators

02

Data selection

- Indicator selection criteria (e.g. relevance, communicability, validity, availability)
- Defining data sources (official, research, reputable corporate providers)
- Choice of years (latest available as the primary option)
- Data coverage requirement and related exceptions

03

Data preparation and processing

- Imputations and missing data (three-step hierarchy)
- Boundary values (three-step hierarchy)
- Rescaling to retain positive relation (i.e., higher score equals better score)
- Weighting and aggregation (equal weighting, for aggregation, see next slide)

04

Validation

- Robustness
- Cross-validity
- Links to other statistics

05

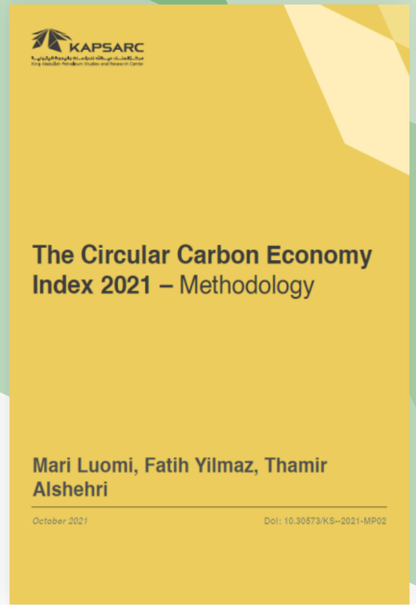
Updates, including metrics, to ensure policy relevance

- Annual/continuous gap analysis
- Proactive requests for inputs, further expert and stakeholder consultations

06

Stakeholder engagement

- Consultations with experts and data providers
- Quality assurance via the International Technical Advisory Committee (currently 5 members)


KAPSARC

The Circular Carbon Economy Index 2021 – Methodology

Mari Luomi, Fatih Yilmaz, Thamir Alshehri

October 2021

DoI: 10.30573/KS--2021-MP02

Source: Luomi, Yilmaz and Alshehri, 2021, The Circular Carbon Economy Index -- Methodology. KAPSARC.

Aggregation logic of the 2023 CCE Index

<table>
<tr><th>Index level</th><th>Sub-index level</th><th colspan="5">Dimension/indicator level</th><th>No.</th></tr>
<tr><td rowspan="3">CCE Index</td><td>Performance score (50%)</td><td colspan="5">Performance indicators (6.25% each)</td><td>8</td></tr>
<tr><td rowspan="2">Enablers score (50%)</td><td colspan="5">Enablers dimensions</td><td rowspan="2">30</td></tr>
<tr><td>Policies and regulation (10%)</td><td>Tech., knowledge and innovation (10%)</td><td>Finance and investment (10%)</td><td>Business environment (10%)</td><td>System resilience (10%)</td></tr>
<tr><td rowspan="4">Oil Producers Lens</td><td rowspan="2">Oil Producers Lens Performance score (50%)</td><td colspan="5">Performance indicators (3.13% each)</td><td>8</td></tr>
<tr><td colspan="5">Oil Producers Lens Performance indicators (5% each)</td><td>5</td></tr>
<tr><td rowspan="2">Enablers score (50%)</td><td colspan="5">Enablers dimensions</td><td rowspan="2">30</td></tr>
<tr><td>Policies and regulation (10%)</td><td>Tech., knowledge and innovation (10%)</td><td>Finance and investment (10%)</td><td>Business environment (10%)</td><td>System resilience (10%)</td></tr>
</table>

Source: Luomi, Yilmaz and Alshehri 2022.

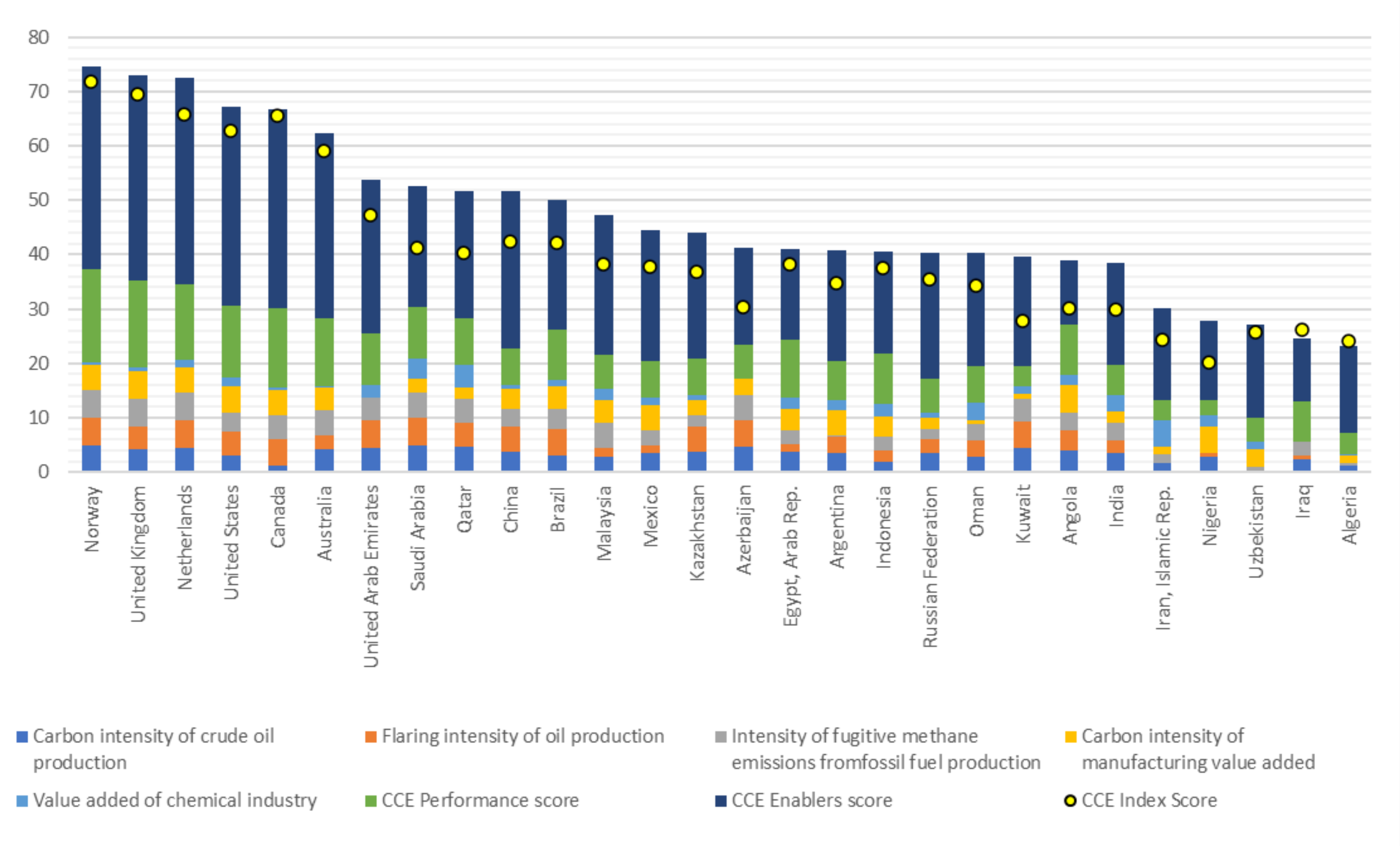
2023 Oil Producers Lens (total)

Top-3 countries:

Norway, UK, Netherlands

Bottom-3 countries:

Uzbekistan, Iraq, Algeria



Source: Luomi, Yilmaz and Alshehri 2023.

2023 CCE Performance

– Regional leaders

Leaders in each region:

Australia

Norway

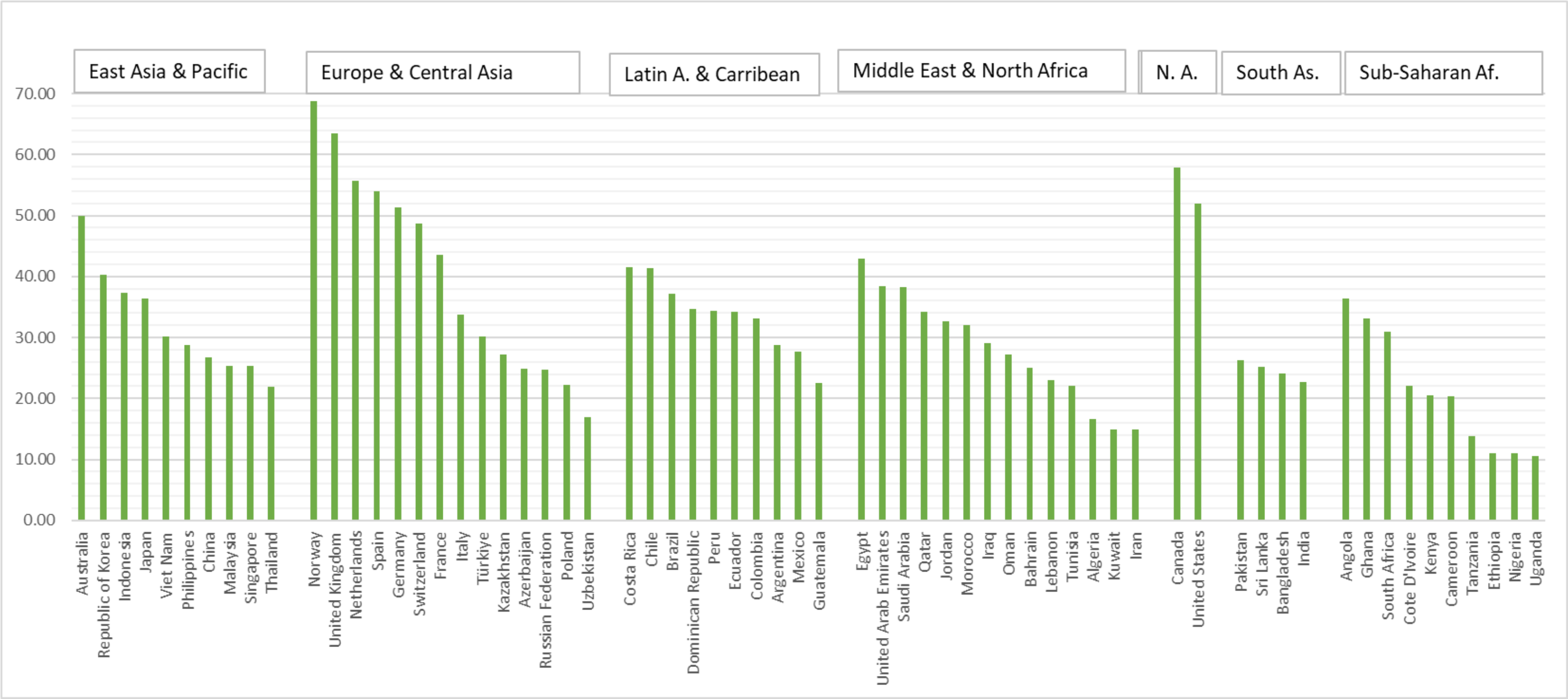
Costa Rica

Egypt

Canada

Pakistan

Angola



Source: Luomi, Yilmaz and Alshehri 2023.

