THOUGHTS ON THE ENERGY TRANSITION

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JAPAN COAL DAY

5 SEPTEMBER 2023

INTERNATIONAL CENTRE FOR SUSTAINABLE CARBON

WHO WE ARE AND WHAT WE DO

INTERNATIONAL CENTRE FOR
SUSTAINABLE CARBON

Technology Collaboration Programme
by IEA

- **We provide independent information and analysis** on how biomass, coal and other carbon sources can become both cleaner sources of energy and non-energy products, compatible with the UN Sustainable Development Goals

- **The International Centre for Sustainable Carbon (ICSC)** is part of a network of autonomous collaborative partnerships focused on a wide range of energy technologies known as Technology Collaboration Programmes (TCPs)

- The TCPs are organised under the auspices of the International Energy Agency (IEA), but are functionally and legally autonomous

- We are funded by national governments (contracting parties) and by corporate industrial organisations (sponsors)

PRESENTATION OUTLINE

- Overview of the aims and approaches to implementing the energy transition
- Highlights that certain fossil energy technologies will still be required in 2050
- There will be regional solutions

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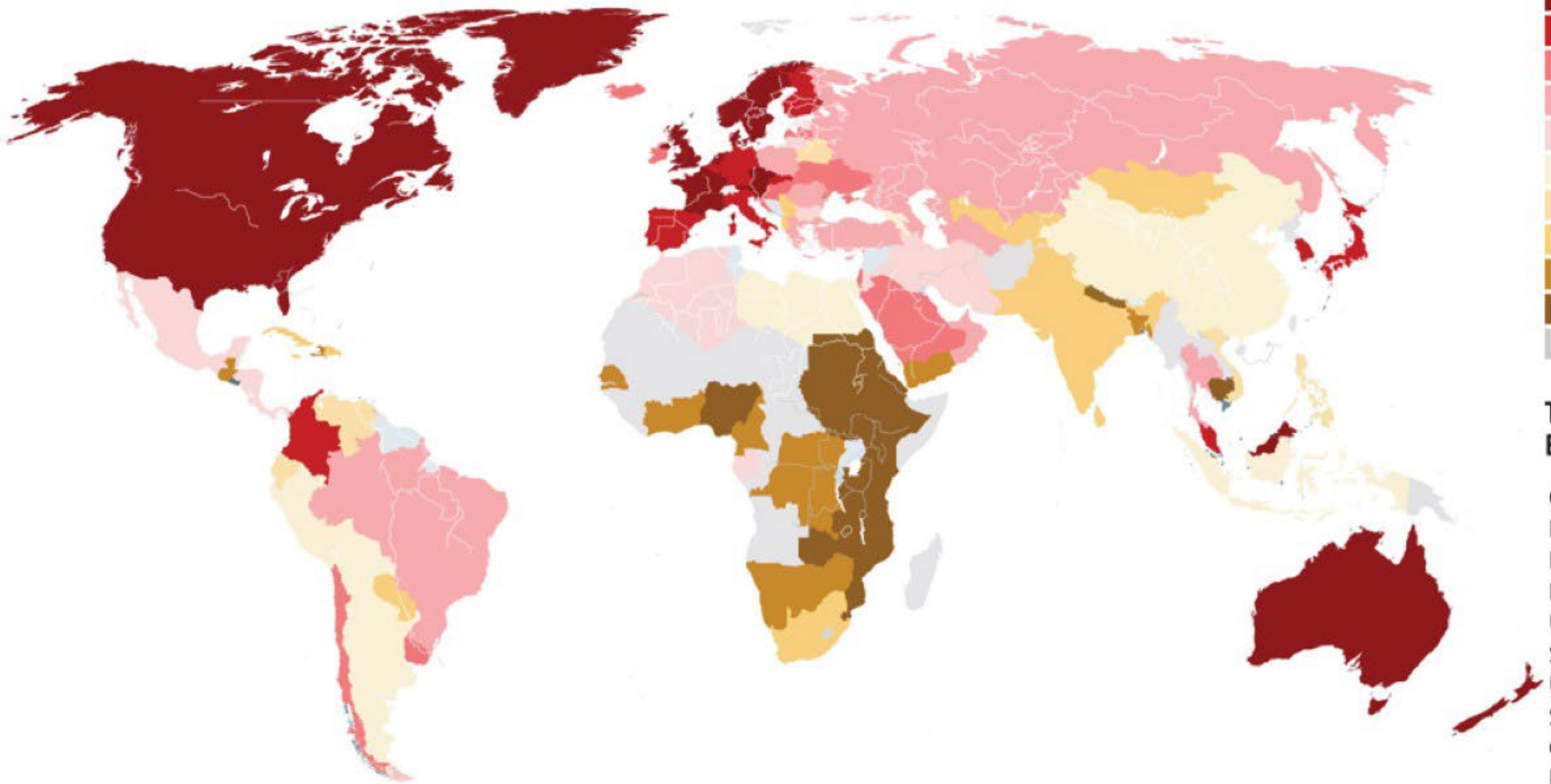
WILL WE ACHIEVE CARBON NEUTRALITY BY 2050?

- Targets based on 2015 Paris Agreement Nationally Determined Contributions (NDCs) and revisions
- Growing realism of the scale of the complex challenges to be met is proving daunting
- 140 countries have announced or are considering achieving carbon neutrality, mostly by 2050, BUT - China and India, combined population 2.8 billion and over 35% of CO2 emissions, have targets of 2060 and 2070
- Average global temperatures have already risen by 1.1 °C since pre-industrial (1850-1900) levels, which means more action is needed

SUSTAINABLE TECHNOLOGY OPTIONS

THERE IS NO ONE SIZE FITS ALL SOLUTION TO CLIMATE CHANGE



EA&S percentile rank

90%–100%	High performance
80%–90%	
70%–80%	
60%–70%	
50%–60%	
40%–50%	
30%–40%	
20%–30%	
10%–20%	
0%–10%	Low performance
	Not covered

Top 10 performers
EAPI energy access and security

Country	EAPI rank	EA&S score
Norway	2	0.95
Denmark	5	0.91
New Zealand	9	0.90
USA	48	0.89
Sweden	3	0.89
UK	16	0.89
Switzerland	1	0.88
Canada	30	0.88
Netherlands	37	0.88
Austria	6	0.88

(World Economic Forum, 2022)

