

# Experiences of Transition to Green Hydrogen Economy in Europe and East Asia: Lessons for South Asia

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- Global Hydrogen Potential
- Hydrogen Potential in Europe and East Asia
- Hydrogen Strategy in Europe and East Asia
- Barriers to Green Hydrogen Development in South Asia
- Drivers of Hydrogen Economy in South Asia
- Policies to Leverage Green Hydrogen Economy in South Asia

# Introduction

- Hydrogen economy targets generation of green hydrogen from
  - renewable energy by replacing fossil fuels energy in
    - transport, industry, residential, and commercial sectors
- Hydrogen economy potentially create substantial advantages to
  - global environment, energy security, food security, economic sustainability, and final consumers in hydrogen value chain
- Transition to hydrogen economy
  - receiving increasing attention in recent years
- Novel plans and policies being operationalized to invite
  - substantial investment in hydrogen production and
  - technologies by public agencies and private players

# Introduction

- Recent initiatives for advancement of a hydrogen economy
  - certainly play a role to achieve low-carbon economy
- Green hydrogen can be a potential path to reach
  - a cent per cent use of renewable energy resources and
    - thus a hydrogen economy
- There has been an agreement on substantial potential of green hydrogen
  - to reach zero-carbon emissions in
    - industrial use, clean mobility, and other possible uses
- However, techno-economic viability necessary for
  - reaching green hydrogen pathways

# Introduction

- In recent past, governments worldwide to invest substantially in
  - development of hydrogen economy
- For instance, EU targets to attain
  - a status of hydrogen economy by 2050
    - expects to achieve more than one-third of automobiles
      - to be run by zero-carbon hydrogen by 2040
- In East Asia, Japan espouse its basic hydrogen strategy
  - to become a hydrogen society
    - through application of cost-efficient technologies across different economic sectors
- Similarly, ROK envisages intrepid goals for hydrogen application
  - in 30% of aggregate energy use by 2040
- Likewise, the PRC also targets to become a key player in hydrogen production and consumption in near future
- Against this backdrop, this paper intends to analyze the experiences of the Europe and East Asia in transition to green hydrogen economy and draws lessons for South Asia.

# Review of Literature

Author(s)	Studies on green hydrogen generation technologies
IEA, 2020a; Ishaq & Dincer, 2019	Green hydrogen generated from diverse energy resources with differential cost & carbon emissions
IEA, 2020a; Mueller-Langer et al., 2007; Schmidt et al., 2017	Alkaline electrolyser technically robust but not cost-efficient
Gautier et al., 2017	Pyrolysis relatively cost-effective
IEA, 2019a; IRENA, 2020a; Glenk & Reichelstein, 2019	Fall in prices of renewable energy and cost-effectiveness of electrolysis
El-Emam & Özcan, 2019	Fossil fuels based hydrogen generation highly cost-effective but carbon-intensive
Mohammadi & Mehrpooya, 2018	Renewable energy based low carbon hydrogen

# Review of Literature

Author(s)	Studies on hydrogen value chain
Timmerberg & Kaltschmitt, 2019	Low-cost hydrogen mobility infrastructure
IEA, 2019b	Efficient transport and storage infrastructure
Kojima, 2019	Ammonia as hydrogen mover
Abánades et al., 2013	Liquid hydrogen for transportation and storage
IEA, 2019a	Lack of pipeline network for hydrogen mobility
Mizuno et al., 2016; Reuß et al., 2017	Need for cost-effective hydrogen movers

# Review of Literature

Author(s)	Studies on hydrogen application
IEA, 2020b and 2020c	Road transport
Ayvalı et al., 2021	Maritime & aviation transport
World Bank Group, 2020	Meeting seasonal energy shortage
CCC, 2018	Heating needs of residential apartments
IEA, 2019a	Industry



# Review of Literature

- Thus, techno-economic and market development issues linked to hydrogen production and value chain widely studied
- The ultimate goal must be transition from production of low carbon hydrogen to zero-carbon hydrogen
  - which can be influenced by availability and use of renewable energy and their cost competitiveness in production of green hydrogen
- Use of renewable energy for production of green hydrogen is likely to involve increasing costs in Europe and dependence on hydrogen trade in East Asia
- International collaboration is essential for hydrogen trade
  - which need robust hydrogen strategies
- Compared to the existing literature, this paper intends
  - to analyze the experiences of the Europe and East Asia in transition to green hydrogen economy and draws lessons for South Asia

