# Energy Transition & Green Hydrogen


Nishant Bhardwaj
GGGI Global Sector Lead Renewable Energy

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# GGGI at a Glance

Headquartered in Seoul, Republic of Korea, GGGI has ***41 Members.***


(updated as of Q4, 2021)

## Our Vision

A **LOW-CARBON**, **RESILIENT WORLD** OF **STRONG**, **INCLUSIVE**, AND **SUSTAINABLE GROWTH**

## Our Mission

**GGGI SUPPORTS ITS MEMBERS IN THE TRANSFORMATION OF THEIR ECONOMIES TO A GREEN GROWTH ECONOMIC MODEL.**

## Our Position

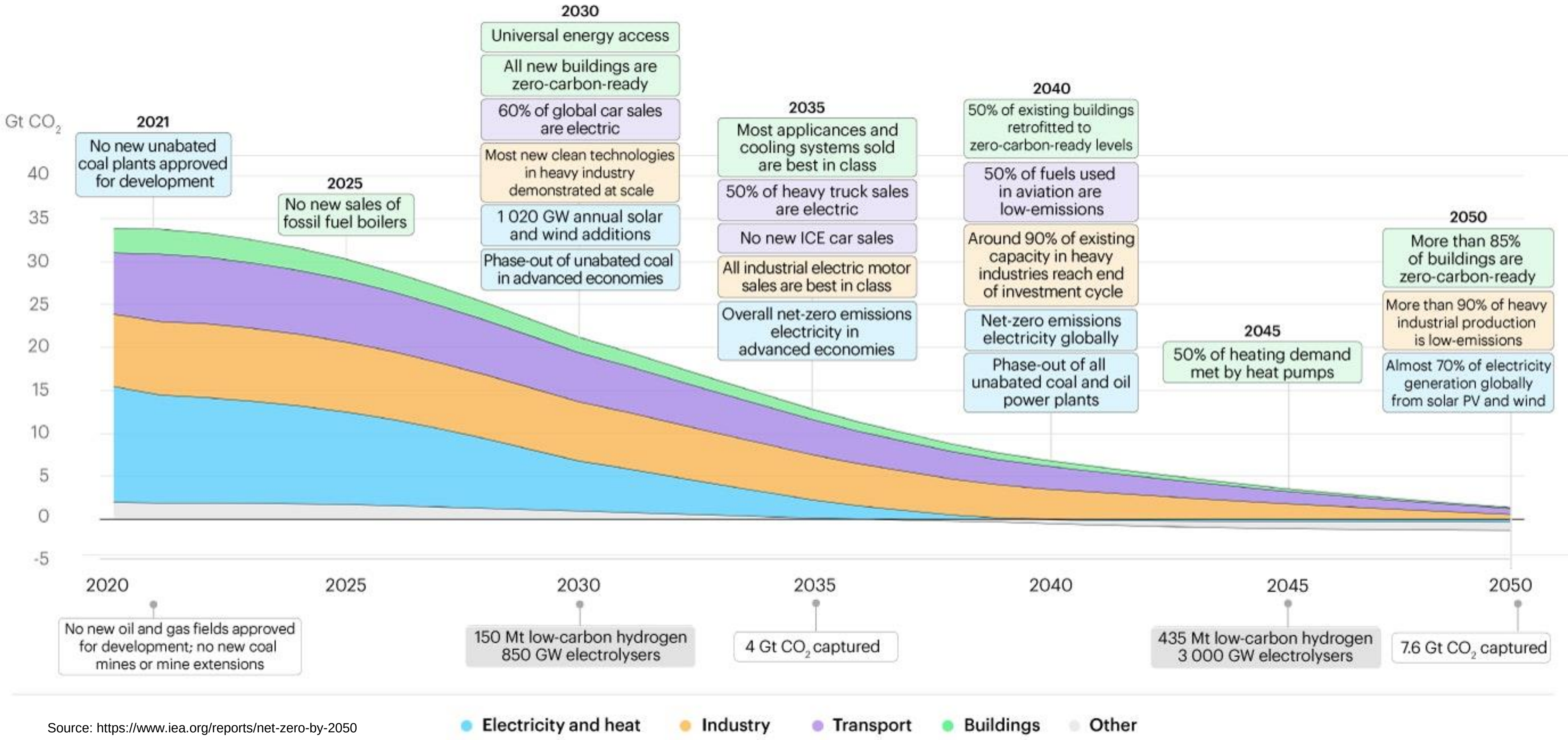
A **TRUSTED ADVISOR** & **DEVELOPMENT PARTNER** EMBEDED IN MEMBER & PARTNER GOVERNMENTS