SUSTAINABLE ENERGY AND THE ENERGY TRILEMMA

Pathways to sustainable energy

"Secure the energy needed for economic development"

- Energy efficiency (energy intensity of economy, rate of improvement of energy intensity, conversion efficiency)

- Fuel mix
- Net energy trade
- Investment requirements

"Minimise adverse energy system impacts on climate and human health"

- GHG emissions from the energy system
- Energy-related air pollution, water use and water stress

"Provide affordable energy that is available for all at all times"

- Access to energy services
- Energy affordability
- Food security (biomass use)

(UNECE, 2022)

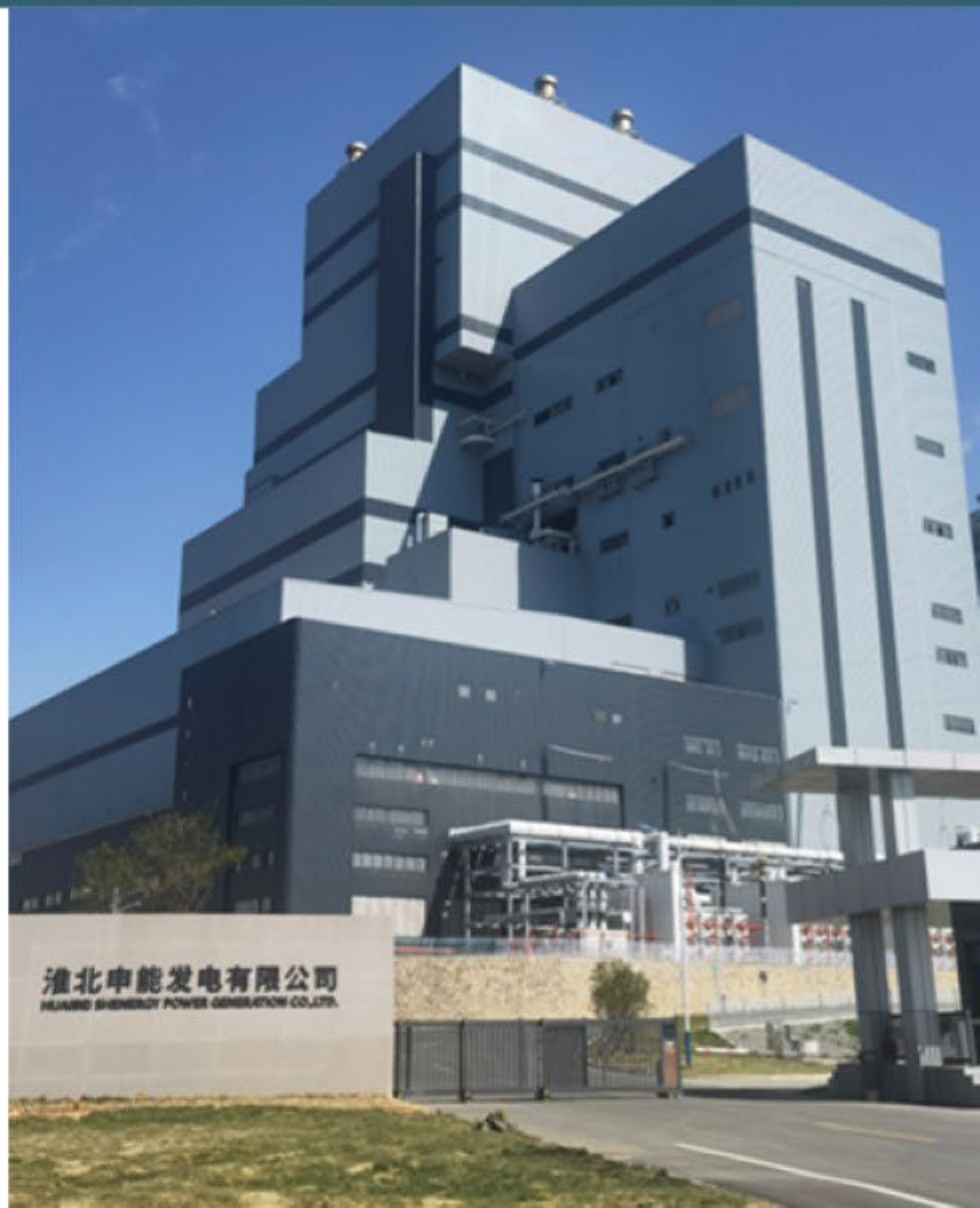
POWER GENERATION OPTIONS AND ISSUES

FUTURE FOR COAL IN POWER GENERATION

- Many OECD countries (North America, European Union), base future plans on VRE with energy storage - a work in progress
- Coal and gas, as dispatchable power sources, will need to remain a part of the energy mix in many countries to guarantee supplies of affordable, reliable electricity
- Developing nations with access to low-cost coal, such as in Asia will go their own ways, may include coal with CCUS

ASPECTS OF CHINA'S APPROACH TO LIMITING CLIMATE CHANGE (CNBC 2022)

- Two years ago, China announced that it would strive for peak carbon emissions in 2030, and carbon neutrality in 2060
- In 2019 manufacturing equated to 55% of total energy consumption, and 59.6% of that energy came from coal
- Government has declared that all production centres must reduce energy consumption by 13.5% and CO_2 emissions by 18% per unit of GDP. Challenge for industry
- Policymakers make it clear that economic growth remains a priority, which currently depends on coal power and VRE



AUSTRALIA'S PLAN

- Long-Term Emissions (LETS) Reduction Plan for net zero emissions by 2050
- Ultra low-cost solar as a priority, goal for solar electricity generation at 15 AU$/MWh, ~ 1/3 of today's cost
- Interest in renewable-based hydrogen, energy storage, low-emissions materials, like steel and aluminium, CCS, soil carbon enhancement
- New infrastructure and low emissions technologies - EV battery charging, hydrogen refuelling stations, digital electricity grid
- Government to invest >AU$20 billion in low emissions technologies over the next decade, to drive AU$80 – 120 billion of public and private investment and create 160,000 jobs
- A very ambitious approach

THE WAY FORWARD FOR JAPAN

- "Green Growth Strategy for achieving Carbon Neutrality by 2050" to transform industrial structures, economy and society

- By 2050, 50 - 60% of electricity from renewables, 30-40% from nuclear and thermal plants with CCUS, 10% of hydrogen and ammonia generation