# Objectives and Methodology

## **Main objectives**

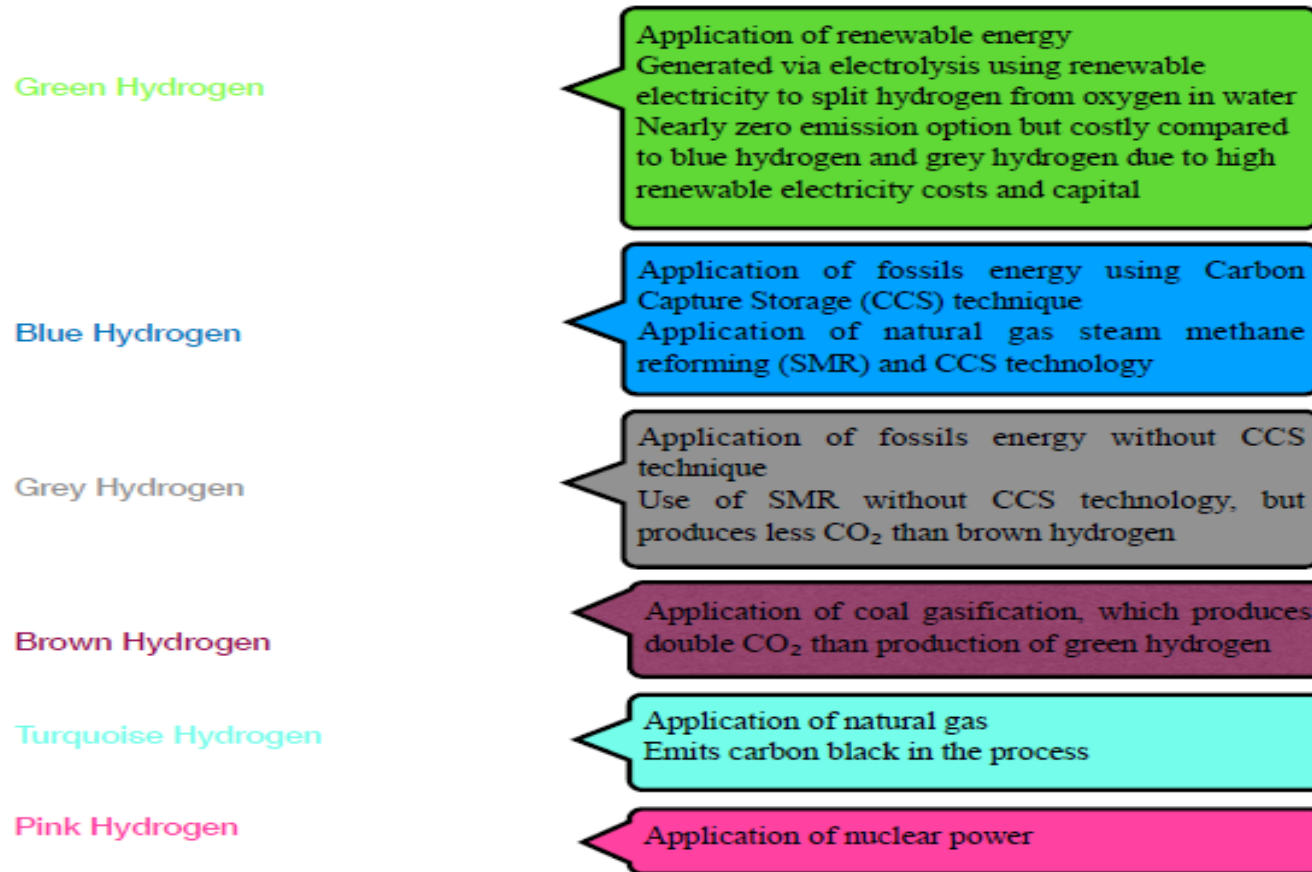
- To analyze the experiences of Europe and East Asia in transition to green hydrogen economy, and
- To draw lessons for South Asia