2023 CCE Enablers –
Regional leaders

Leaders in each region:

Republic of Korea

Switzerland

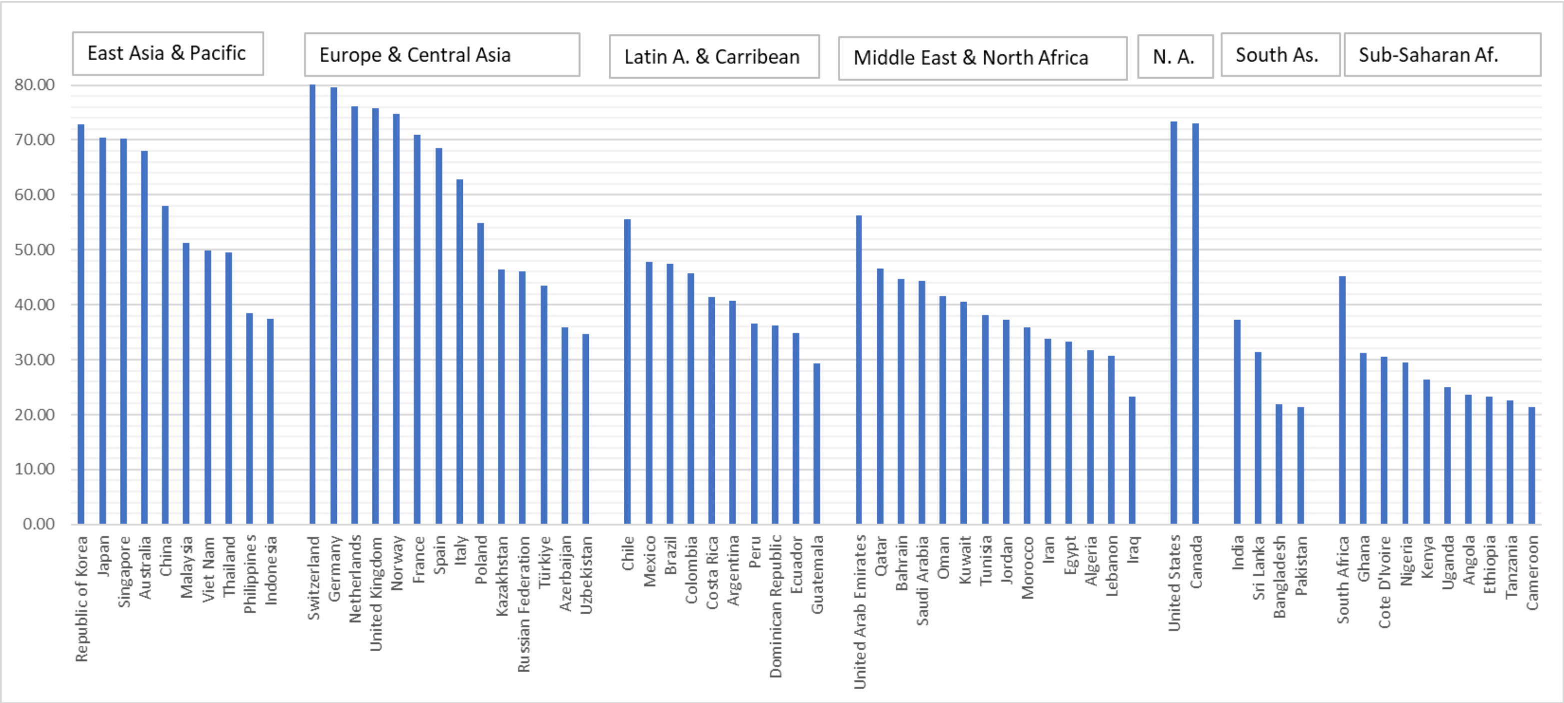
Chile

UAE

United State

India

South Africa



Source: Luomi, Yilmaz and Alshehri 2023.

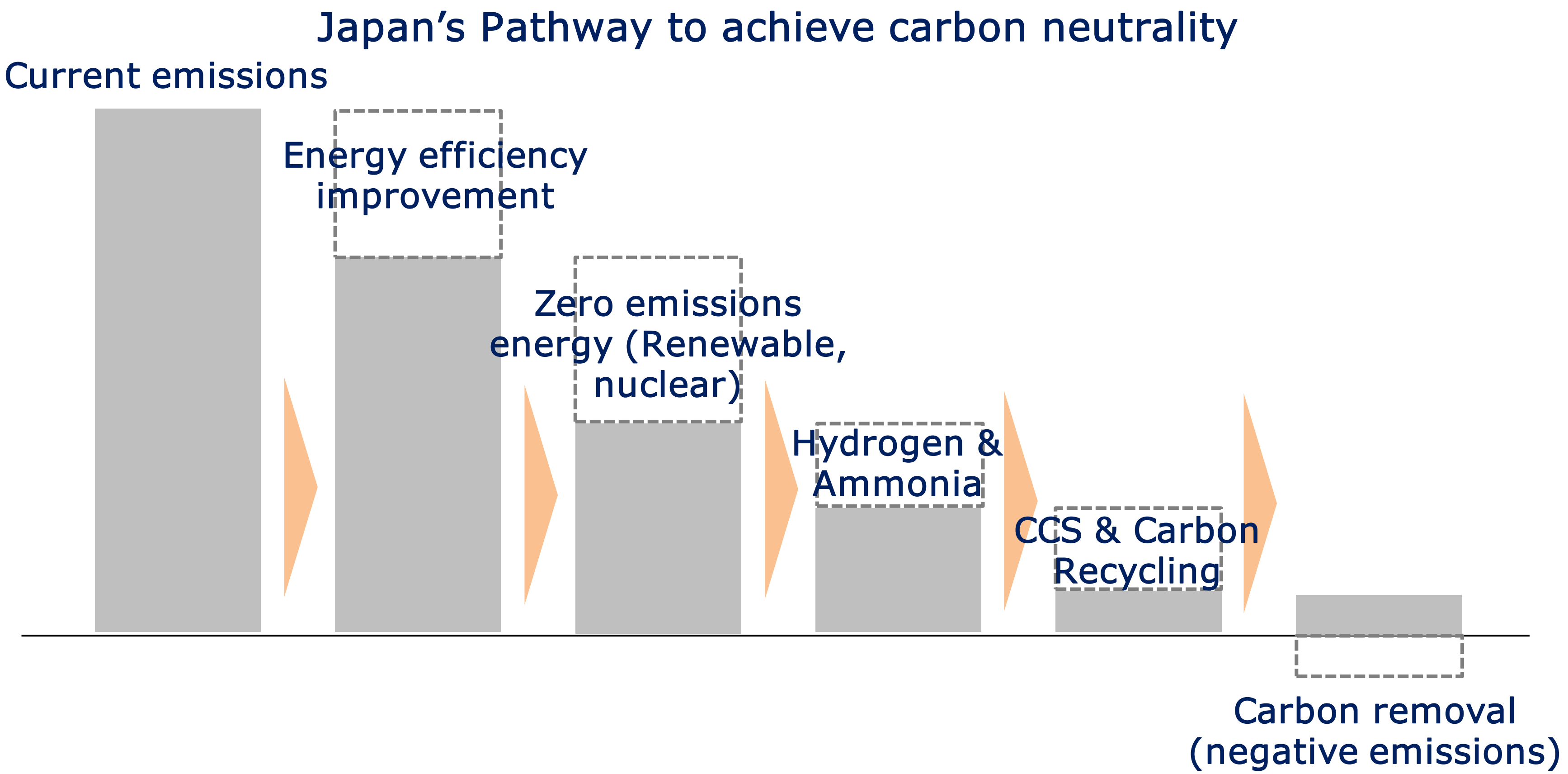
Implementing Circular Carbon Economy in Japan

January 2024

Yoshikazu Kobayashi
The Institute of Energy Economics, Japan (IEEJ)

Importance of the concept of CCE to Japan

- Japan is the fifth largest energy market with limited renewable energy resources and slow restart of nuclear power generation units.
- Holistic approach based on technology neutrality of CCE match the traditional 3E plus S conception of the Japanese energy and climate policy



Carbon Recycling Roadmap (June 2023)

- The RM says that the CR technologies can recycle 100 to 200 million tons of CO_2 for fuel, chemical, and mineralized products.

Present — **2030** — **Beyond 2040**

Promote R&D, particularly technological development of products that do not require hydrogen and products with a high level of technological maturity.

Chemicals

Further reduction of CO_2 emissions through process improvements

Fuels

Reducing costs to about 1/8 to 1/16 of current levels

Minerals

Reducing costs to about 1/3 to 1/5 of current levels

Possibility of bringing forward by cost reduction and business environment improvement

Expected to spread from 2030

- **Chemicals** Polycarbonate, etc.
- **Fuel** Synthetic fuel, SAF, synthetic methane
- **Minerals** Concrete products (for roadblocks, etc.)

Expected to spread from 2040

- **Chemicals** Commodity chemicals (olefins, BTX)
- **Fuel** Green LP gas
- **Minerals** Concrete products (for buildings, bridges, etc.)

Source: METI modified by IEEJ

Technologies for CR

- Chemicals, fuels, and mineralized products are three major CR product.
- Mineralized products that do not require H_2 are closer to commercialization.

CR products	Current Status	Major issues	2030 Target	After 2040
Synthetic Gas, Methanol, etc.	Partially commercialized: Innovative processes (using light, electricity) are at the technology development stage.	Improvement of conversion efficiency, reaction speed, enhancement of catalyst durability	Reduction of production cost	Further reduction of production cost
Basic chemicals (Olefins, BTX, etc.)	Partially commercialized (using synthetic gas ,coal feed stock).	Improvement of conversion rate and selectivity	Reduction of production cost	Further reduction of production cost
Oxygenated compounds	Partially commercialized (Polycarbonates etc.),	Further reduction of CO_2 emissions for Polycarbonate Improvement of conversion rate and selectivity)	Cost equivalent to existing products	Further reduction of production cost
Bioproducts, Bio-derived chemicals	Technology development stage (Production using CO_2 and non-edible biomass as feedstock)	Cost reduction; efficient preprocessing technology; microbial modification technology	About 1.2 times the cost of existing products	Further cost reduction
Liquid fuel (Biofuel (SAF))	Technology development /demonstration stage [Price Example] SAF 1,600 JPY/L	Improvement of production rate, low cost & efficient preprocessing technology	Reduction of production cost	Further cost reduction
Liquid fuel (Synthetic fuel (e-fuel))	Technology development stage (Synthetic fuel (e-fuel)) [Price Example]Synthetic fuel approx. 300-700 JPY/L	Improvement of processes; selectivity, system optimization	—	Cost equivalent to existing products (about 100-150 JPY/L)
Gas fuel (Synthetic methane, LP gas, etc.)	Technology development/demonstration stage	System optimization, scaling up, high efficiency	Reduction of production cost	Cost equivalent to existing products (40-50 JPY/Nm^3) ※4
Concrete, Carbonates, Carbon, Carbides	Partially commercialized, [Price Example] Few hundred JPY/kg (roadblock)	sequestration of active ingredients that react with CO_2, pulverization, cost reduction, etc.	Utilization for roadblocks and other products cost equivalent to existing products	For products with expanded applications, cost equivalent to existing products

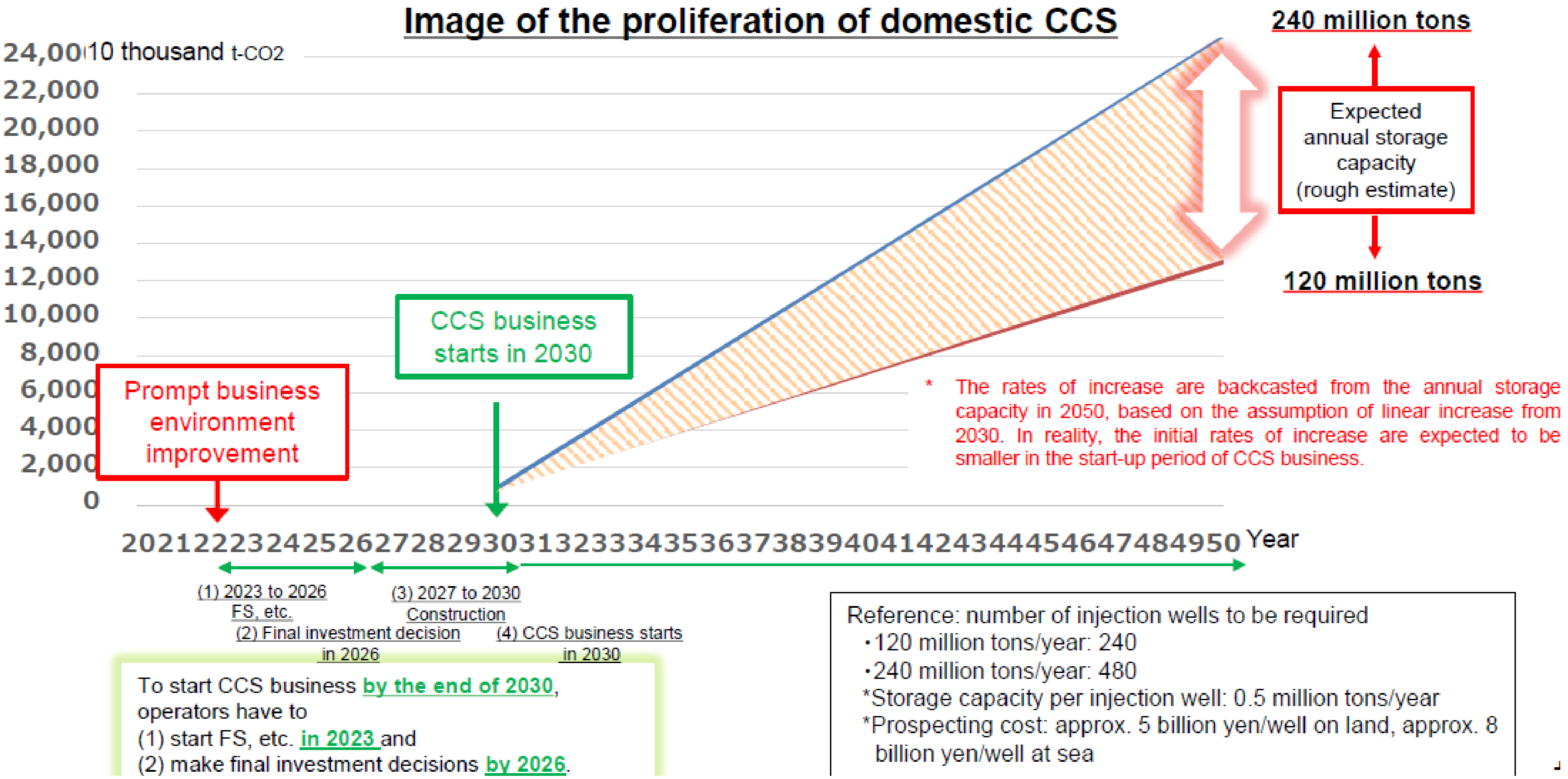
Source: METI

Policy supports for CR commercialization

- **Technology development for commercialization**
  - Effective support with accelerating the technology development for H_2 and CCS.
  - Fostering social momentum where the incremental cost of CR products is accepted,
- **Inter-industry collaboration**
  - Identifying issues for closer collaboration (ex. regulations, data sharing, etc.)
  - Creating model cases and expand them to other industrial areas
  - Development of collaboration patterns for small to medium-sized CO_2 emitters and users.
  - Identifying the roles of CO_2 management operators who handle overall management including optimal CO_2 transportation, matching of CO_2 users and suppliers, balance of supply and demand, and ensuring CO_2 traceability.
- **Environmental value assessment and international deployment**
  - Collaboration with other countries and foreign companies for CR technologies.
  - Establishing a system that can properly evaluate the emission reduction value by CR.
- **Creation of Ecosystem of CR technology development and deployment**
  - Support for startups in the field of carbon recycling, human resource development, international business expansion, and regulatory assistance.