# Mega Trends in the Energy Sector

Supply side – replacement of fossil fuels with clean, RE


Demand side - electrification

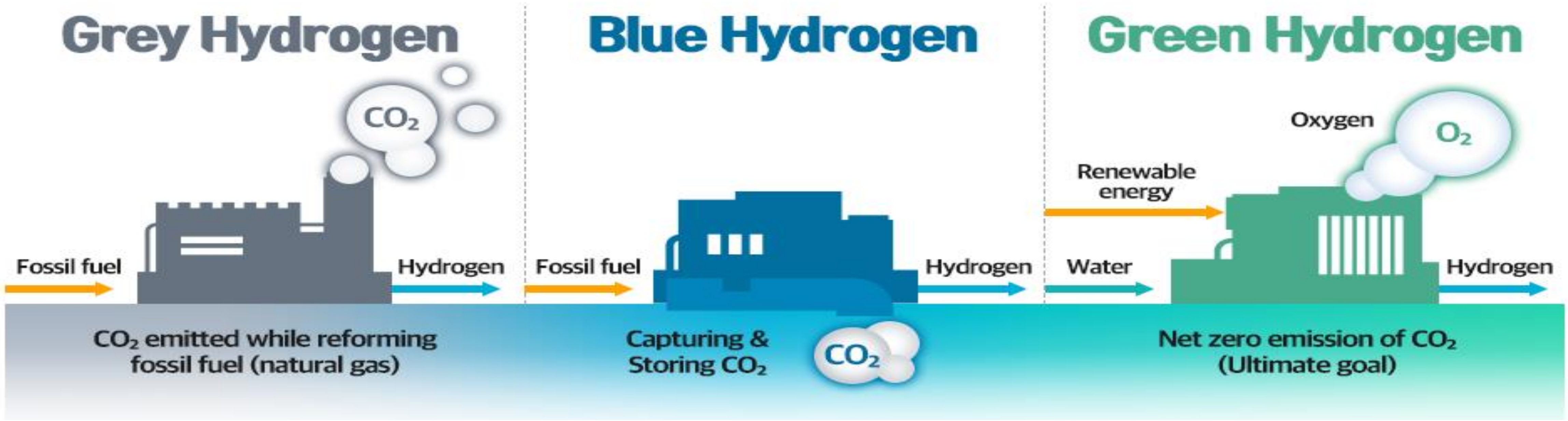
# 1.5°C & Energy Sector Transformation - IEA




Source: https://www.iea.org/reports/net-zero-by-2050

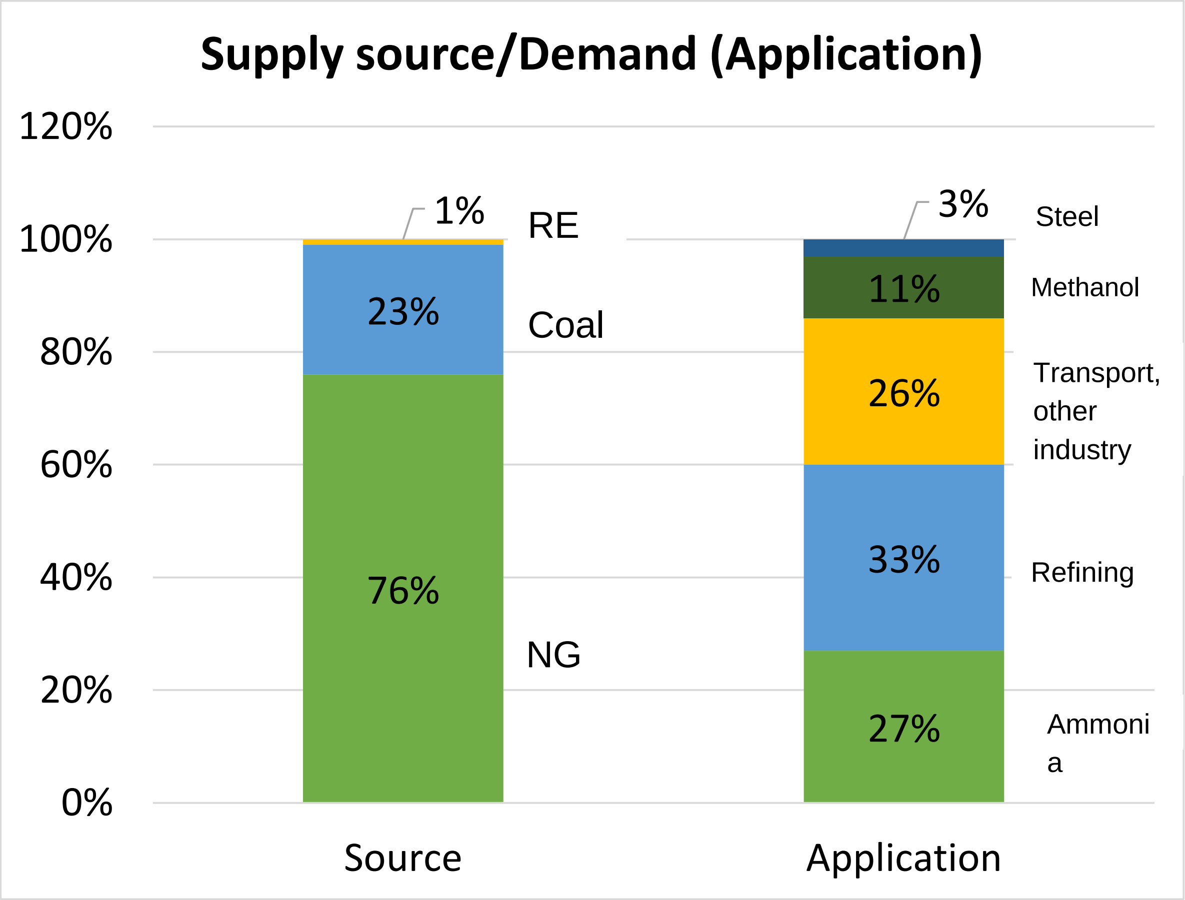
# Understanding Hydrogen

**Hydrogen is classified in Grey, Blue and Green based on the feedstock and the process used minimize the CO2 emissions**




