KAUST hydrogen seminar:
Future of hydrogen in the Middle East

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Saudi Arabia Ministry of Energy
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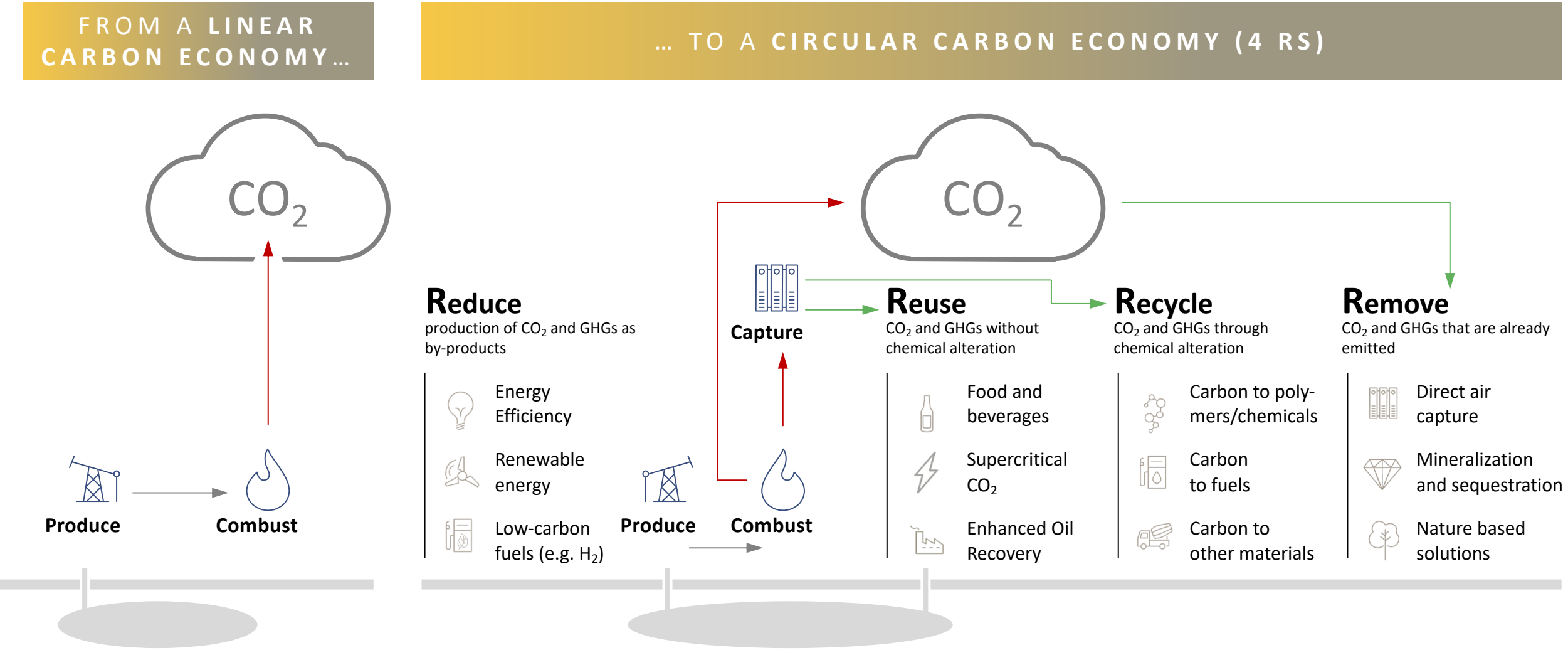
On October 2021 KSA announced its ambition to achieve net-zero emissions by 2060 through adoption of the CCE framework

> I announce today, that the Kingdom of Saudi Arabia targets to achieve **net-zero emissions by the year 2060** through the adoption of the **Circular Carbon Economy framework….**

SAUDI GREEN INITIATIVE

The Kingdom has pioneered the "Circular Carbon Economy" as a holistic framework to manage carbon emissions



CCE is a holistic framework to manage carbon emissions across the 4Rs

REDUCE

- Energy Efficiency
- Renewable Energy
- Liquid Displacement
- Hydrogen

REUSE

- Enhanced Oil Recovery
- Carbon for Refrigerant
- Carbon for Food & Bev.