Japan's CCS target

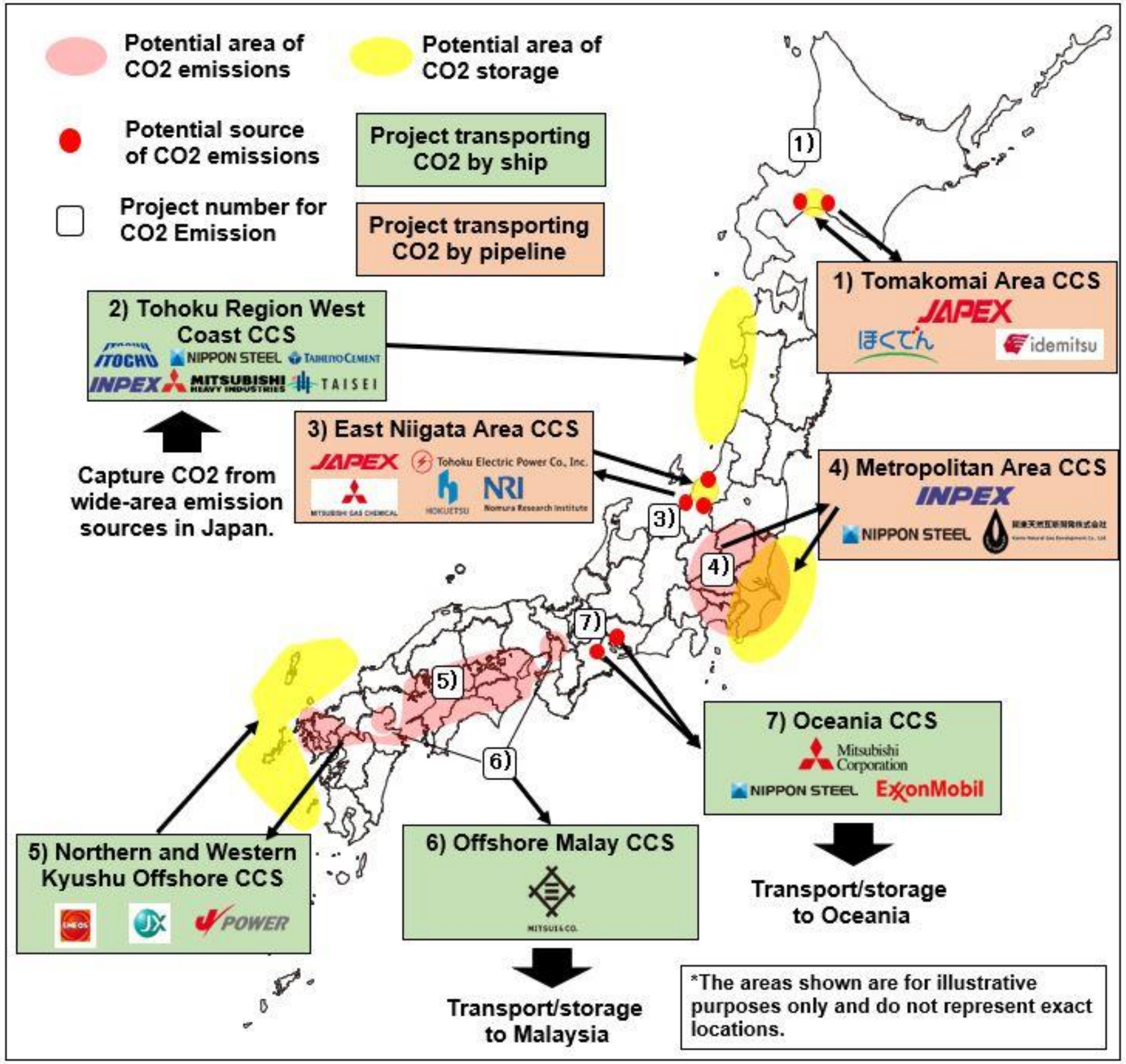
- Japan targets to store 120 to 240 million tonnes of CO2 by 2050.
- In order to realize the 2050 goal, the government aims to secure 600 to 1,200 thousand tonnes of CO_2 storage in Japan



Source: METI

Japan's CCS projects

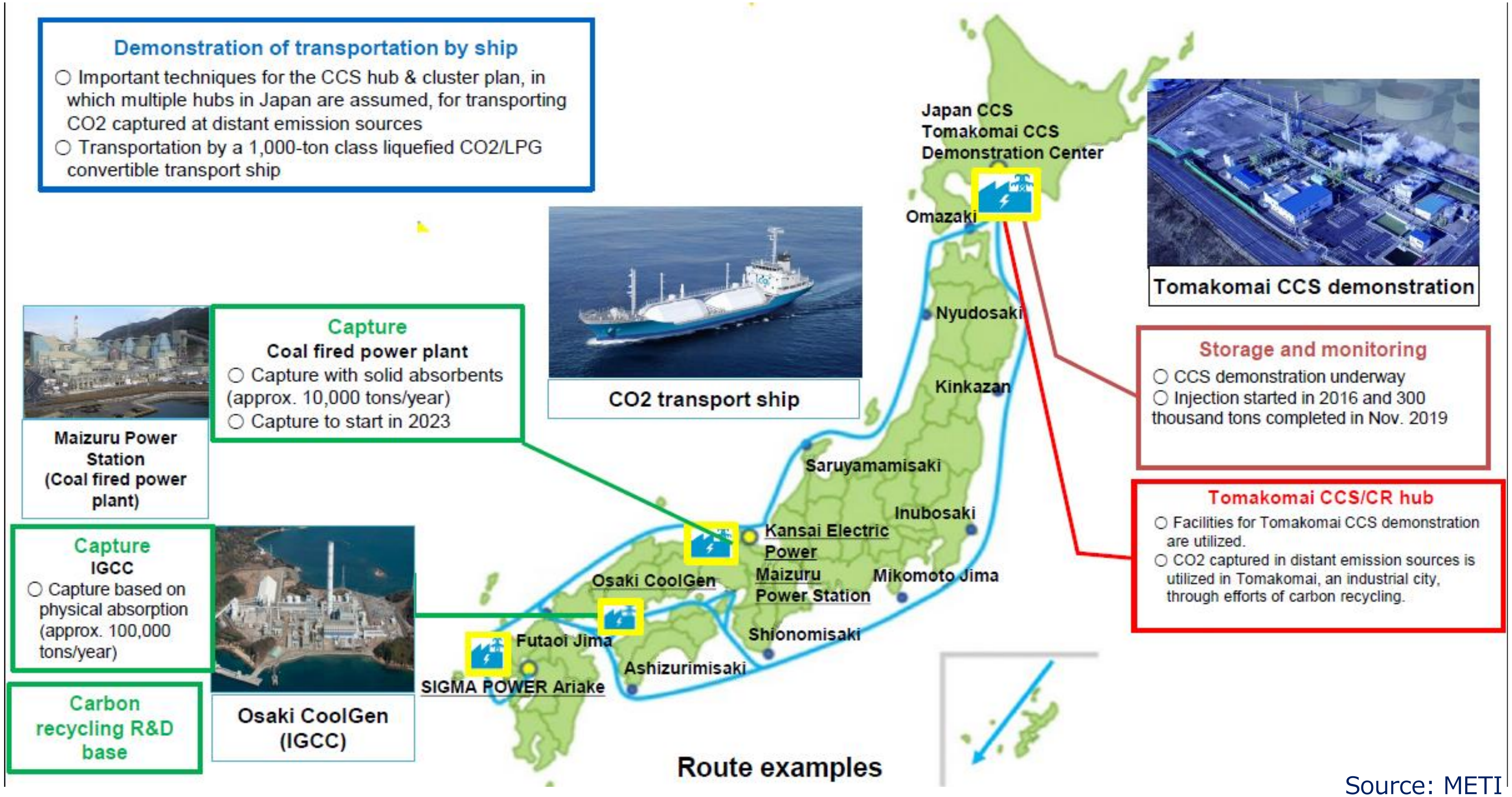
- The Japanese government announced it will support seven domestic and international CCS demonstration projects.
- The total CO_2 storage volume may be up to 13 million tonnes. All projects aims to start storage from 2030.



Source: METI

Demonstration test of CO_2 shipping for CCS

- Demonstration test to transport CO_2 from Maizuru to Tomakomai is scheduled to start in 2024.



Source: METI

Japan's CCS policies

- Japan targets to store 120 to 240 million tonnes of CO_2 per year by 2050
  - The government aims to secure 6 to 12 million tonnes of storage capacity by 2030.

- CCS Business Act (temporary named) is in the process of enactment this year.
  - The act provides legal framework of CCS business in Japan by specifying rights and responsibilities of the government and CCS operators.
  - The act also provides principles of operational safety in Japan.

- The government promotes feasibility studies of CCS projects (previous page) as well as pilot project of maritime transportation of CO_2 by tanker.

- Financial support system for CAPEX and OPEX for CCS operators are under discussion.

- Cost reduction (particularly CO_2 capture), securing sufficient storage locations, and obtaining public acceptation are considered as major challenges to realize CCS projects in Japan.

Conclusions

- Endowed with limited renewable energy resources, Japan needs to adopt all available decarbonization means to achieve carbon neutrality. Holistic approach based on technology neutrality of the concept of CCE perfectly matches the Japan's traditional energy and climate policy making.

- Reuse / Recycle of CO_2 will be realized in Japan through the development of carbon recycling technology. Mineralized products that do not use hydrogen are closer to commercialization, and fuels and chemicals that need to be compounded with hydrogen need further cost reductions.

- Japan intends to use CCS as a means of Remove of CO_2. Seven demonstration projects have already begun, and the Japanese government has set a goal of capturing and storing up to 13 million tons of CO2 by 2030.

Johanna Fiksdahl
Policy Officer, Directorate-General Energy

European Commission

slido.com code: **#CCEThinkTank**

Shaping the future CO_2 transport network for Europe

Tumara, D., Uihlein, A., Hidalgo González, I.