| | | |
|---|---|---|
| • Grey Hydrogen is produced either using Natural Gas or Coal with CO2 emitted in air.<br>• Hydrogen is produced through the "Steam Methane Reforming Process" using NG<br>• Hydrogen is produced using the "Coal Gasification Process" using Coal. | • Blue Hydrogen is produced either using Natural Gas or Coal using the similar process as grey Hydrogen<br>• Additionally. Blue Hydrogen uses Capturing and Storage of CO2 emission to reduce the environmental impact. | • Green Hydrogen uses the process of Electrolysis of water to breakdown it into H2 and O2 which is emitted<br>• Process of electrolysis requires electricity and electricity generated from Renewable Energy sources is used. |

# Global Hydrogen Demand and Supply

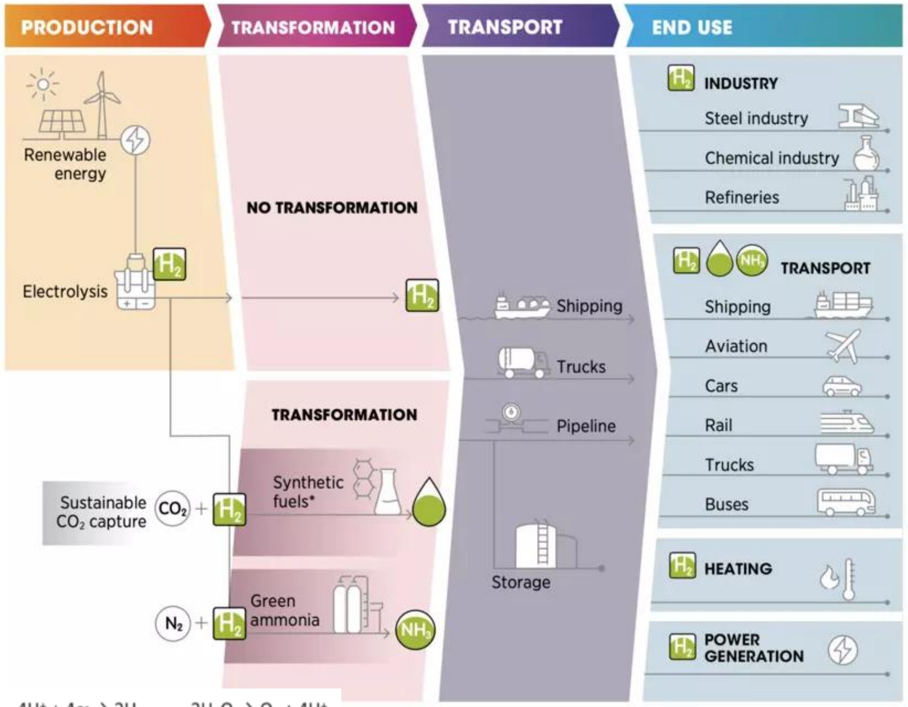


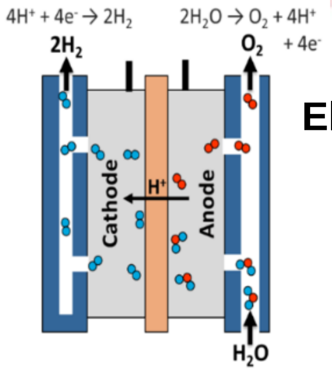

*Source: KPMG report*

- Including hydrogen that is consumed in combination with other gases (syngas) adds 45 million tonnes, to make total **hydrogen volumes around 115 million tonnes** all of which uses fossil fuel as feedstock;
- **830 million tons of CO2** every year as result.
- Demand is going to increase only
  - Demand of Ammonia will rise from 235 million metric tons in 2019, to nearly 290 million metric tons by 2030.
  - Transition to EV will take time and with stringent emission standards for combustion vehicles Hydrogen in refinery will be needed to reduce sulphur.