RECYCLE

- Synthetic Fuels
- Synthetic Chemicals
- Carbon Cured Concrete
- Synthetic aggregates

REMOVE

- Carbon Capture & Sequestration
- Direct Air Capture
- Nature Based Solutions

CCE National Program focuses on a sub-set of initiatives covering the 4Rs

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☐ Part of CCE National Program (30+ initiatives)

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Hydrogen

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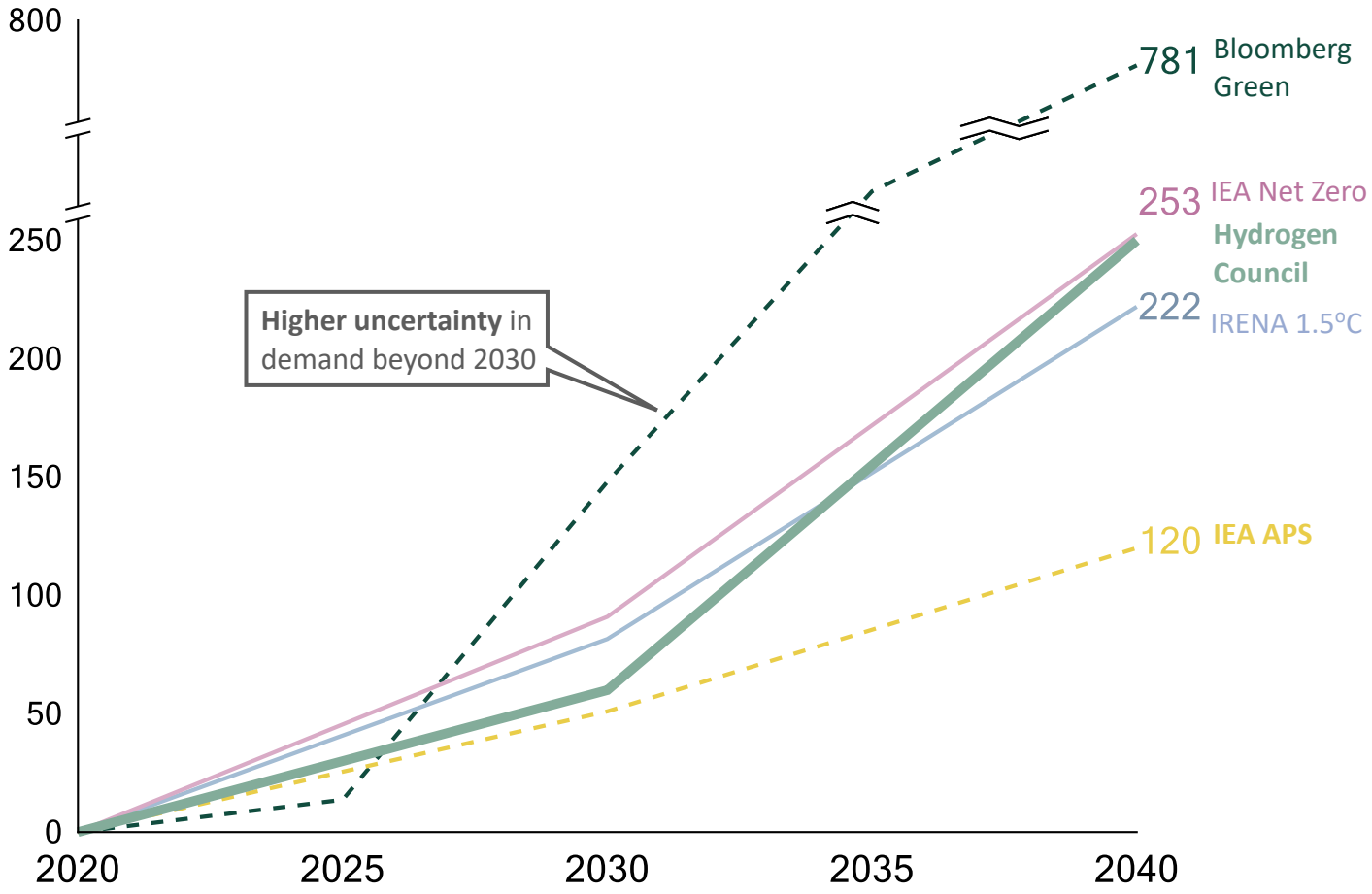
☐ **Hydrogen** (11 initiatives)