Joint Research Centre (JRC), European Commission

Directorate C – Energy, Mobility & Climate (Petten)

Project objectives

WHO

The JRC upon request of and in close collaboration with DG ENER

WHAT

Cost-optimal match of CO_2 sources with CO_2 sinks

WHEN

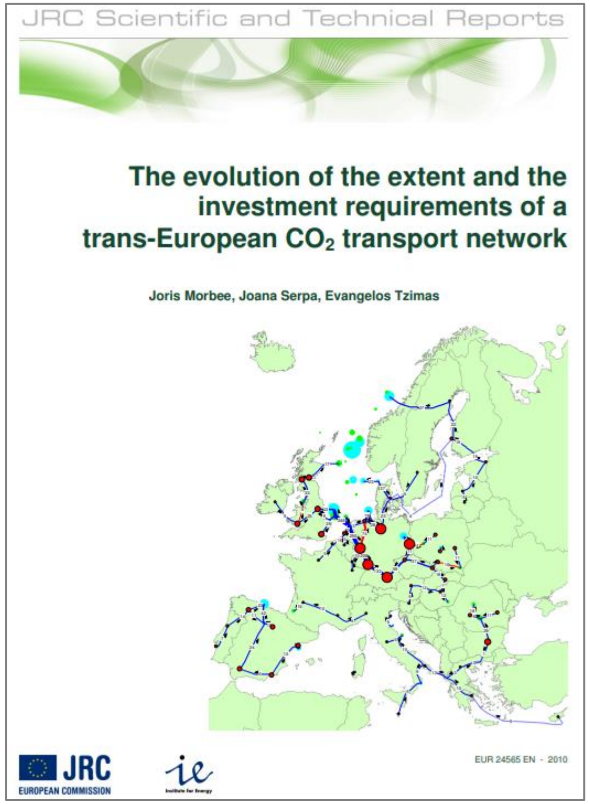
Time horizon 2050 with snapshots for the years 2030 and 2040

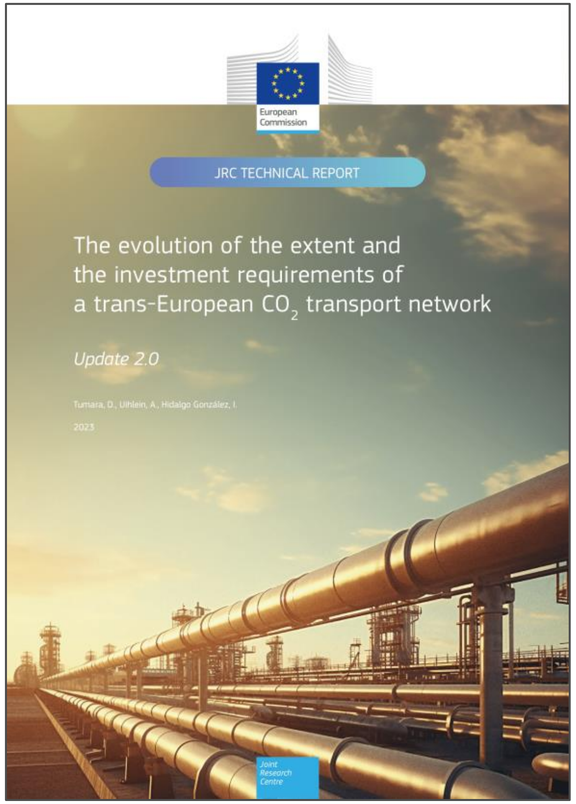
AREA

EU Member States + UK and Norway storage

TRANSPORT

Onshore and offshore pipelines + maritime ships

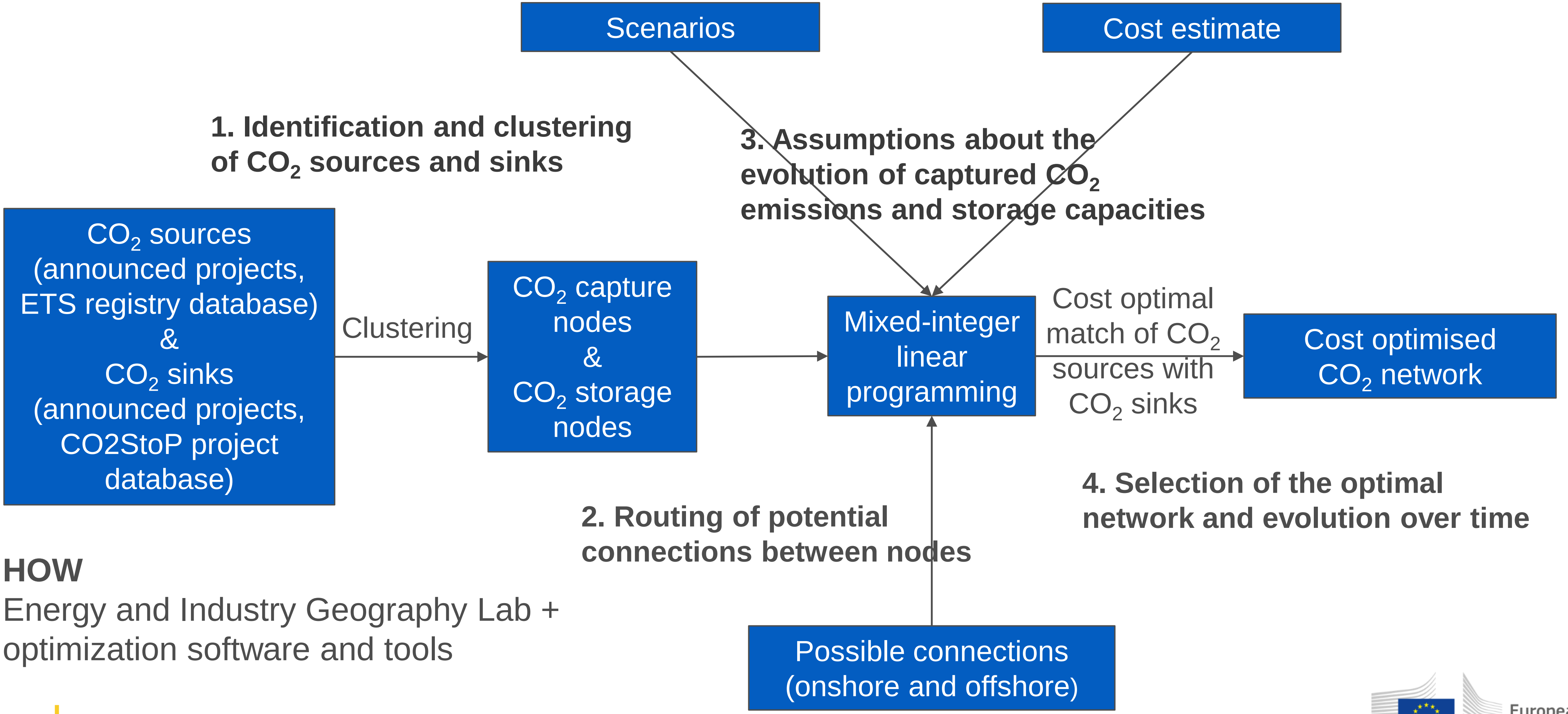




European Commission

Methodology

CO_2 captured at any given point in time must be stored at that point in time!



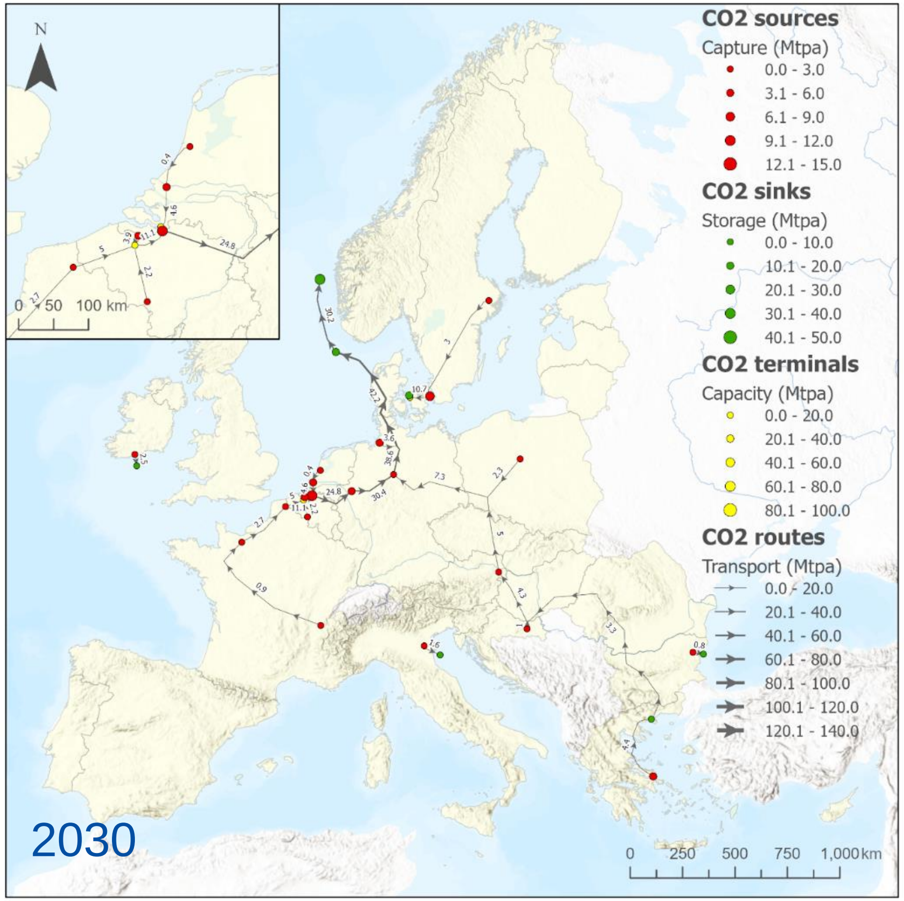
HOW

Energy and Industry Geography Lab + optimization software and tools

Key issues

- Storage data availability
- Inconsistent and outdated CCUS project databases
- Overlapping projects - targeting same emitters (cluster approach)
- Vague project starting dates and capacities
- Lack of spatial data
- Challenges with the implementation of projects (CCS early adopters)