# Green Hydrogen Technologies

## Green Hydrogen Value Chain




**Electrolysis reaction**

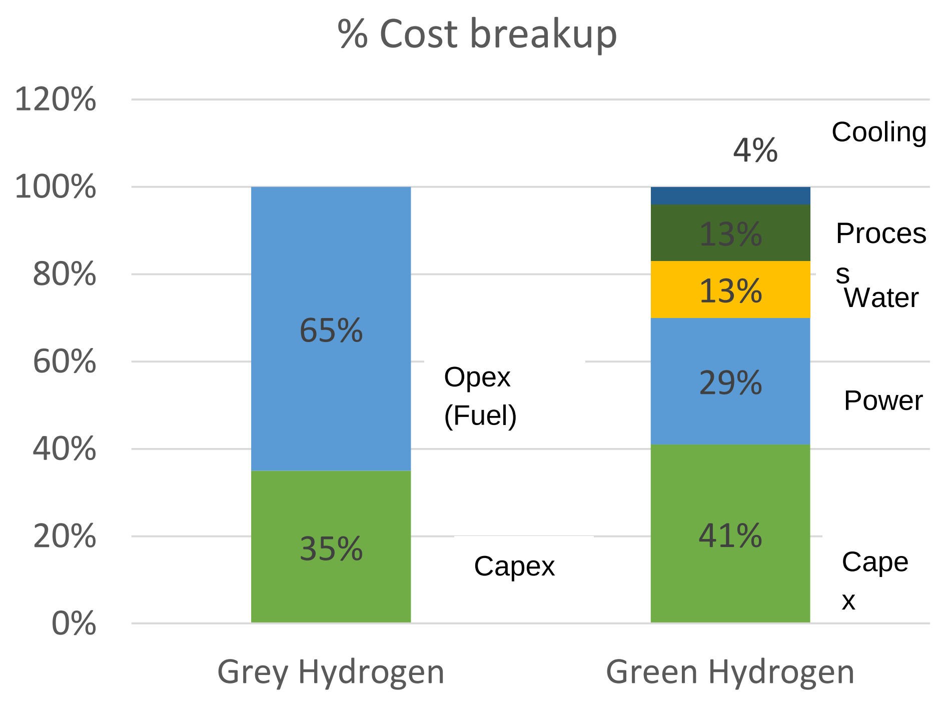
**Electrolysis Technologies –** The most common/promising technologies are Alkaline, PEM (Polymer Electrolyte Membrane) and SOEC (Solid Oxide Electrolysis Cell)

| Technology | Description |
|---|---|
| Alkaline | Alkaline electrolyzers operate via transport of hydroxide ions (OH-) through the electrolyte from the cathode to the anode with hydrogen being generated on the cathode side. Electrolyzers use liquid alkaline solution of sodium or potassium hydroxide as the electrolyte. |
| PEM | The electrolyte is a solid specialty plastic material. Water reacts at the anode to form oxygen and positively charged hydrogen ions (protons). The electrons flow through an external circuit and the hydrogen ions selectively move across the PEM to the cathode. At the cathode, hydrogen ions combine with electrons from the external circuit to form hydrogen gas. |
| SOEC | Solid oxide electrolyzers, which use a solid ceramic material as the electrolyte that selectively conducts negatively charged oxygen ions (O2-) at elevated temperatures. |

| Technology | Cost for system (USD/kW) | Efficiency (kWh/kg H2) | Availability | Size |
|---|---|---|---|---|
| Alkaline | 500-1000 | 50-70% | Commercial | Large |
| PEM | 700-1400 | 50-83% | Developing | Compact |
| SOEC | +2000 | 45-55% | Experimental | |

# Economics of Hydrogen Production

- Grey Hydrogen costs between USD 1-2/kg, Blue Hydrogen between USD 2-3/kg and Green Hydrogen between USD 2.5-7/kg
- A European alliance targets to produce green hydrogen at USD 1.82/kg by 2030 including transmission and storage cost