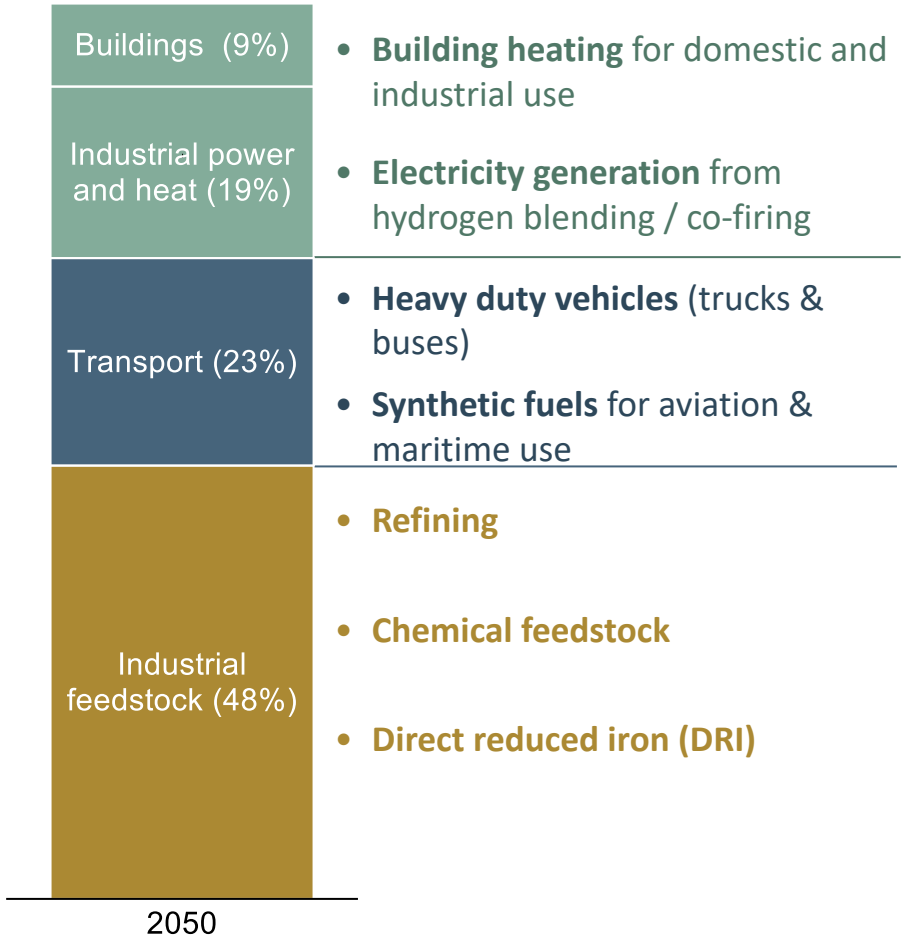
Global clean hydrogen demand is expected to grow with high uncertainty in demand between 2030-2040