- Hydrogen - central role in Japan's clean energy transition, aim to make hydrogen cost-competitive with natural gas

- By 2030, Japan aims to have 800,000 fuel cell vehicles, >5 million
- residential fuel cells and an international hydrogen supply chain

IDEAS FROM INDIA

- Fairly industrialised, vast potential and even greater challenges
- Many plans and policies to upgrade power plants, buildings, factories, vehicles, but lack of commitment can limit funding
- Carbon neutral by 2070, but energy demand growing hugely. Needs rapid economic development with a very small increase in emissions
- Financially struggling electricity distribution companies limit the urgent transformation of the sector
- Indian cities have some of the worst air quality in the world

HARD TO ABATE COAL-BASED INDUSTRIES

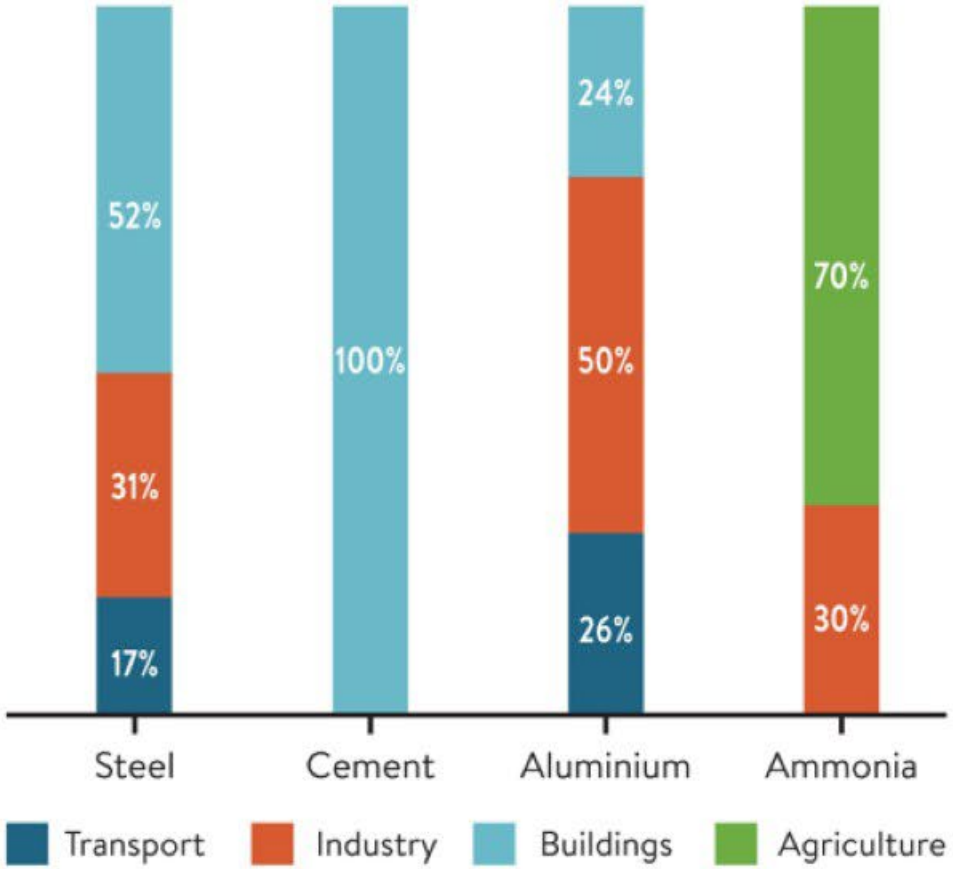
IMPORTANCE OF COAL IN THE INDUSTRIAL SECTORS

- Many industries fulfil a critical role in establishing essential infrastructure
- Heavy industries are ‘hard to abate’ because of need for high-temperature heat, inherent process emissions and relatively young fleet life
- They can be made NZE compliant through measures including demand reduction, increased recycle, fuel-switch and CCUS. The latter technology will need to be deployed extensively

HEAVY INDUSTRIES ARE INTEGRAL TO OUR WAY OF LIFE

- Concrete requiring 4100 Mt/y cement is second most used material on earth after water
  - Forms much of global infrastructure including buildings road bridges and dams
- Steel at 1800 Mt/y used in infrastructure, vehicles and tools
- Aluminium at 95 Mt/y, with demand forecast to grow by 50% by 2050 for light-weight electric vehicles, packaging and renewables construction
- Chemicals to make 180 Mt/y ammonia for fertilisers and 400 Mt/y plastics