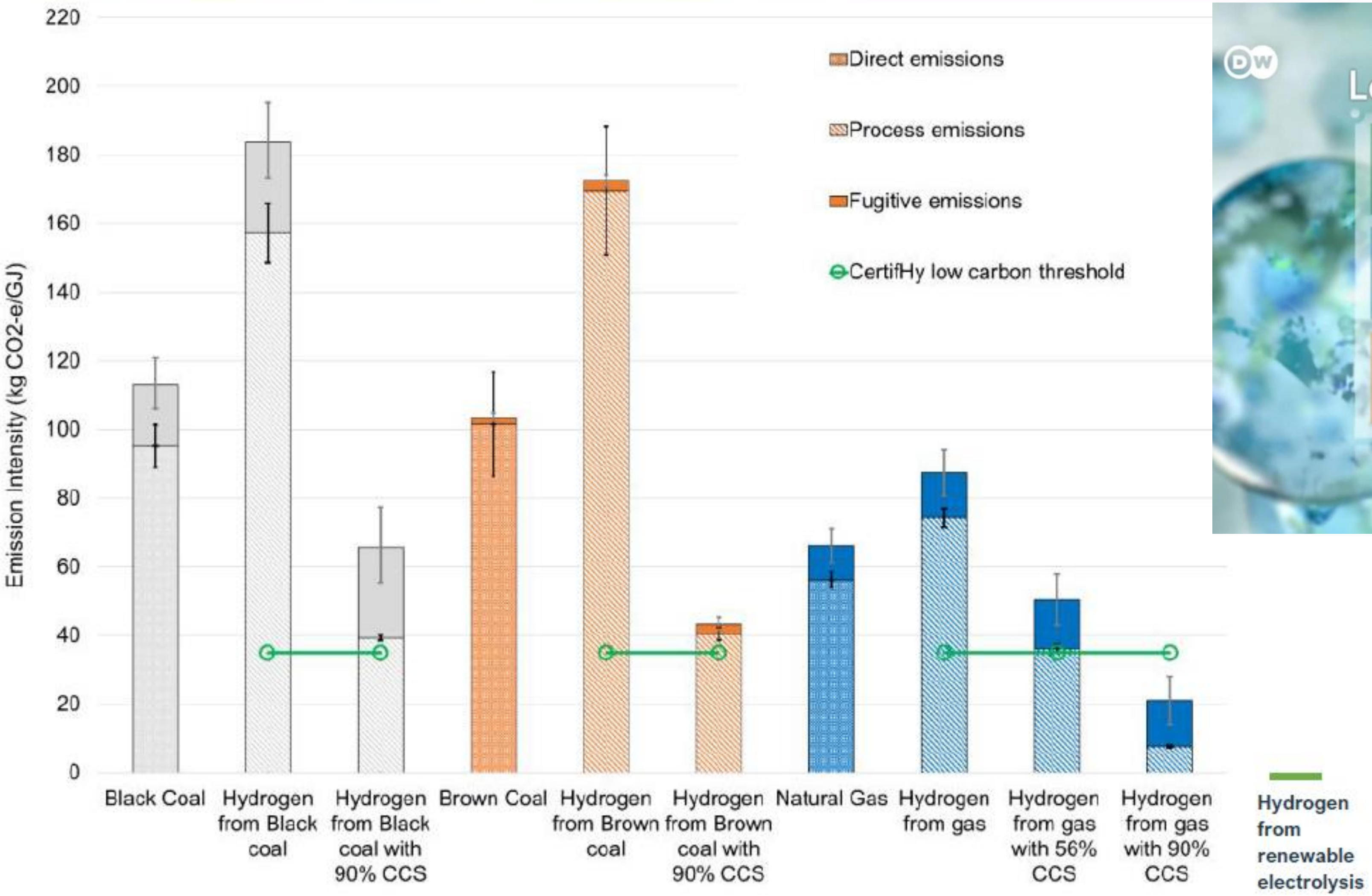


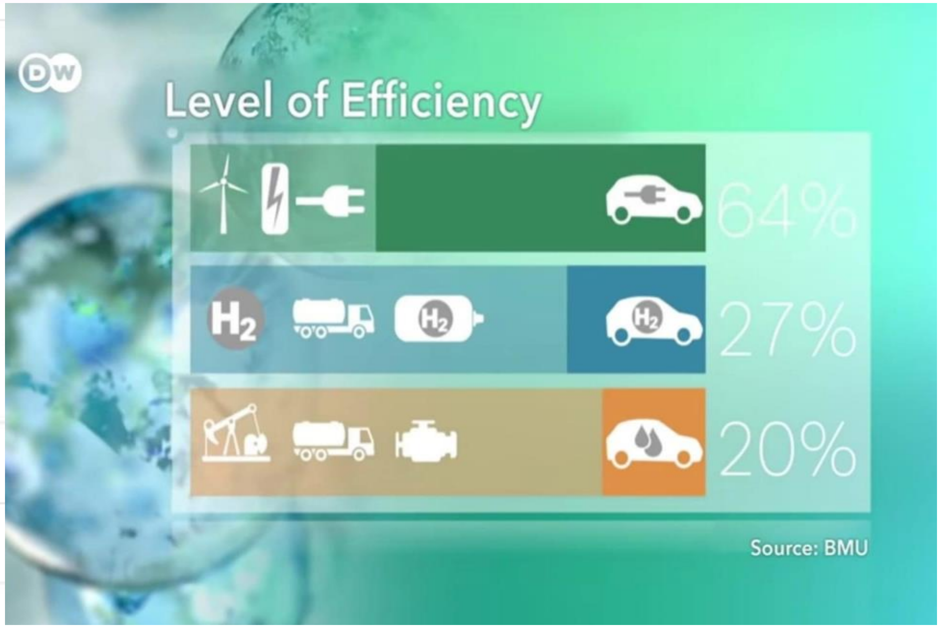

Source: IRENA

| Low ($/kg of $H_2$) | High ($/kg of $H_2$) | Year | Electricity cost (Cents/kWh) | Capacity Factor (%) | System Capex ($/kW) | Electrolyser System effncy | Ref |
|---|---|---|---|---|---|---|---|
| 4 | 6 | 2020 | 4-10 | 20-30 | 750 | 65 | H2 Council |
| 3.75 | 5.1 | 2018 | | | 1124 | 63 | E3/UCI |
| 2.7 | 6.8 | 2018 | 2.3-8.5 | 26-48 | 840 | 65 | IRENA |
| 2.5 | 6.8 | 2019 | 3.5-4.5 | | 1400 | | BNEF |

To produce Green Hydrogen two technologies are there
- PEM – Polymer Electrolyte Membrane (USD 700-1400/kW)
- Alkaline Electrolyser (USD 500-1000/kW)