Results



>19000 km

up to16 € bn_{2021}

247.2 Mtpa in 2050

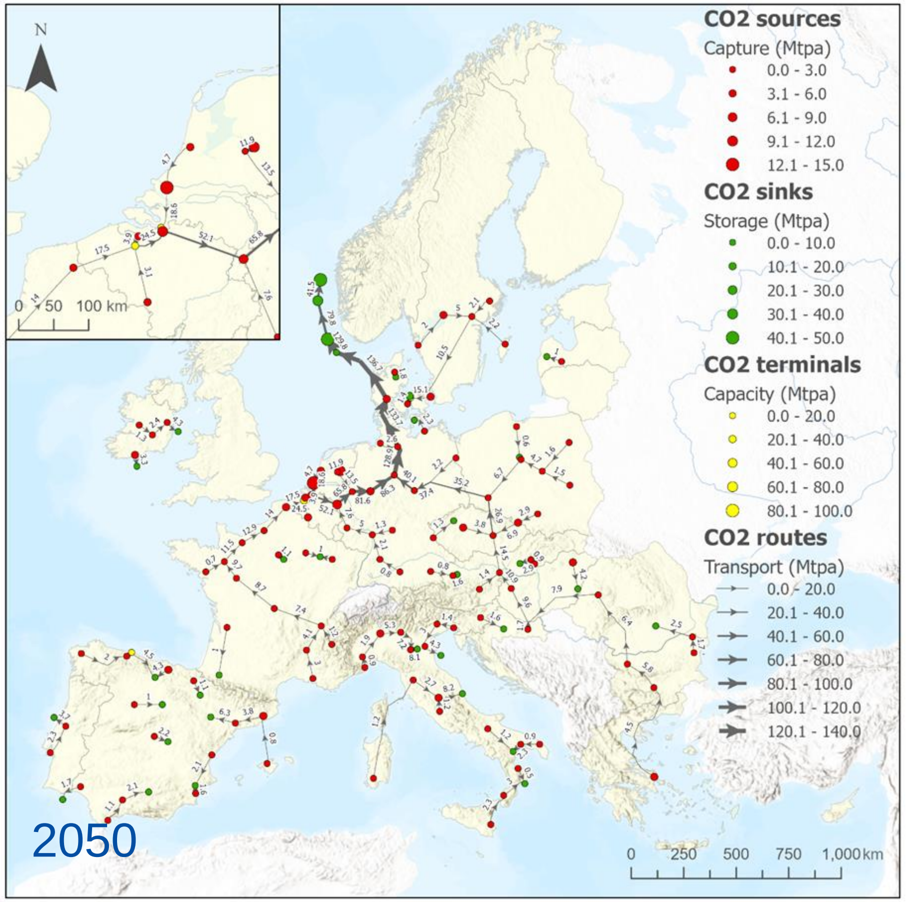
3.9 Gt by 2050

CO_2 captured in 21 countries

CO_2 stored in 17 countries

29 cross border points

CO_2 network in 23 countries



Announced projects

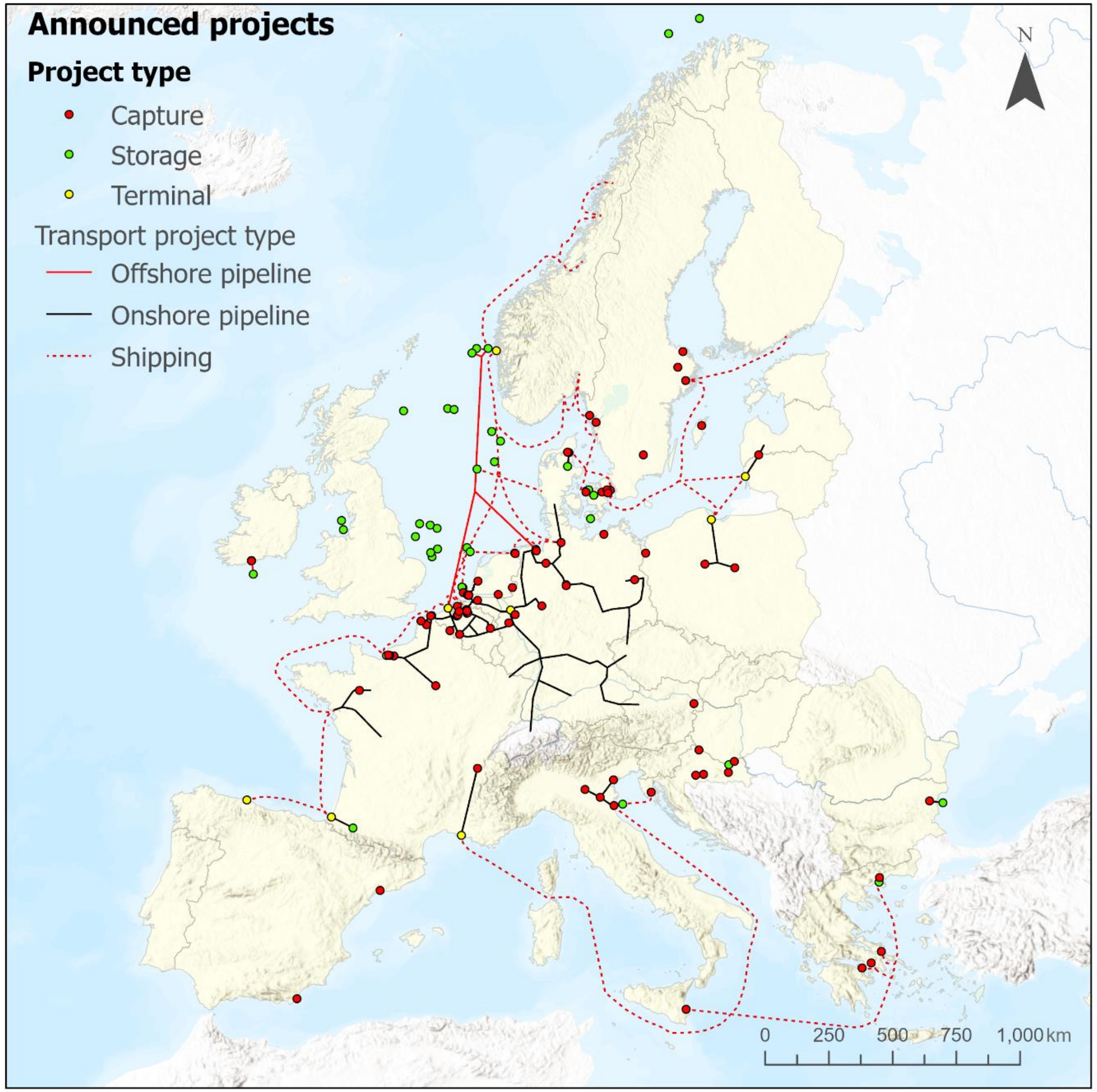
Pipeline infrastructure

+

Shipping

+

Alternative modes (trains, trucks, barges...)



Conclusions

- Up to 7 300 km by 2030 and 19 000 km by 2050
- Up to EUR 19.5 billion by 2030 and 23.1 billion by 2050
- Early CSS adopters have a significant impact on the evolution and the extent of the CO_2 transport network
- Lack of the commercially-proven storage capacity in the early phase of the network development
- Updated CO_2 storage atlas and CO_2 quality standards for transport and storage needed
- CO_2 transport network is a key enabler of the deployment of CCS in Europe
- International coordination and collaboration is crucial for the successful and cost-optimised development of the CO_2 transport infrastructure

Thank you

European Commission

Keep in touch

EU Science Hub
joint-research-centre.ec.europa.eu

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EU Science Hub

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European Commission

Part 3 – Present and Future Technologies to Actualize the CCE

Suhas Dixit
CEO, APChemi

Erica Bhasin
Low Carbon Consultant, Worley Consulting

slido.com code: **#CCEThinkTank**

Circular Carbon Economy - Technology Level Discussion on **Biochar & Advanced Recycling**

APChemi

MI THINK TANK

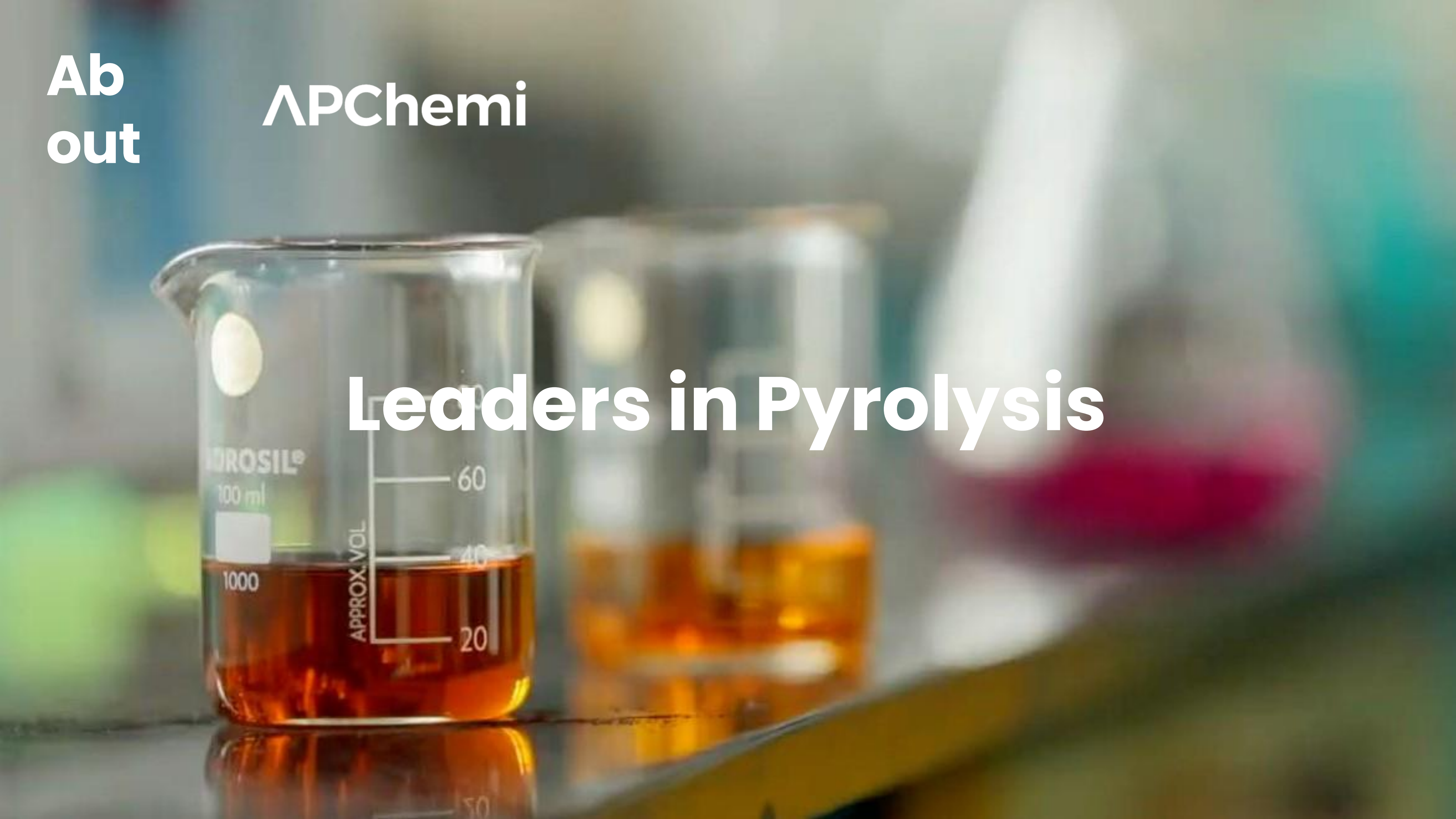
KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

APChemi

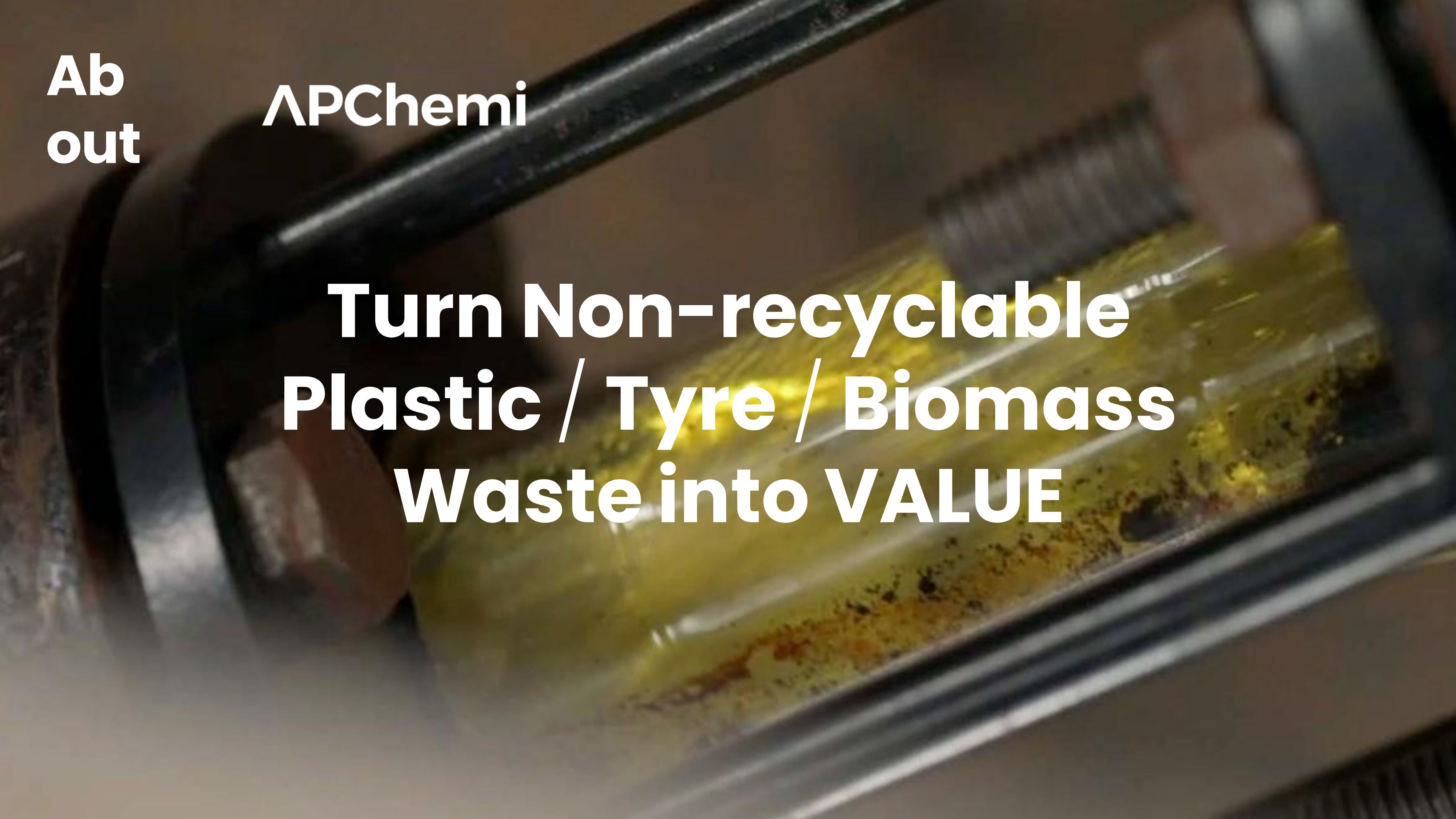
APChemi

Technology	Stage	Description
Chemical absorption of CO_2 from ammonia production and natural gas processing	Mature	Widely deploy ed technol ogies
Biochar based carbon sequestration	Mature	
Mechanical Recycling of Plastic/Tyre Waste	Mature	
Chemcial Recycling of Plastic/Tyre Waste	Early Adoption	Commercial technologies, but needs policy support for scale-up
Chemical absorption from coal-fired power generation	Early Adoption	
Hydrogen production from natural gas	Early Adoption	
CO_2 capture from cement kilns	Demonstration Stage	Not yet commercially available, but has been demonstrated at a small scale
CO_2 storage in saline aquifers	Demonstration Stage	
Direct Air Capture (DAC)	Prototype Stage	Still in development, but has been tested at a small scale

About



Leaders in Pyrolysis



About

APChemi

Turn Non-recyclable Plastic / Tyre / Biomass Waste into VALUE

About ΛPChemi

Developed 47 Pyrolysis Plants Since 2007

Ab
out

APChemi

Transformed 179 Million Kg of Plastic over 1.3 Million Hours of Technology Performance