Global hydrogen demand, Mtpa of hydrogen



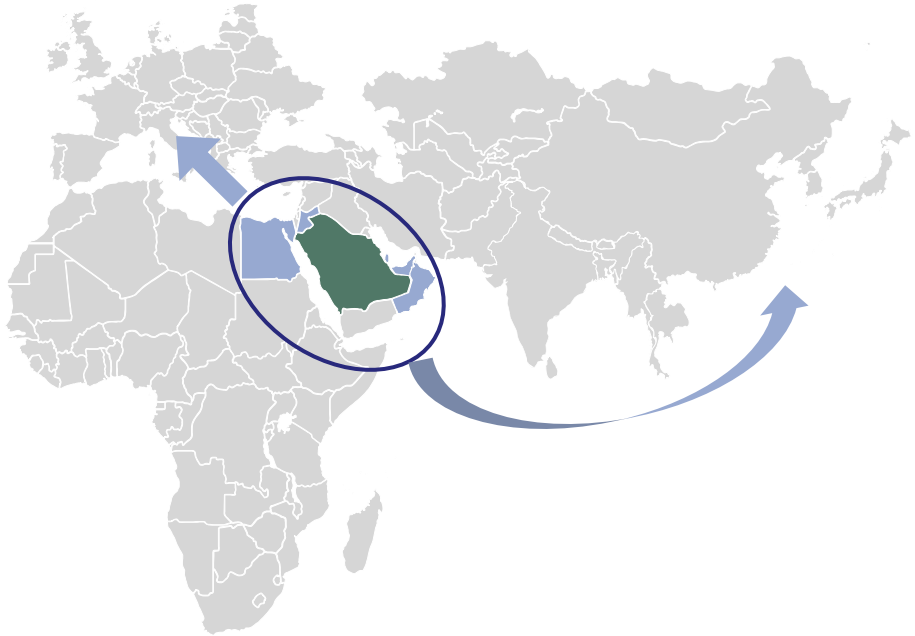
Note: APS: Announced policy scenario;
Source: IEA, Hydrogen Council, BNEF, IRENA

Key demand sectors for clean hydrogen



The Middle East region is equipped with large renewables and clean hydrogen potential to supply clean energy needs to global demand centers

Strategic location to supply clean energy needs in target markets



Benefits from clean hydrogen ecosystem in the Middle East

Benefits to clean hydrogen producers

- **Ability to leverage** high quality renewable energy resources in the region for low-cost production
- **Diversification of energy** and commodity exports to renewable fuels
- **Attraction of investments** in clean energy projects

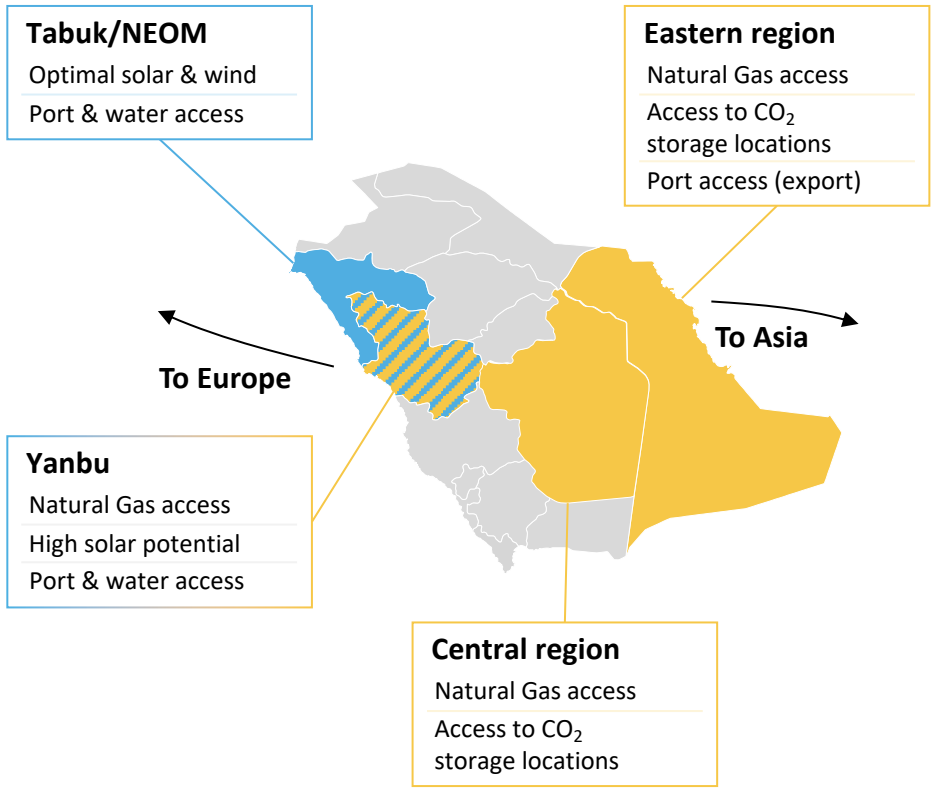
Benefits to clean hydrogen offtake countries