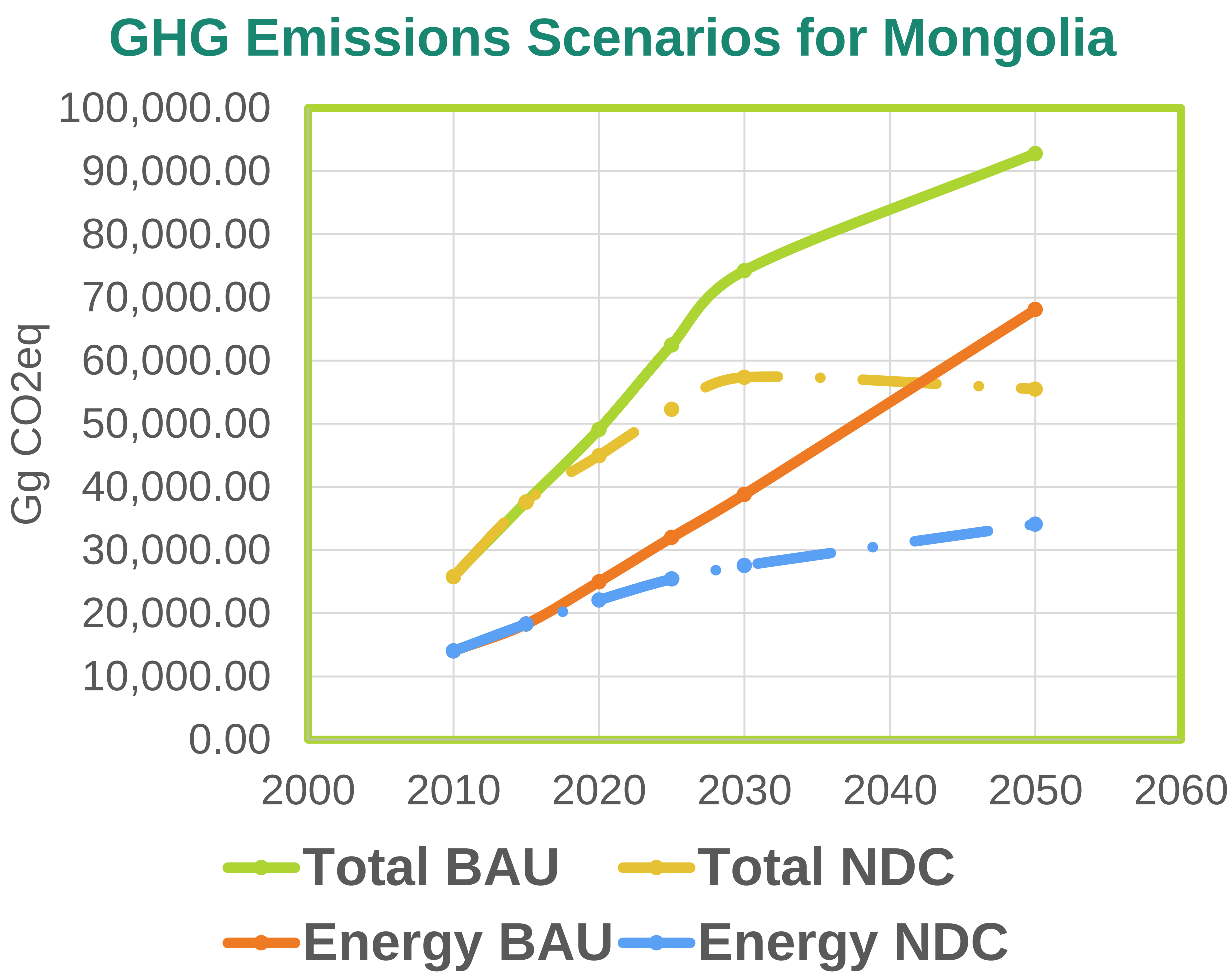
# Role of Hydrogen in Reducing GHG Emissions and Increasing Energy Efficiency