About

APChemi

Supported by Shell Petrochemicals

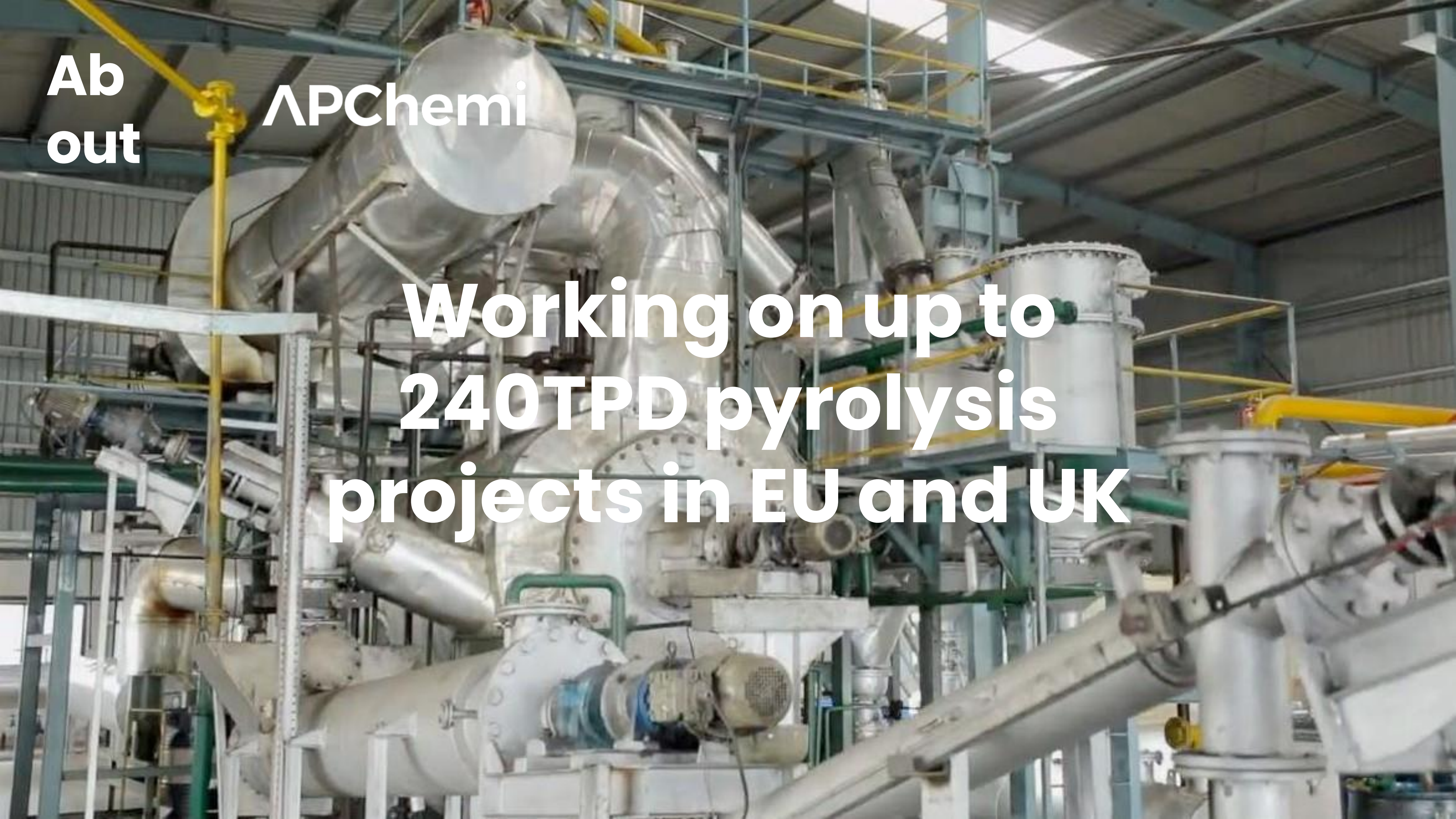
Shell
E4

Ab
out

APChemi

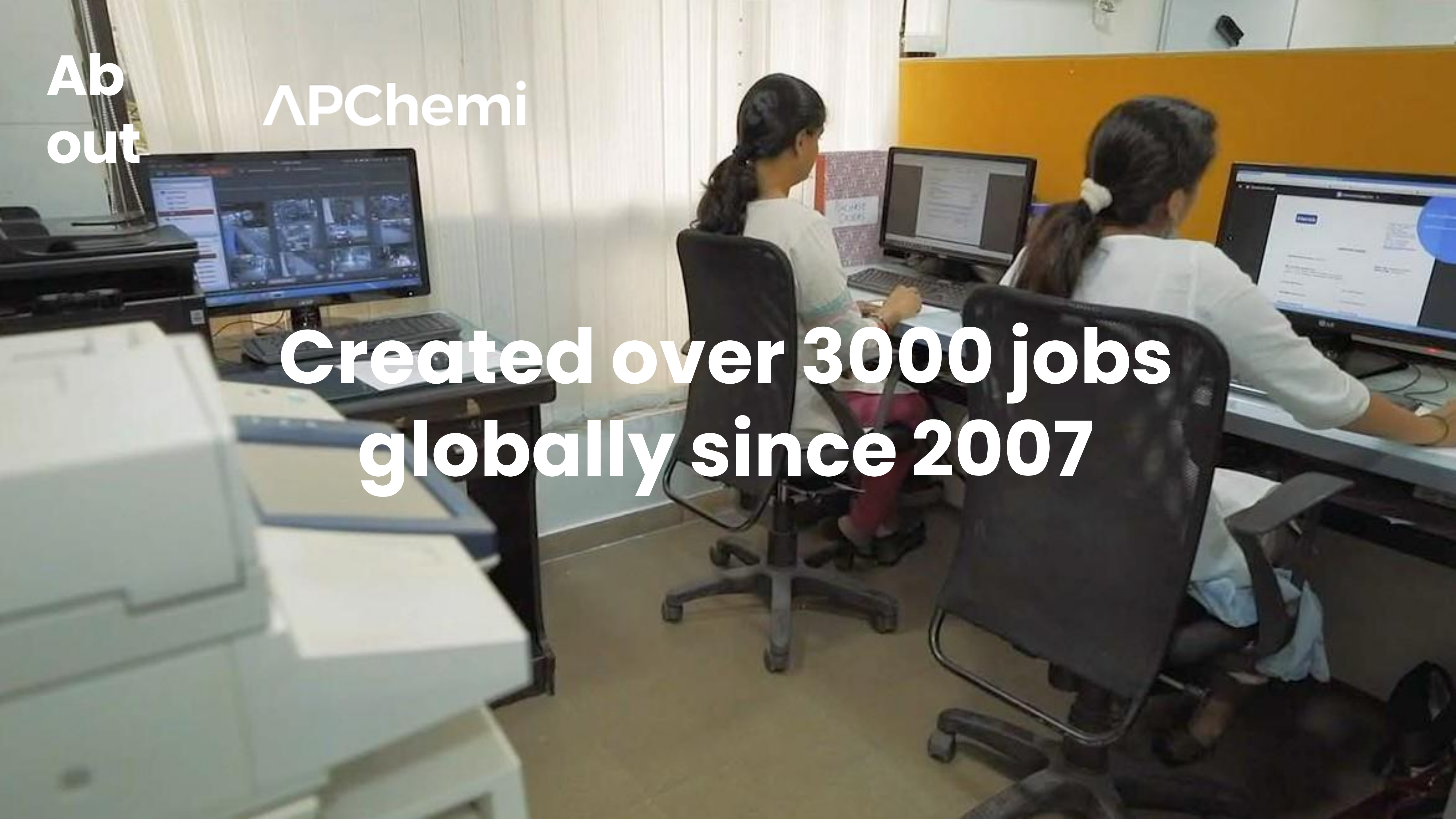
Jointly raised $2.4M for Plastic & Biomass to Green Hydrogen

AALBORG UNIVERSITY
DENMARK


About
APChemi
Working on up to 240TPD pyrolysis projects in EU and UK

Ab
out

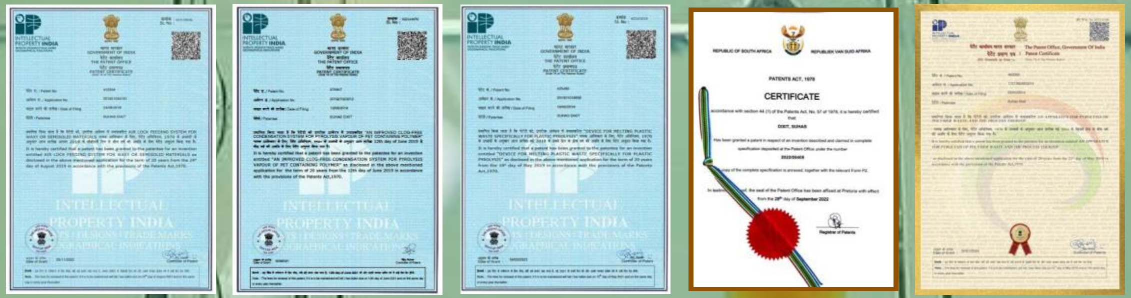
APChemi



Created over 3000 jobs globally since 2007

Ab
out

ΛPChemi



Over 12 Patents in Pyrolysis and PyOil Purification Tech

1)
Biochar based CCUS

Other uses: Construction

Quality Biochar Production

via Biomass Pyrolysis

1. Licensed Technology
2. Supplied Biomass Pyrolysis Plants
3. Global Biochar Quality Standards
4. 50TPD Bamboo Continuous Pyrolysis Technology

APChemi

2)
Chemical/Advanced Recycling

Plastic Waste

Circular Plastics

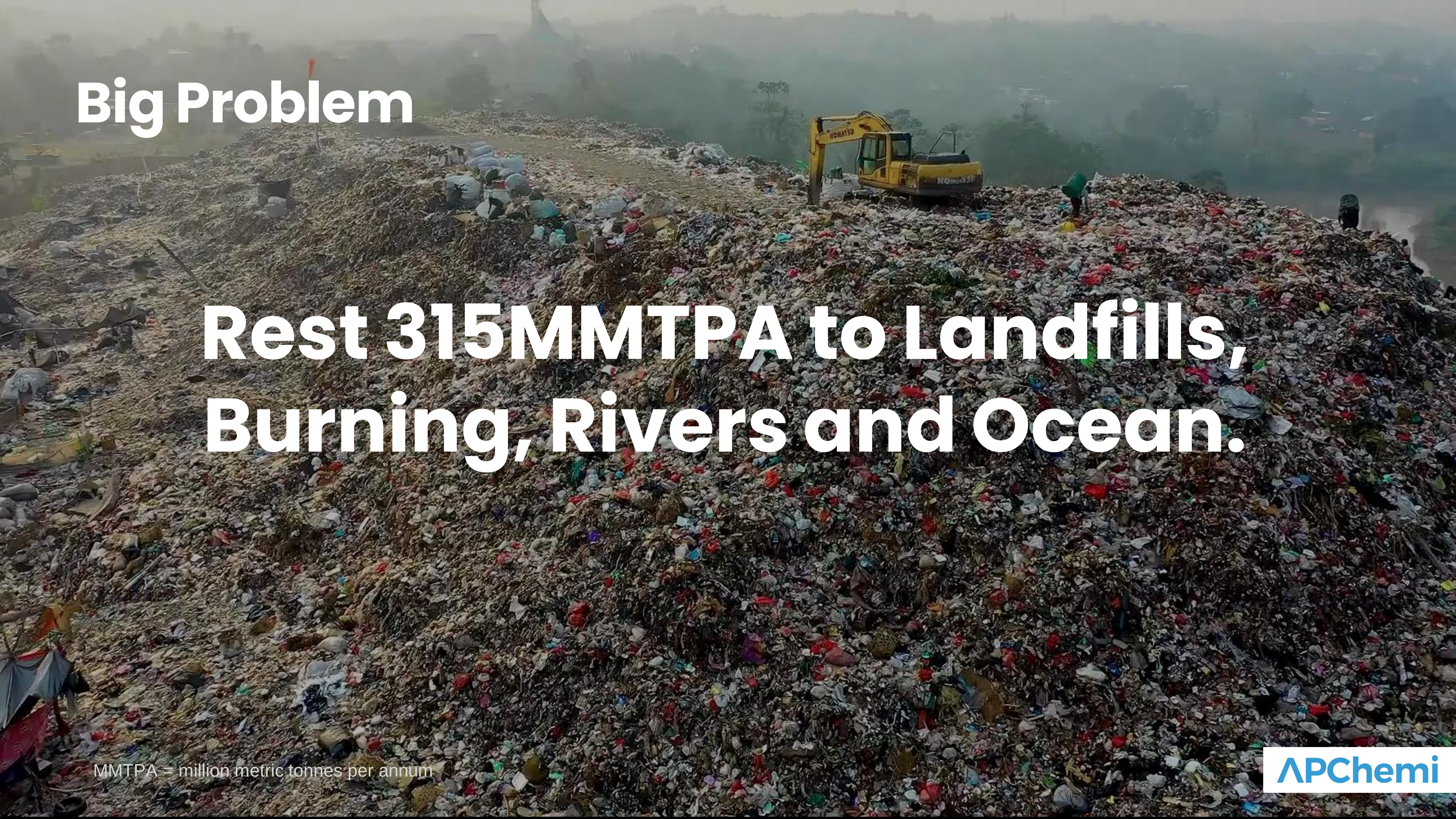
APChemi

Big Problem

Less than 10% of 350 MMTPA plastic waste is recycled

MMTPA = million metric tonnes per annum

APChemi


Big Problem
Rest 315MMTPA to Landfills, Burning, Rivers and Ocean.
MMTPA = million metric tonnes per annum
APChemi