- **Decarbonization of multiple sectors** and achievement of national GHG reduction targets
- **Availability** of low-cost clean energy supply
- **Potential to leverage established energy supply chain** for cross-border trade

KSA is well positioned to play a leading role and become a major exporter of clean hydrogen

KSA can produce large volumes of clean H_2 across the nation

KSA AMBITION TO PRODUCE 4 MTPA OF CLEAN HYDROGEN BY 2030



KSA's strategic advantages make it an ideal exporter

CLEAN HYDROGEN PRODUCTION

Low levelized costs and **ample solar** and **wind** resources in **KSA**

Large **available land areas** suitable for development of renewable projects and production of large H_2 volumes

Availability of **low-cost natural gas**

Suitable geological formations for carbon capture & storage

INDUSTRIAL & EXPORT INFRA-STRUCTURE

Existing infrastructure to globally export hydrogen

Strategic location with trade routes for **energy products** from **KSA** to **Europe and Asian markets**

FINANCING

Ability to raise **low-cost debt capital** given high credit rating

KSA has developed the National Hydrogen Strategy focused on production, exports and domestic uses of clean hydrogen

Production

2030

H_2 ***Saudi Arabia has announced an ambition of producing 4 Mtpa clean Hydrogen by 2030 as a part of the Saudi Green Initiative***