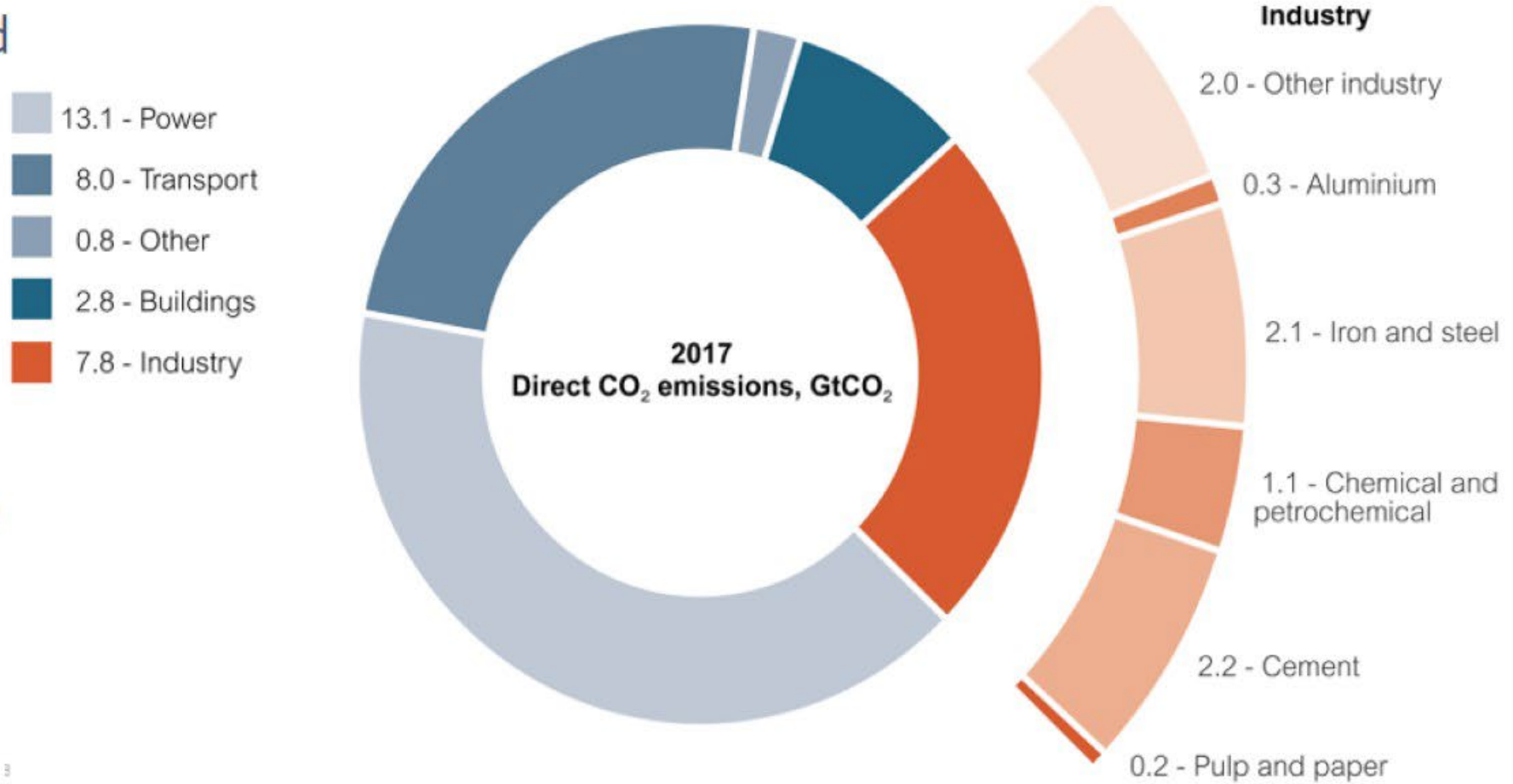
These materials are difficult to replace due to their inherent properties



End use by sector (WEF, 2022)

INDUSTRIAL MANUFACTURE EMISSIONS

- Industry produces around 8GtCO$_2$/y of direct emissions
  - 23% of total global CO$_2$
- Including indirect emissions, this increases to almost 40%
- Cement, iron & steel, chemicals and aluminium are nearly 75% of industrial emissions
- Reducing these 'heavy industry' emissions is a key challenge



Global industrial direct emissions (Zapantis, 2022)

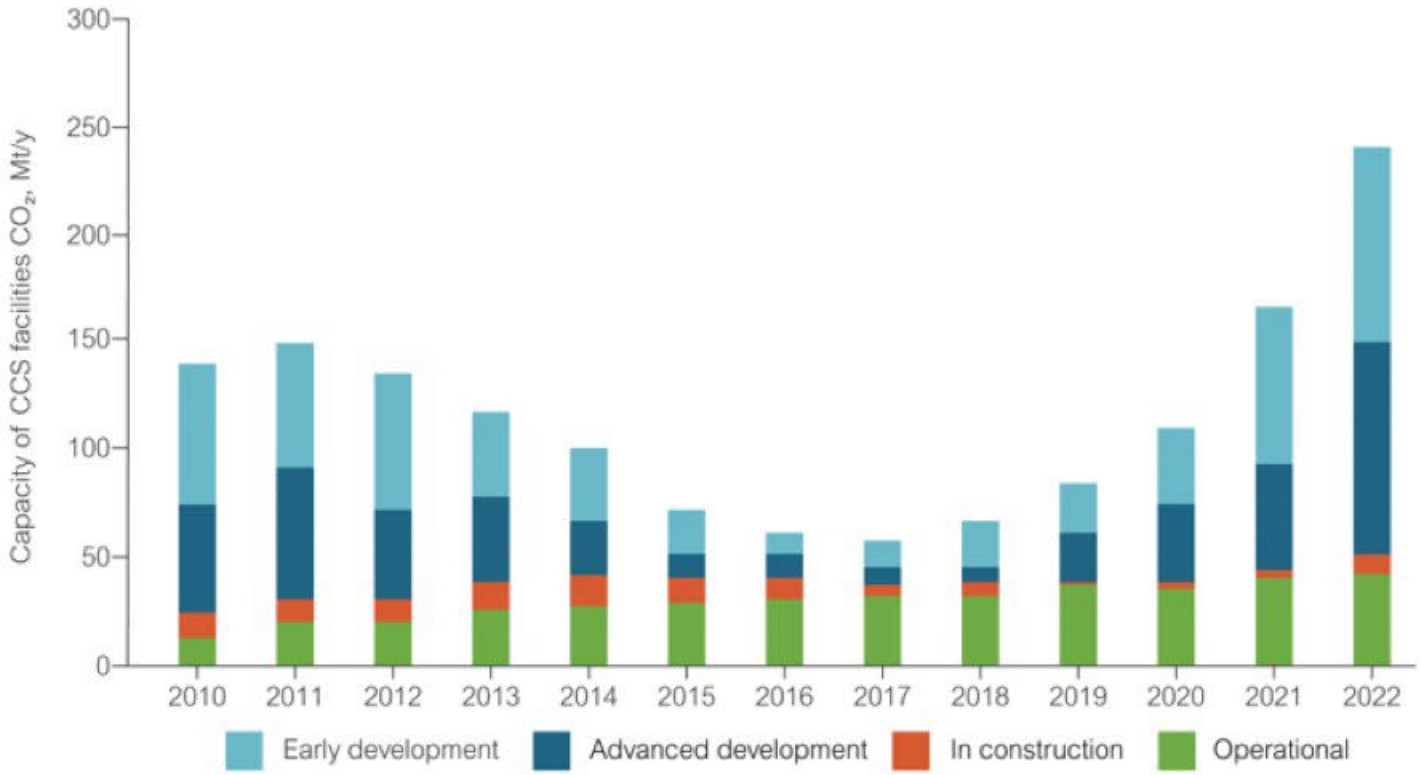
CCUS AS A KEY ENABLING TECHNOLOGY

CCUS CAPACITY IS GROWING

- 44% growth in CCUS pipeline over last 12 months (GCCSI, 2022)
- 196 projects, with 244 $MtCO_2/y$ storage potential
- Chemicals and hydrogen feature strongly with some technologies
- T&S infrastructure through hubs and cluster approach
- Limited coal applications in recent projects
- Trajectory is good but much more is needed