Big Problem

Plastic Waste Burning Generates 300 MMTPA CO_2 Emissions

MMTPA = million metric tonnes per annum

APChemi

Big Problem

From now to 2030, Waste Burning 1.2 Billion Tons of Plastic Waste Will Emit 3.5 Billion Tons of CO

MMTPA = million metric tonnes per annum

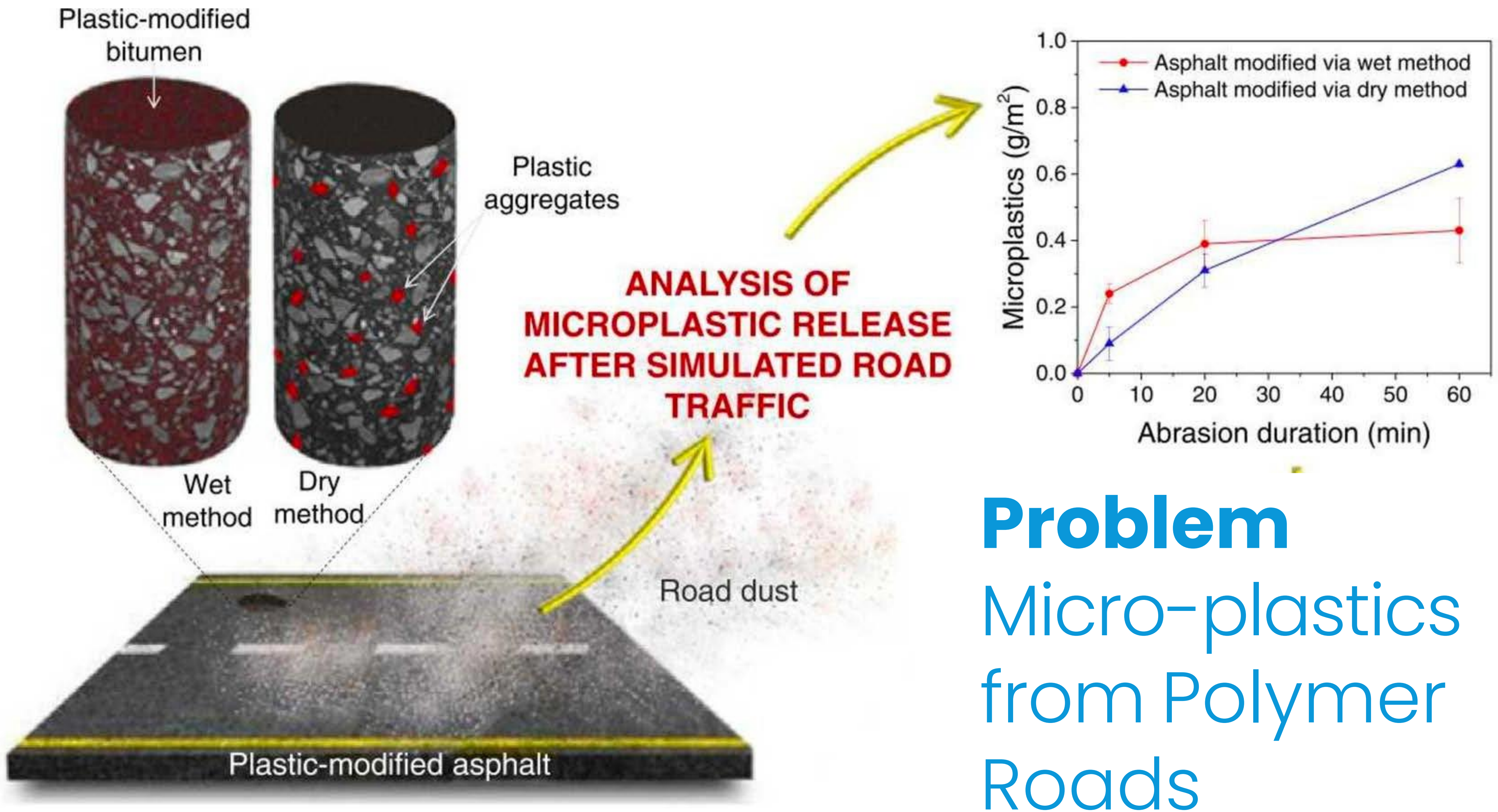
APChemi

Big Problem

400 MMTPA of Crude Oil & Gas is pumped to make new plastics.

MMTPA = million metric tonnes per annum

APChemi



Problem

Micro-plastics from Polymer Roads

APChemi

Big Problem

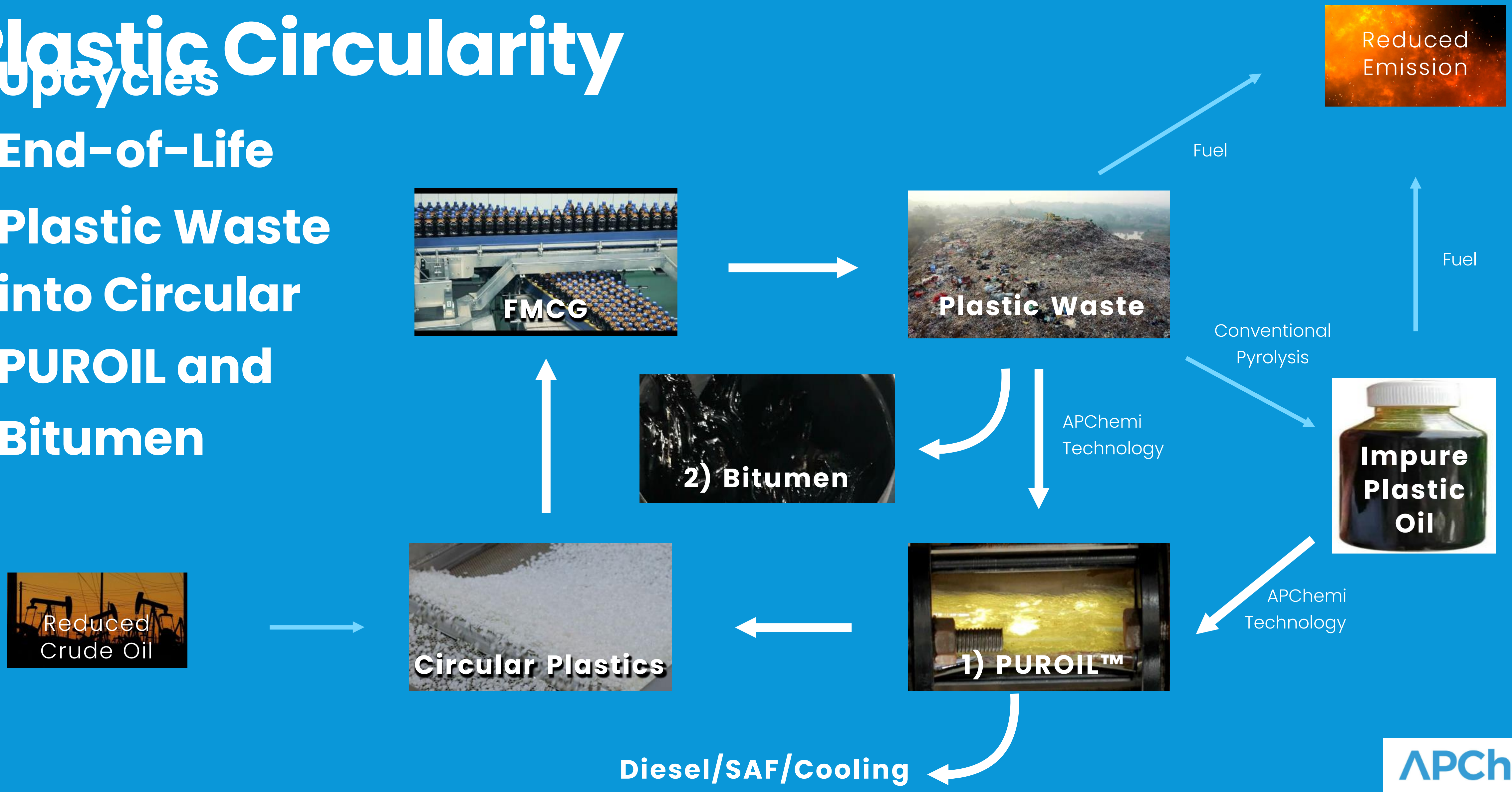
Impurities in Waste

Plastic Stop Plastic Circularity

APChemi

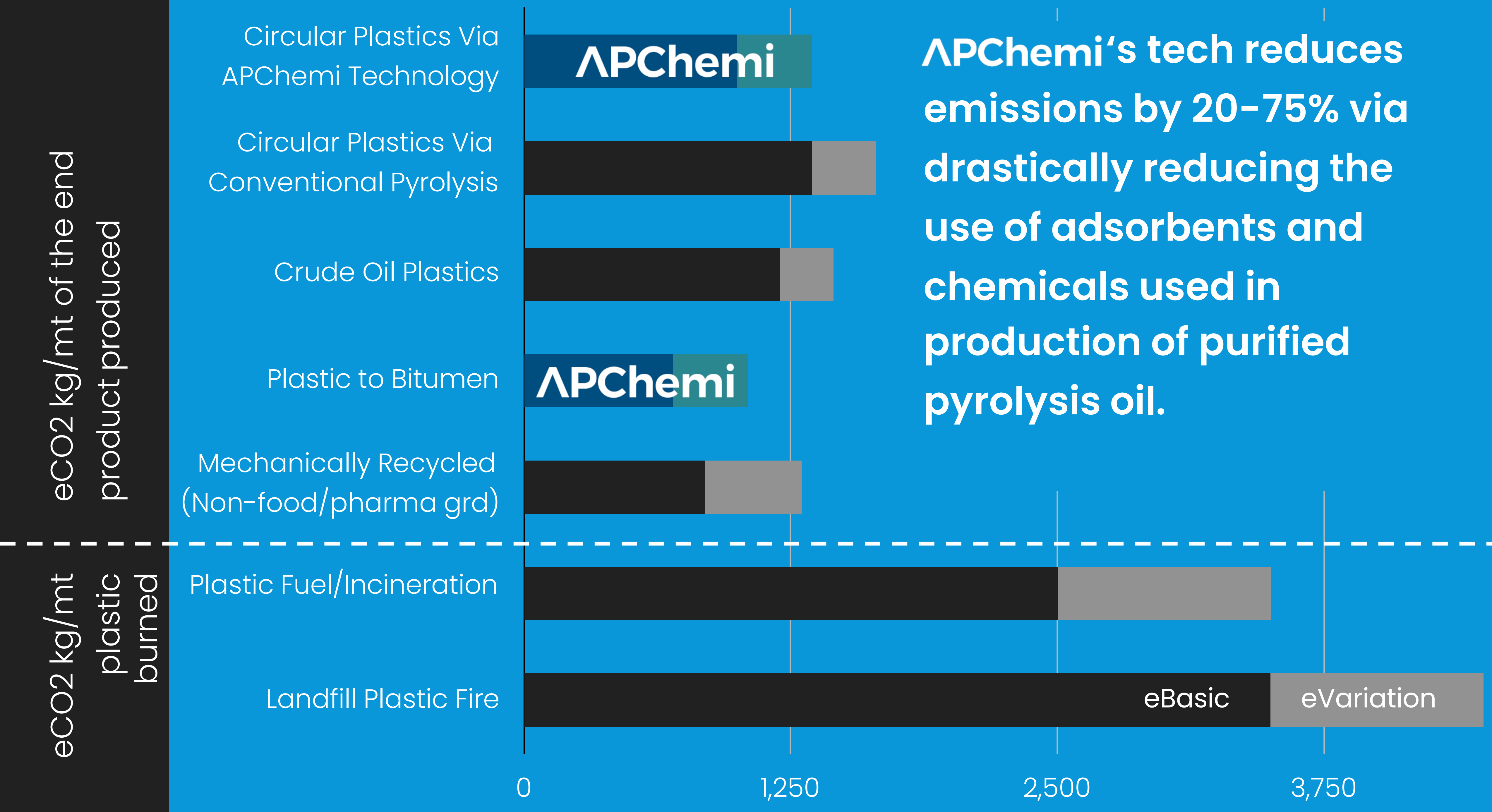
Solution 1) - Plastic Circularity

Upcycles End-of-Life Plastic Waste into Circular PUROIL and Bitumen



APChemi

ΛPChemi's tech reduces emissions by 20-75% via drastically reducing the use of adsorbents and chemicals used in production of purified pyrolysis oil.