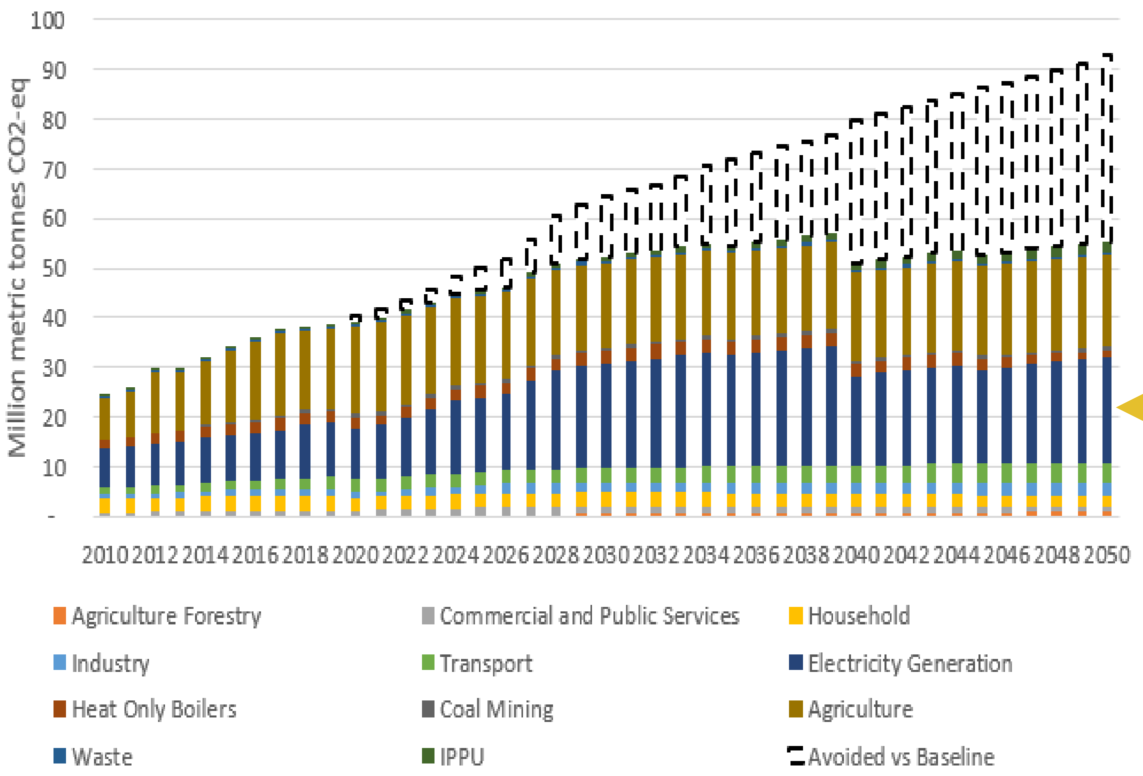




Source: Australian National University, Zero Carbon Energy for the Asia Pacific research programme

# Energy Transition and Prospects for Net-Zero in Mongolia




Emissions from Electricity Generation Remain Substantial in 2050



# RE Challenges & Opportunities towards Net-Zero in Mongolia

## OPPORTUNITIES

- Large RE resources
- Experience w RE on/off grid
- Strong interest of private and financial sectors
- Competitive procurement can lower price of RE and make it more competitive
- Decentralization
- Comparative advantage in NEAsia for RE
- Co-benefits – reduced air pollution, health, jobs
- substitute coking coal exports with green hydrogen

## CHALLENGES

- Limited capacity in the grid to absorb RE
- Tariffs & Subsidies
- Absence of clear long-term commitment to RE
- Policies in place, but incentives throughout the ecosystem lacking
- Curtailment and breach of existing PPAs for RE
- Massive scale up in investment required to improve energy system (10 times current annual investment levels)

# About GGGI’s Green Hydrogen Program

- Newly launched multi country initiative of GGGI’s to develop a Green Hydrogen ecosystem through pilot project development.
- Leverage international collaborations with public/private sector stakeholders to develop a business model.

**$500** Million Investment target in three countries

**3** Year Program Tenure

**3** Target Countries
- India
- Indonesia
- Morocco

**Indonesia (Plan for 100 MW)**

- Focus on the North Sumatra region and carry out exploratory studies to identify potential demand centres/ power supply sources/ location etc.
- Engage with the government/ministries for developing supportive policies.

Morocco (Plan for 20 MW)

- Two Electrolyzer technologies will be deployed i.e.10 MW Alkaline (AWE) and 10 MW Polymer (PEM)
- RE source (Wind Solar Hybrid) to power
- Ammonia production target – ~30 tonnes per day or ~10,000 tonnes per annum.

**India (Plan for 10 MW pilot)**

- Develop 10 MW pilot with a fertilizer/petrochemical industry
- Leverage the experience of public sector companies and develop a demonstration project to understand key financial viability, operational aspects etc.

**Engagements with key governments (Korea, Indonesia, Morocco, India), and partnerships with public and private sector companies like KOGAS, Fortescue Future Industries etc…**