Demand

Target markets

Exports

Domestic use

Use-cases

Heavy-Duty vehicles

Light-Duty vehicles

Refining

Chemicals

DRI Steel

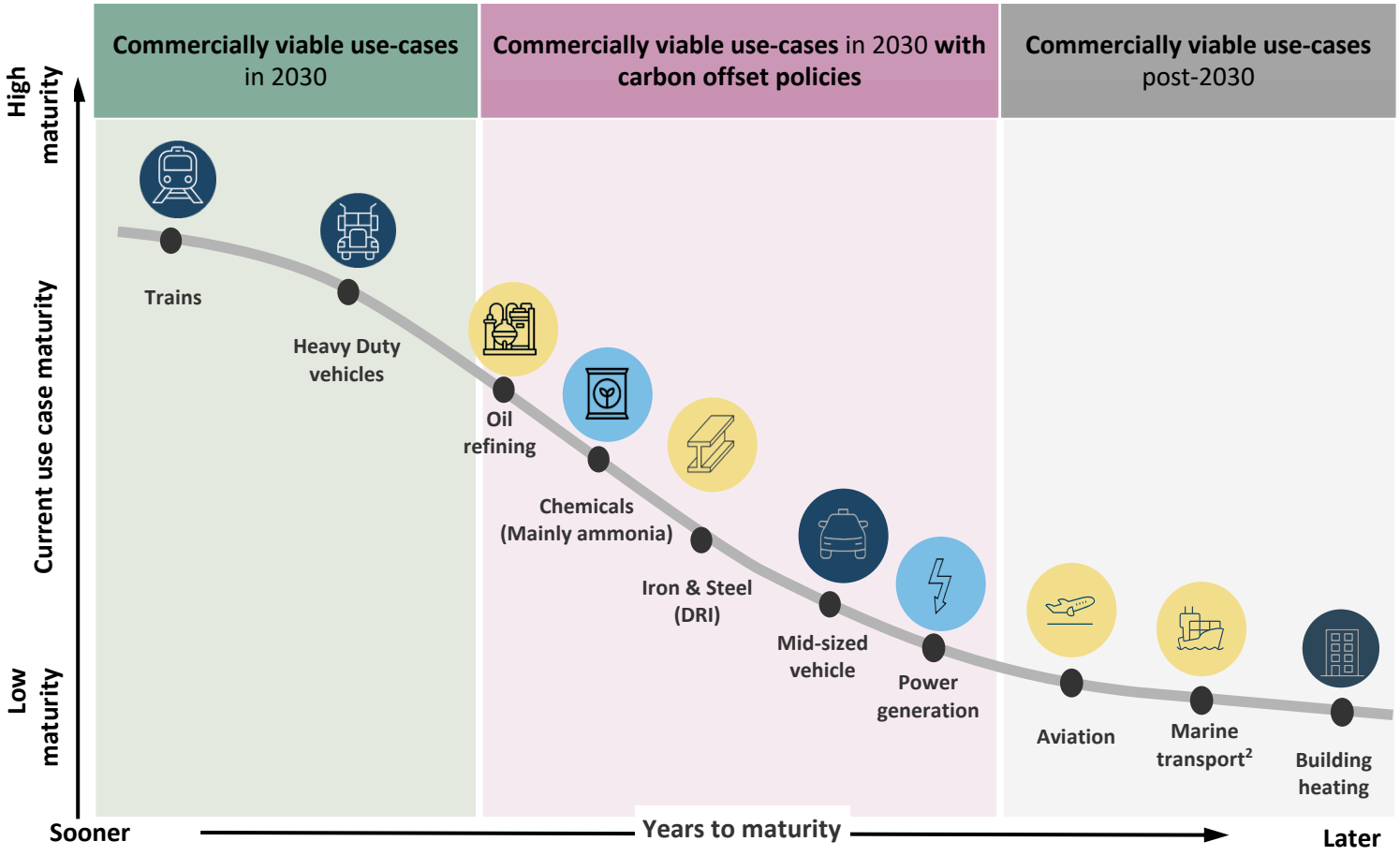
Aviation fuel

Marine fuel

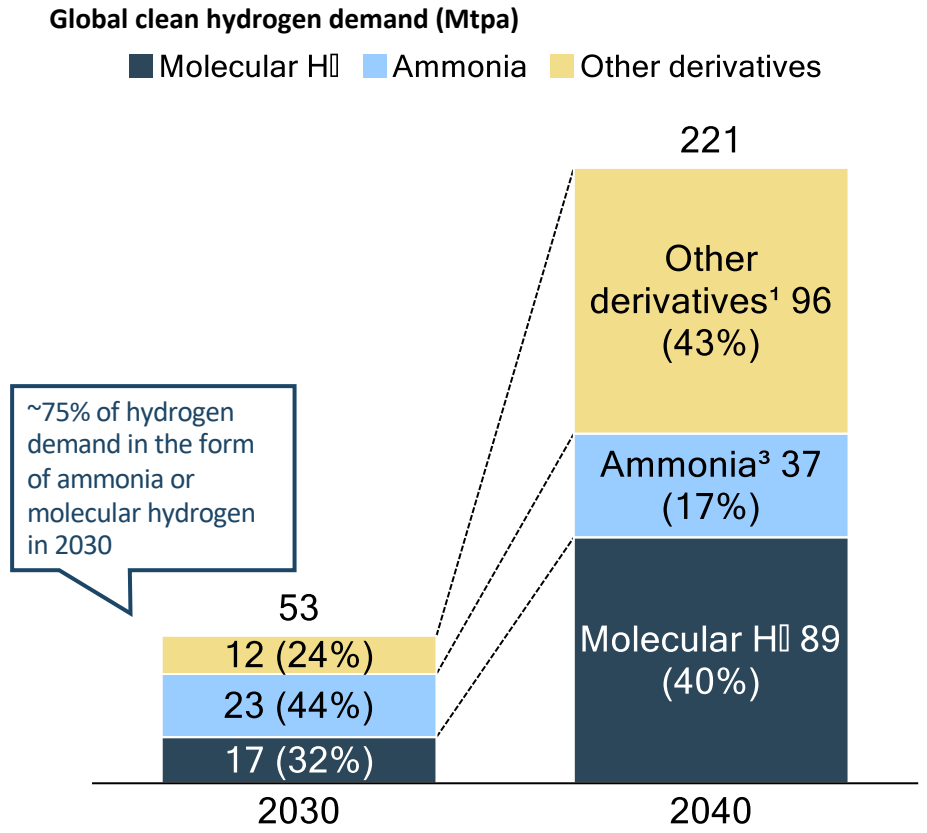
Maturity levels of use-cases detailed next

Most derivatives are expected to mature post 2030 and constitute an increased share in 2040 global clean hydrogen demand

Clean hydrogen enables decarbonization of hard to abate sectors, multiple use cases expected to become cost competitive by 2040