TABLE 1 COMMERCIAL CCUS FACILITIES AND TOTAL CO_2 STORAGE CAPACITY (GCCSI, 2022)

Classification	Operational	In construction	Advanced development	Early development	Operation suspended	Total
Number of facilities	30	12	77	75	2	196
Capture capacity, $MtCO_2/y$	42.6	11.1	96.1	91.9	2.3	244



Pipeline of CCUS facilities (GCCSI, 2022)

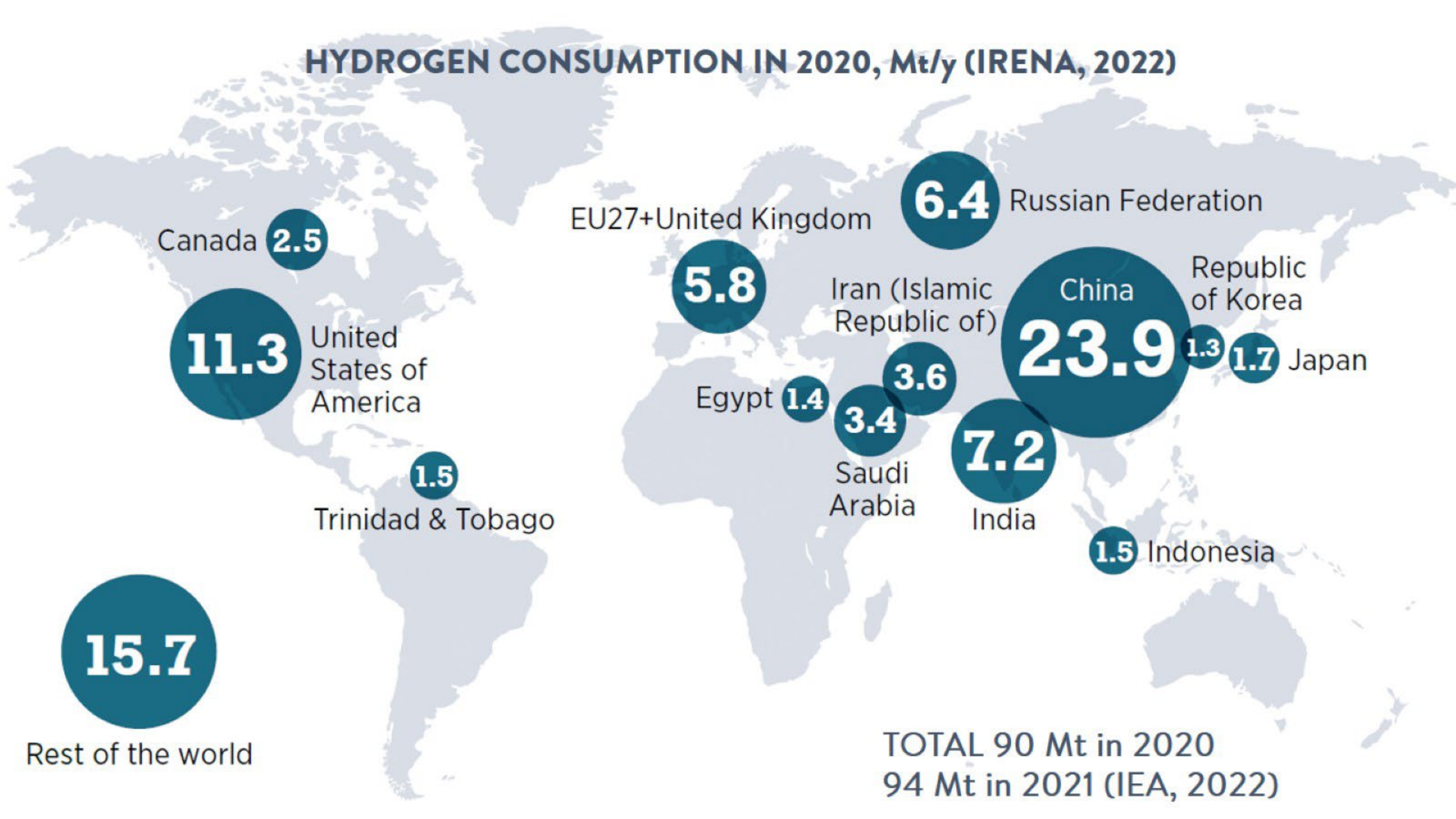
COAL WITH CCUS SUPPORTS LOW-C ELECTRICITY

- 10 GW power Huaneng Longdong plant due to be operational in 2023
- Comprises 8 GW of VRE and 2 GW of USC coal with CCUS
- 1.5 $MtCO_2/y$ capture primarily going to geological storage although potential for EOR
- Example of how coal with CCUS can support high VRE grid penetration to provide low-carbon electricity for industrial electrification, whilst providing grid stability and high availability

Artist's impression of 10 GW Huaneng Longdong Multi-energy power plant (Liu, 2021)

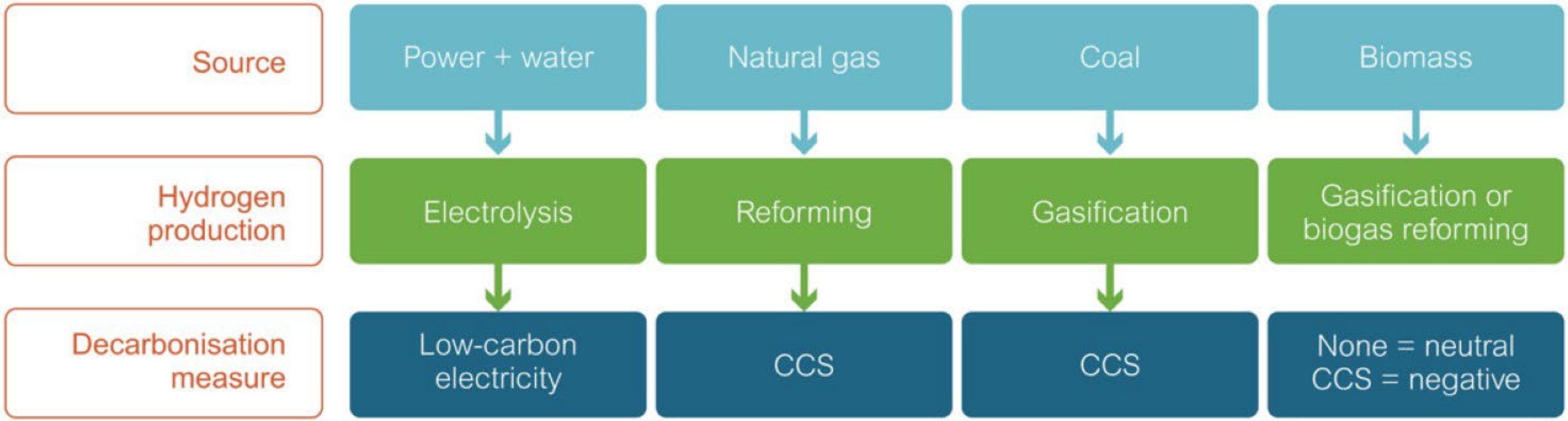
THE ROLE OF COAL IN THE HYDROGEN ECONOMY