# Thank You

**Nishant.Bhardwaj@gggi.org**

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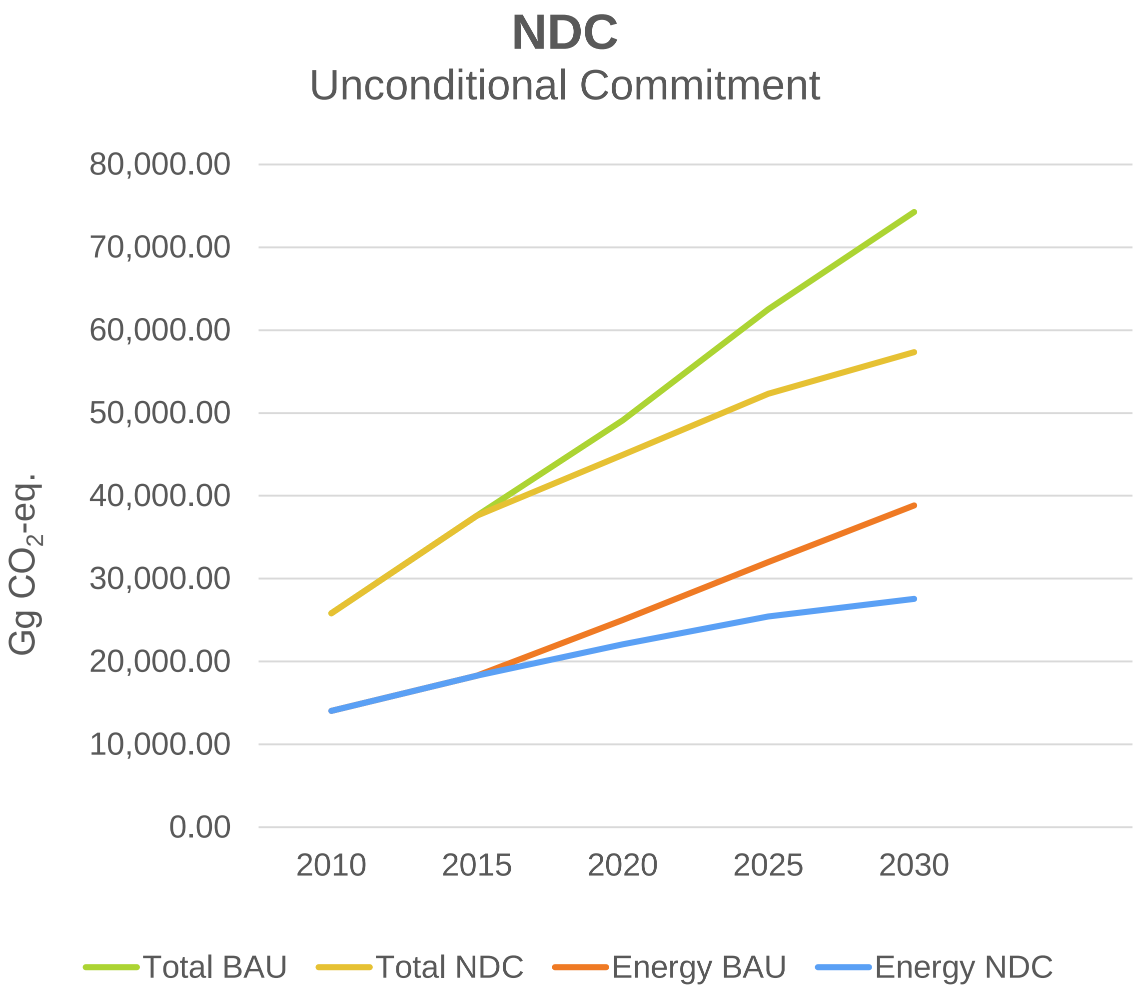
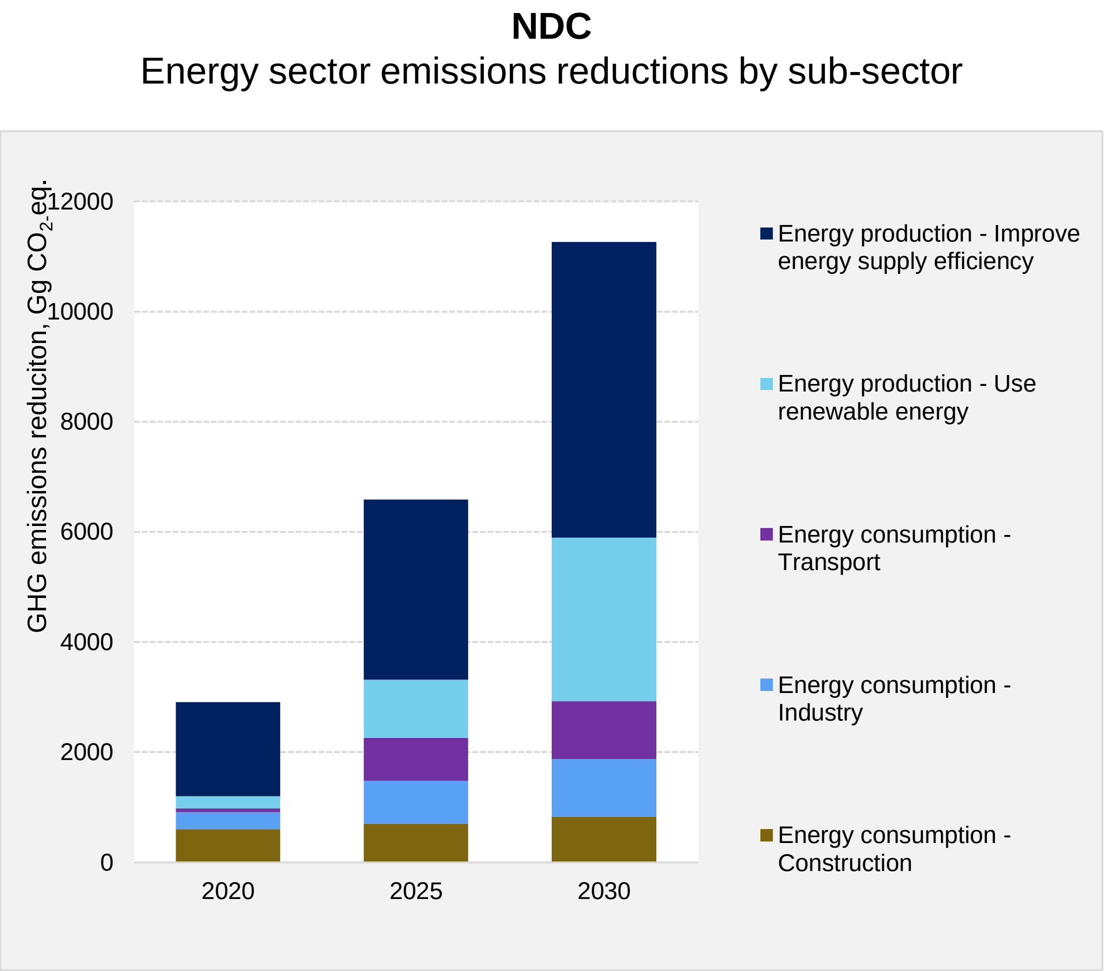
# Climate & Energy in Mongolia




*Source: Final NDC 2019*