Share of clean hydrogen demand in 2030 & 2040 by form of hydrogen use

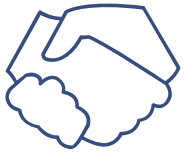


Demand from other segments not classified for 2030 & 2040 (2030: 7 Mtpa, 2040: 29 Mtpa)

Note: (1) Other derivatives include iron & steel, H2 based fuels, maritime fuels (green methanol) & other chemicals (e.g. green methanol) (2) Marine transport includes use of green methanol as marine fuels (3) Share of ammonia in 2040 horizon declining compared to 2030 as maturity of derivatives & other molecular hydrogen use cases such as hydrogen mobility applications increases

We have already entered the implementation phase and are focusing on five priority actions

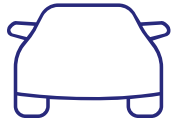
1



G2G engagements

Conducting **G2G engagements to secure partnerships** in the H_2 ecosystem, e.g., offtake agreements, R&D partnerships etc.

2



Mobility pilots

Supporting **Hydrogen mobility pilots** (buses, taxis, rail) across the Kingdom with multiple stakeholders

Deep-dive next

3

Export infrastructure

Exploring **feasibility study for Hydrogen or RE export infrastructure** (e.g., pipeline) from KSA

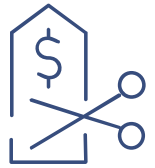
4

Certification

Establishing **regulatory framework for H_2**, i.e., **standards & certification;** advocating for **global harmonization of standards**

Deep-dive next

5



Enablers

Introducing **enablers** to expedite Hydrogen related investment and H_2 vehicle adoption

8 MoUs signed on hydrogen mobility pilots, 7 of which already in their implementation phase

2 MOBILITY PILOTS

The Ministry of Energy, Saudi Arabia, signed 8 MoUs on Hydrogen mobility pilots

"The MoUs cover performance tests of hydrogen fuel vehicles, analysis of the lessons learned from pilots, efforts to acquire techno-commercial expertise, and raising public awareness of hydrogen in the Kingdom", Jan 20, 2022

MoU signed → **Implementation launched**

Early stage → Advanced stage

- The Red Sea Development Company
- SAR
- جامعة الأميرة نورة بنت عبدالرحمن Princess Nourah Bint Abdulrahman University
- NEOM نيوم
- AQONIA ENERGY تقنية للطاقة تطور بلا حدود
- KINGDOM OF SAUDI ARABIA
- الهيئة الملكية لمدينة مكة المكرمة والمشاعر المقدسة ROYAL COMMISSION FOR MAKKAH CITY AND HOLY SITES
- SGS

3 pilots are currently in an advanced implementation stage at Princess Noura University, Royal Commissions of Makkah City and Taqnia energy

2 MOBILITY PILOTS

Most mature → Least mature

	PNU FCEV pilot	RCMC Bus pilot	Taqnia synfuels pilot
Overview	Pilot focused on deployment of **buses** and **taxis** for raising **public awareness on H_2 vehicles**	Deployment of FC buses for **public transportation**	Development of **150K liter/year synthetic fuel pilot**
Location	Riyadh	Makkah	TBD
Key entities identified	TOYOTA; وزارة النقل والخدمات اللوجستية Ministry of Transport and Logistic Services; TOYOTA TSUSHO CORPORATION	TOYOTA; AIR PRODUCTS QUDRA; HYDROGEN SYSTEMS	sunfire; (주)에프씨아이 FUEL CELL INNOVATIONS

3 pilots for hydrogen road transportation are in progress with 8 cars and 8+ buses planned for deployment

KSA entities are working together to institute a clean hydrogen certification framework that is inclusive and accepted by target markets

4 CERTIFICATION

Clean hydrogen certification framework

Objective

Develop a certification framework that is **inclusive of all carbon neutral hydrogen production pathways** and **accepted by target markets and offtakers**

- Aligned with KSA's **clean hydrogen** and **Vision 2030 ambitions**
- Focused on **lifecycle emissions** associated with production of clean hydrogen
- Inclusive of and **directly mappable to criteria** set by target markets' **governing bodies** and **certification schemes**

Stakeholders

Certification efforts driven through **unified effort in partnership with national champions and institutions**


Thank you!