HYDROGEN CONSUMPTION IN 2020, Mt/y (IRENA, 2022)



TOTAL 90 Mt in 2020
94 Mt in 2021 (IEA, 2022)

HYDROGEN PRODUCTION METHODS



313/15-ICSC2021

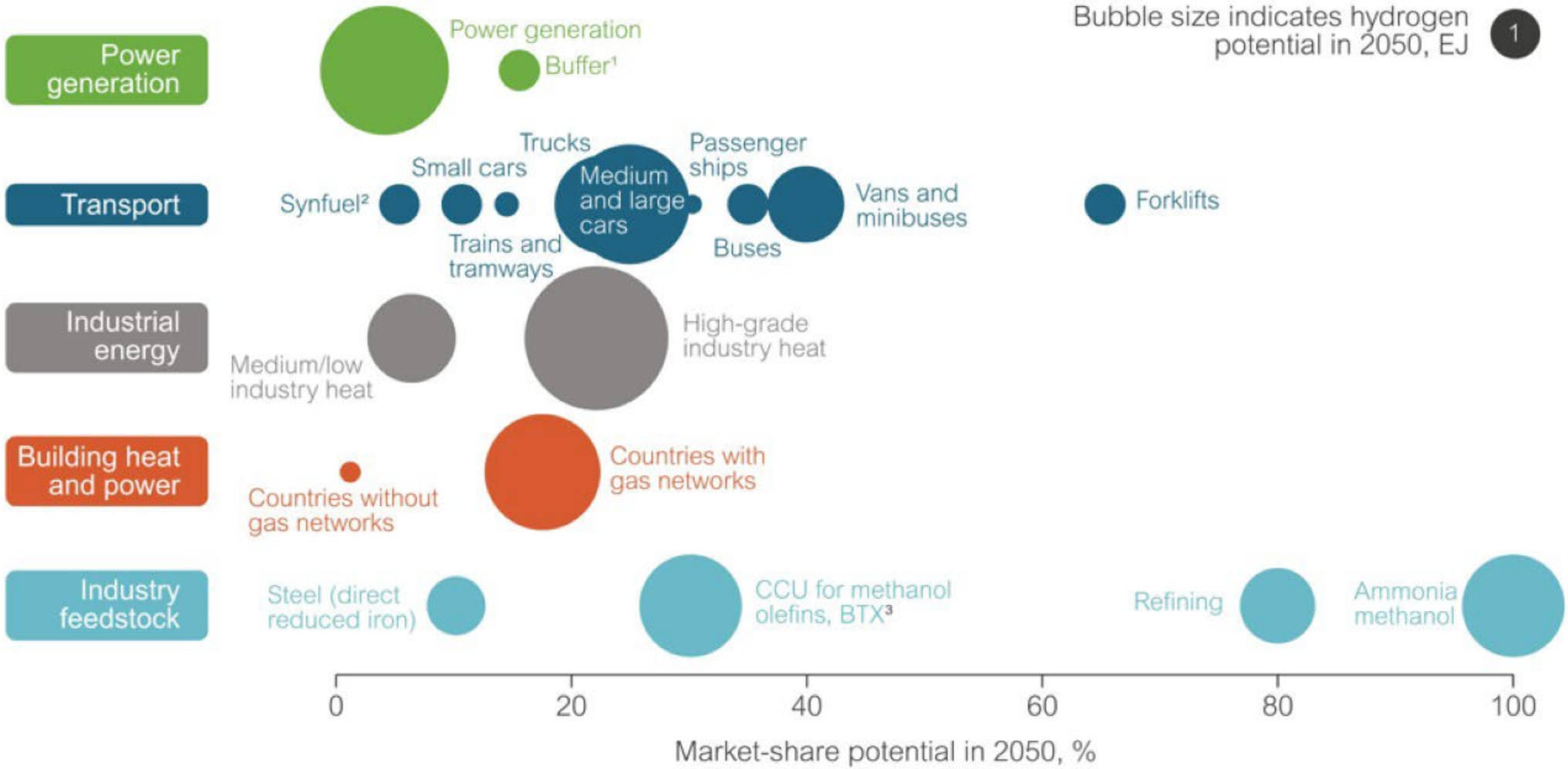
Proportion of H_2 produced:	1%	>70%	27%

<1% of hydrogen currently produced from electrolysis of water

(Aarnes and others, 2018)

HYDROGEN POTENTIAL MARKET SHARE IN 2050

H_2 potential major market share in industry, around 20% of buildings heat and power, industrial energy and transport



(USDOE, 2020)

¹ % of total annual growth in hydrogen and variable renewable-power demand

² For aviation and freight ships

³ Carbon capture and utilisation (CCU); % of total methanol, olefin and benzene, toluene and xylene (BTX) production using olefins and captured carbon

KEY FINDINGS

- Gap between existing hydrogen demand, targets and renewable hydrogen production capacity
- For China, India and others, hydrogen production from coal gasification with CCUS will be vital in meeting domestic demand