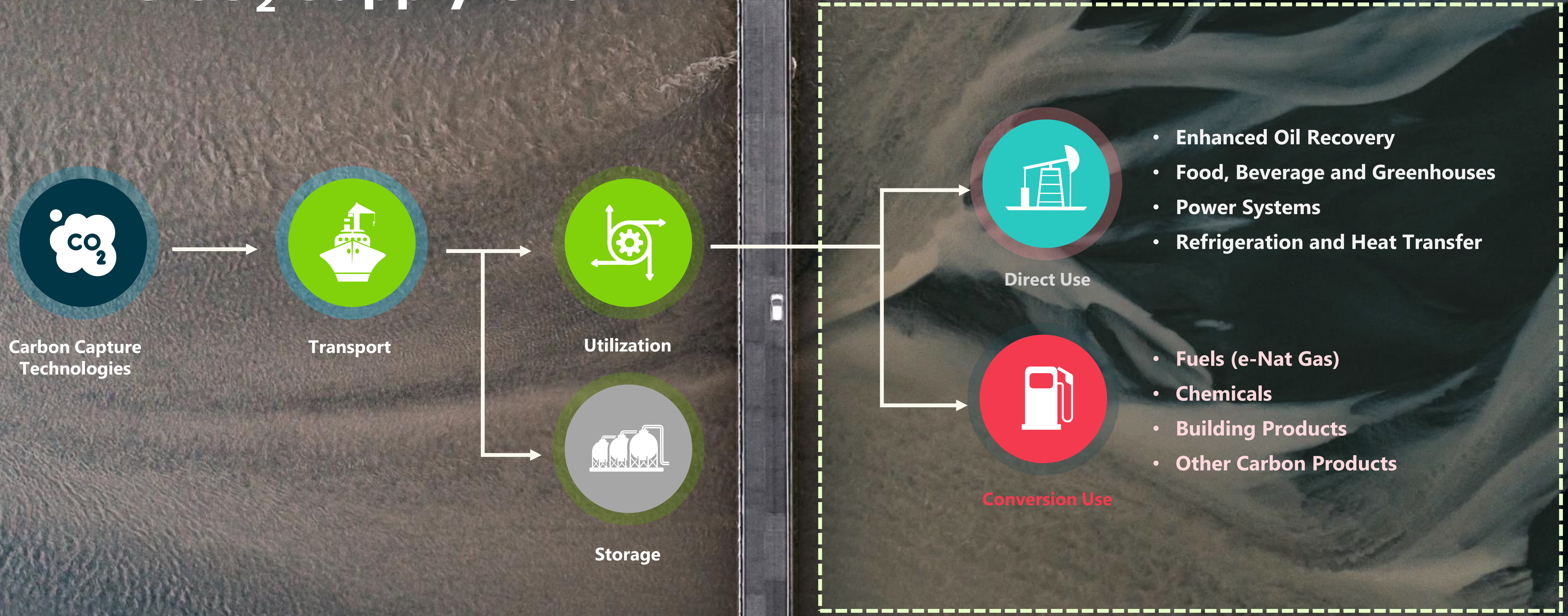


CO_2 Utilisation

Circular Carbon Economy MI
Think Tank Event

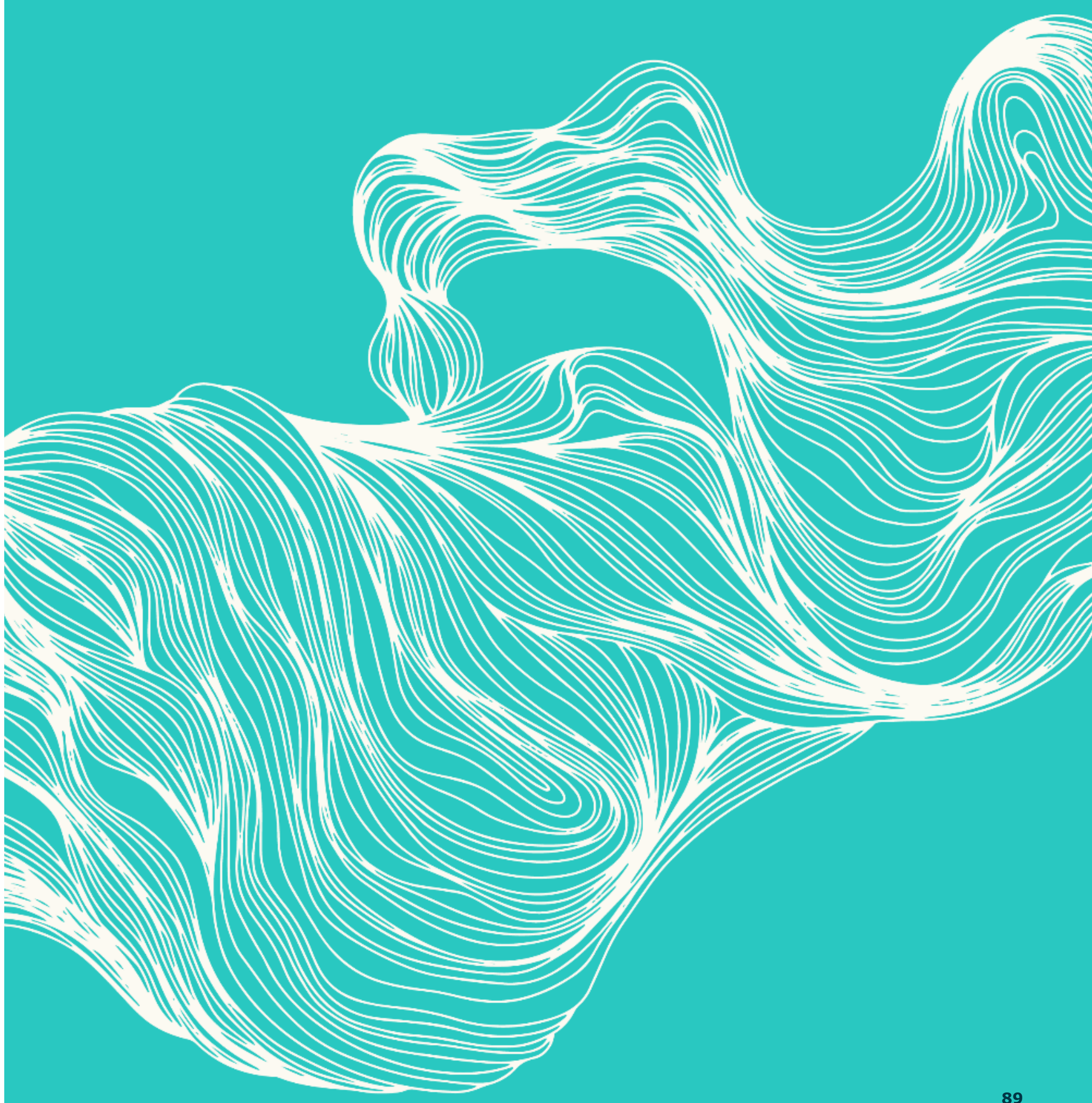
Technologies of the Future
Erica Bhasin
erica.bhasin1@worley.com

The CO_2 Supply Chain



Direct Use Opportunities

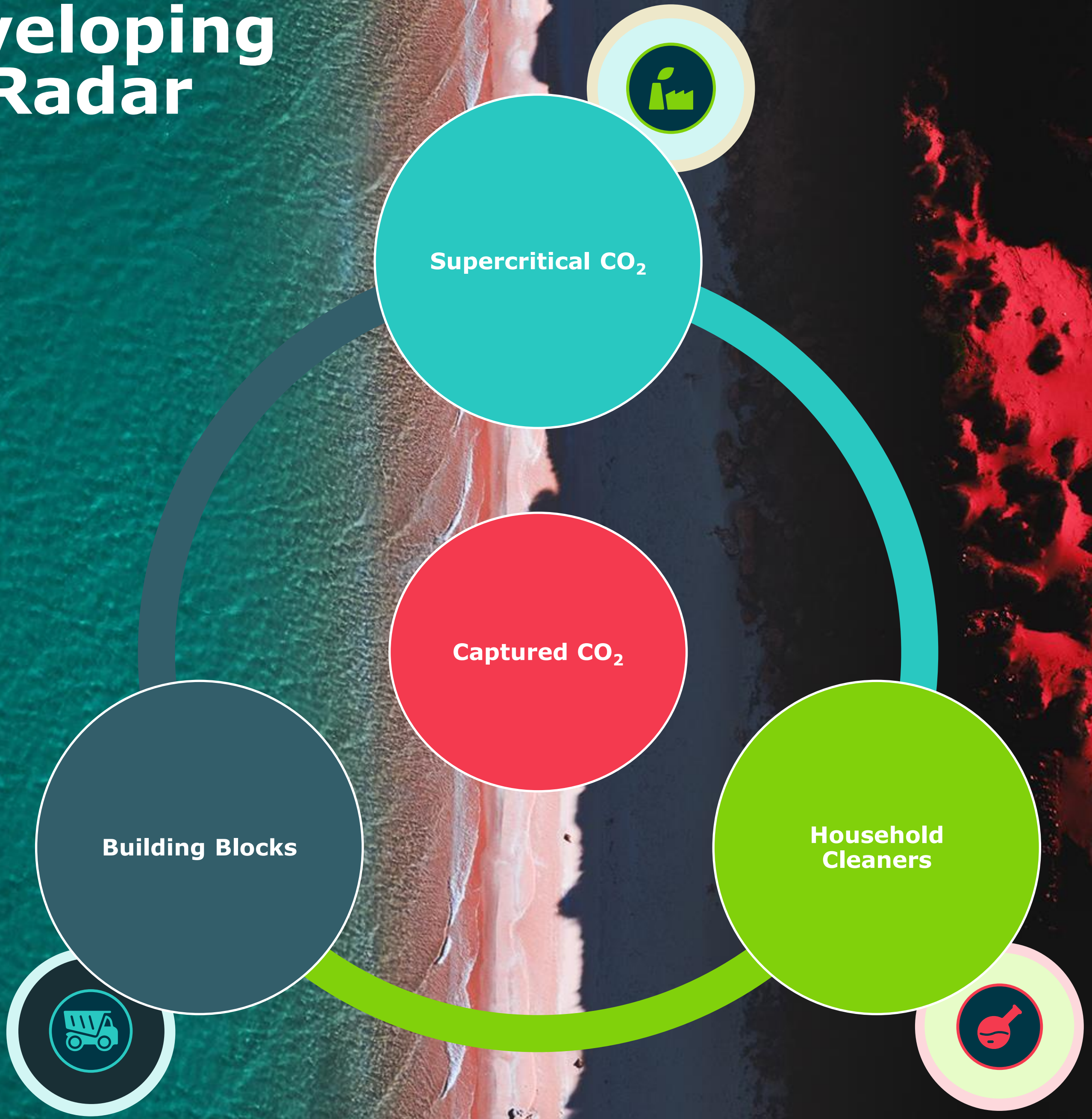
Direct Utilization Technology	TRL	CRI
Use in Enhanced Oil Recovery (EOR)	9	High
Food	9	High
Beverages	9	High
Horticulture (greenhouses)	9	High
Supercritical CO_2	3	Low
Supercritical CO_2 heat removal systems	2	Low
Supercritical CO_2 Solvents	9	High



Conversion Opportunities

Category	Conversion Technology	TRL	CRI
Fuel	CO_2 to hydrocarbon fuels	9	High
Fuel	CO_2 to synthetic methane fuel	6	Medium
Fuel	CO_2 to methanol fuels	7	Medium
Chemical	CO2 to green urea	9	Medium
Chemical	CO2 to methanol	9	High
Polymer	CO2 to polyolefins	9	High
Polymer	CO2 to polyols	7	Medium
Building Block	CO2 in carbon nano tubes	3	Low
Building Block	CO2 in graphene	1	Low
Building Block	CO2 to concrete blocks	9	Medium
Building Block	CO2 to cement / concrete	9	Medium
Building Block	CO2 to carbonate	4	Low
Other	CO_2 to surfactants	3	Low
Other	CO_2 in pharmaceuticals	9	High
Other	CO_2 in medical applications	9	High

Selected Developing Technology Radar



Supercritical CO_2 for Heat Recovery

Removing residual heat without the requirement for external power sources using the Brayton cycle

sCO_2-HeRo

CO_2 to Carbonates

Carbon mineralization methods are either aimed at storing CO_2 in carbonate minerals (referred to as *solid storage*) or both removing CO_2 from air and storing it in carbonate minerals

Carbfix, OCO, Orbix, Blue Planet

CO_2 to Surfactants

Continuous production processes that facilitate the manufacture of novel surfactants based on CO_2 are a potential conversion use of captured CO_2

Covestro, ViridiCO_2 , India Glycols

Note: this is not an exhaustive list of CO_2 utilisation companies / projects

Q&A

worley
consulting

Event Discussion and Q&A

- Today's event will use slido for audience Q&A and discussion.
- Discussions questions at the end of the event will be selected from slido
- Join the event and ask your questions through the QR Code on screen , or at slido.com with code: **#CCEThinkTank**

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Q&A and Conclusion

Brian Efird

Director for Strategic Partnerships

King Abdullah Petroleum Studies and Research Center

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