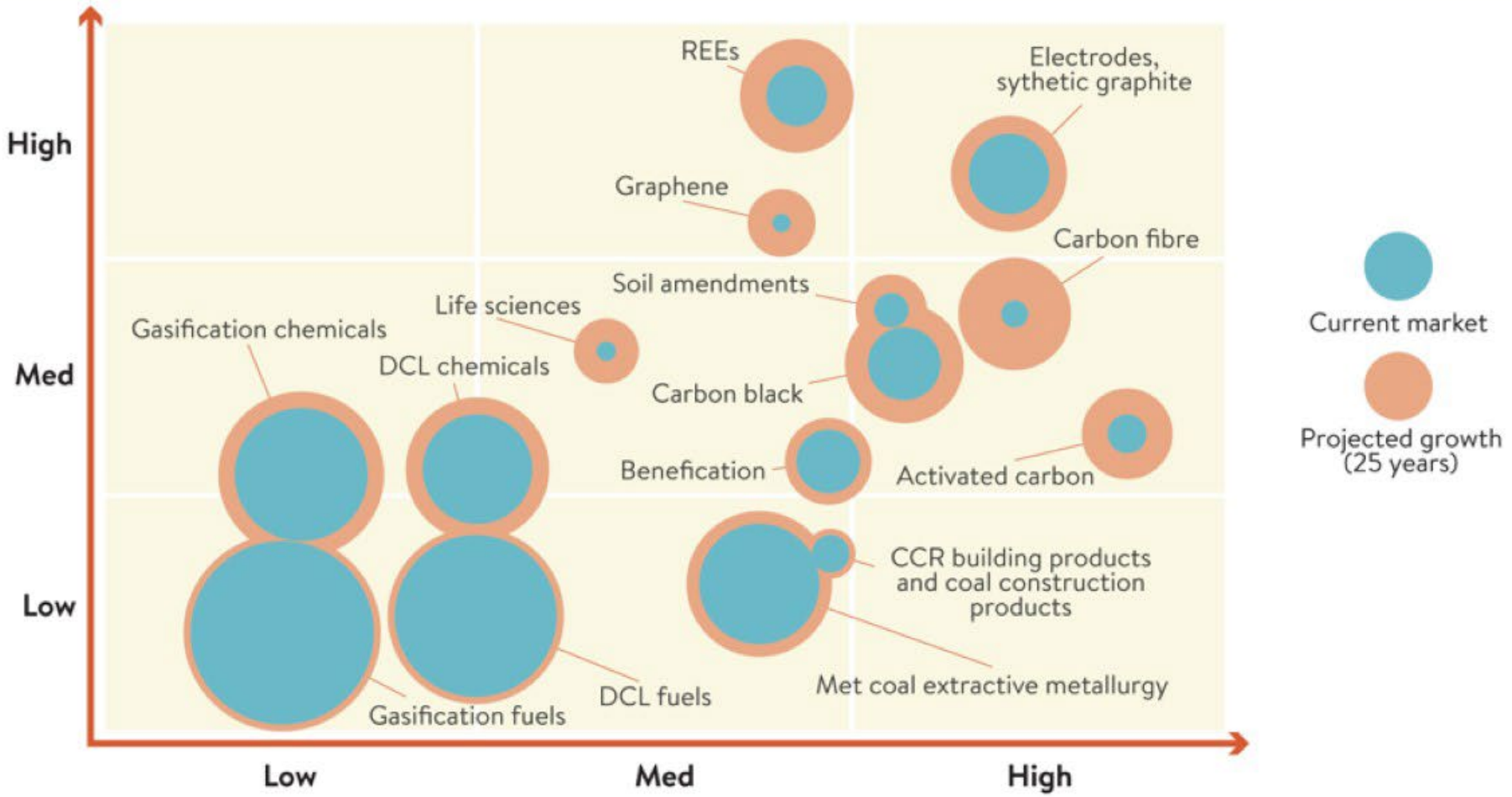
Shutterstock

- The transition to large-scale, low-carbon hydrogen will require the production of hydrogen from fossil fuels with CCUS, both on cost and on reduced emissions grounds

COAL AS A MULTI-PURPOSE NON-ENERGY RESOURCE

COAL AS A RESOURCE

Market attractiveness
- Market size
- Market growth rate
- Attributes



Competitive strength
- Relative market share
- Ability to compete on price and quality
- Competitive strengths and weaknesses

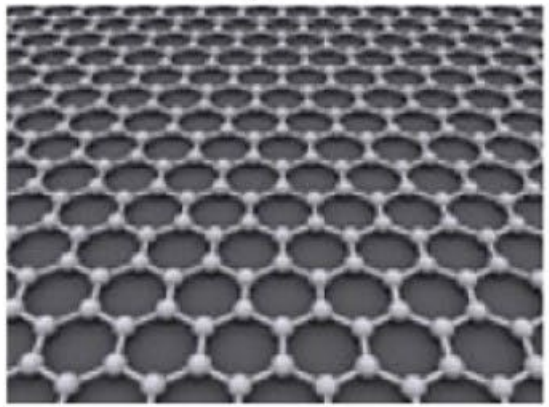
Ramaco Carbon, 2022

SIGNIFICANT COAL GASIFICATION PRODUCTS CONVERTED TO CARBON BASED NON-ENERGY MATERIALS (WIKIPEDIA)

Activated carbon

Carbon fibre

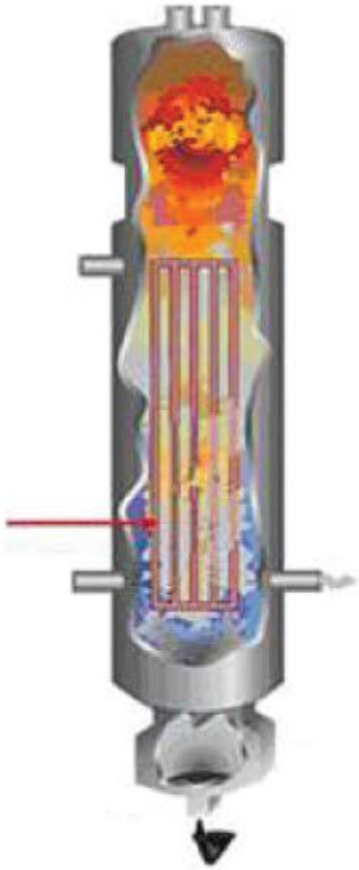
Graphene



Li-ion battery

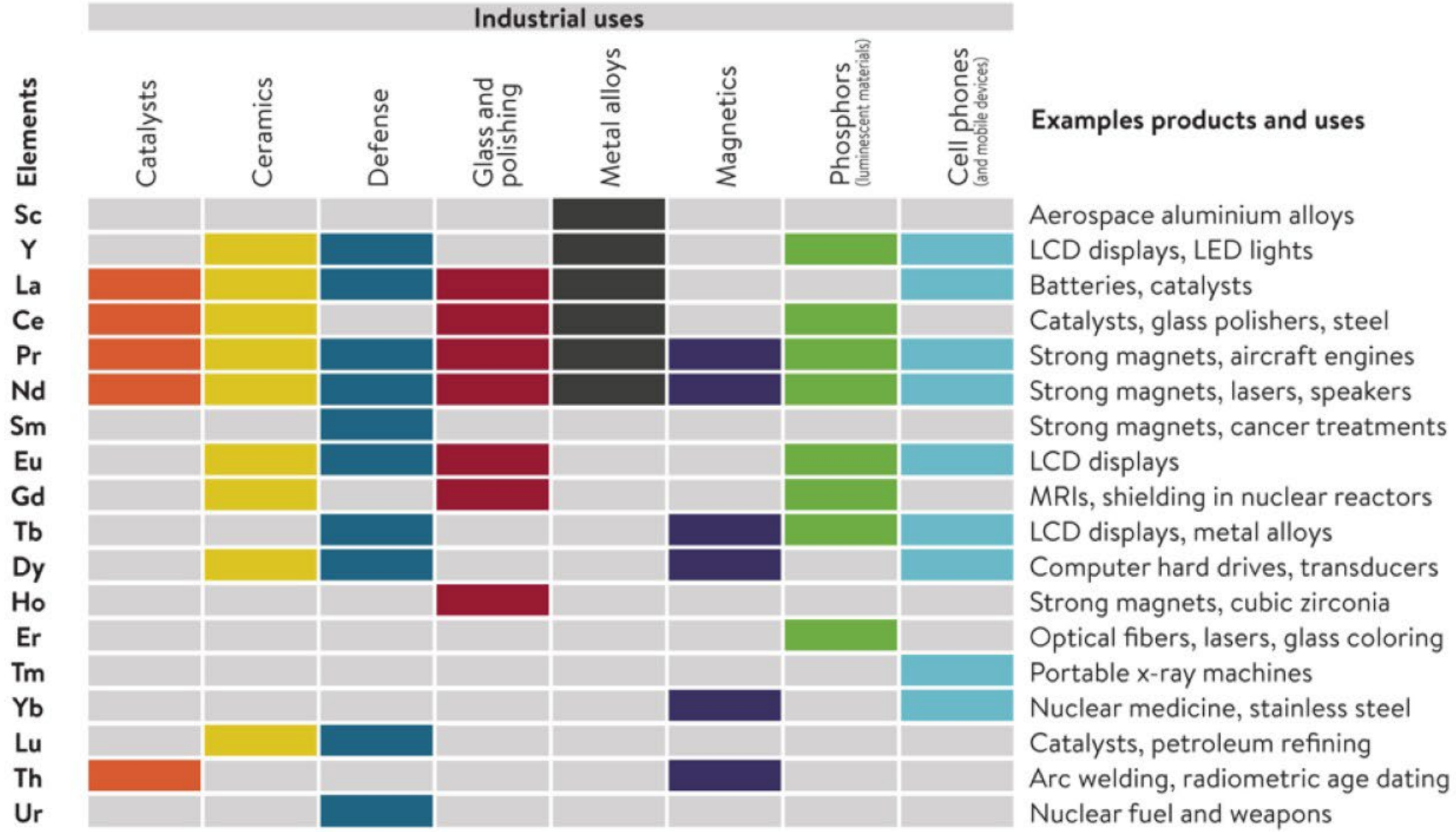
Synthetic graphite

Rare earths and others



Gasification and tar chemicals

KEY PRODUCTS THAT INCLUDE REE



KEY TAKEAWAYS

- Coal use in power generation is under pressure because of its carbon emissions, but a critical need for it remains in:

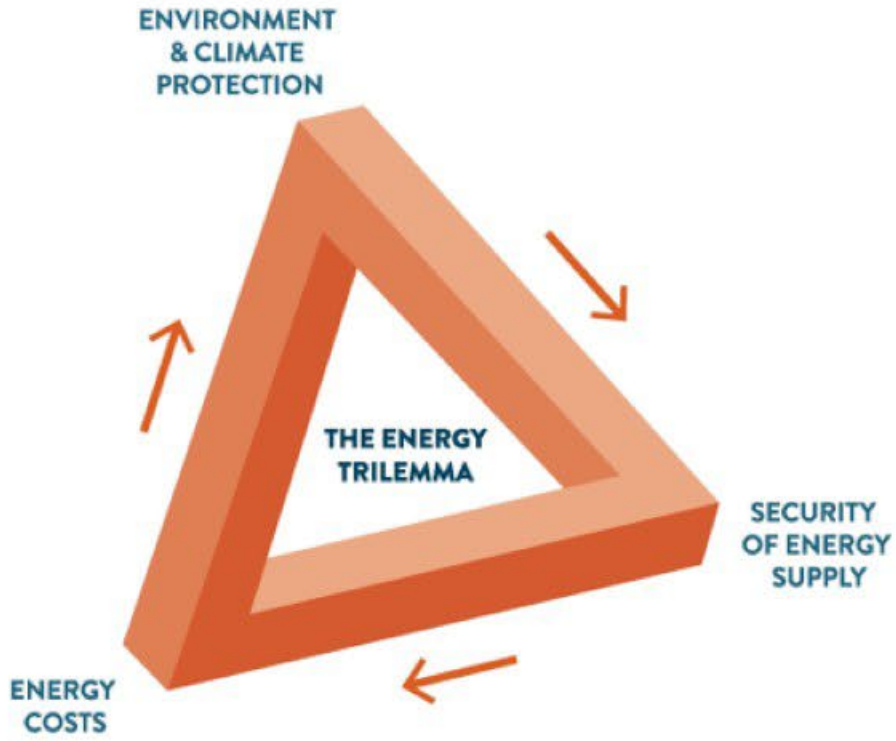
- cement manufacture
- steel making
- chemicals and hydrogen production

- Versatility of high value carbon products without associated carbon emissions shows significant commercial potential

- Significant quantities of valuable rare earth metal compounds, have been located in various coal processing systems, including coal seams

- Scope to use modified lignite as a soil conditioner

All these options suggest promising routes forward for future coal use without adding to the global CO_2 inventory



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THANK YOU FOR LISTENING

ANY QUESTIONS?

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