## **Methodology**

- Desk approach research
  - reviewed relevant extant literature and scientific reports of various national and international organizations
- Review of grey literature and scientific studies
  - helped identifying the problem statement
  - find out the research gaps
  - develop the goals and hydrogen taxonomy and value chain

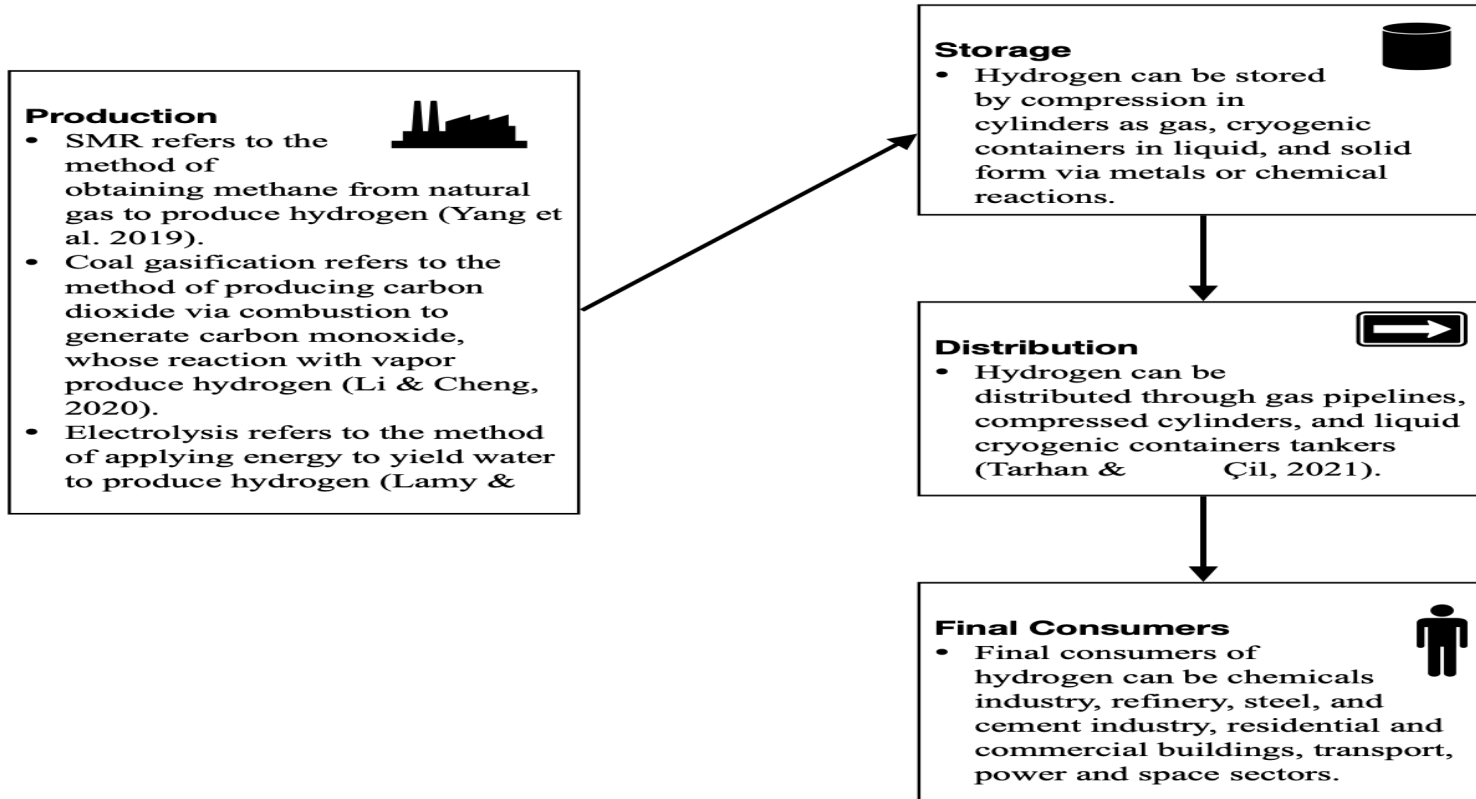
# Hydrogen Taxonomy

Figure 1: Hydrogen taxonomy



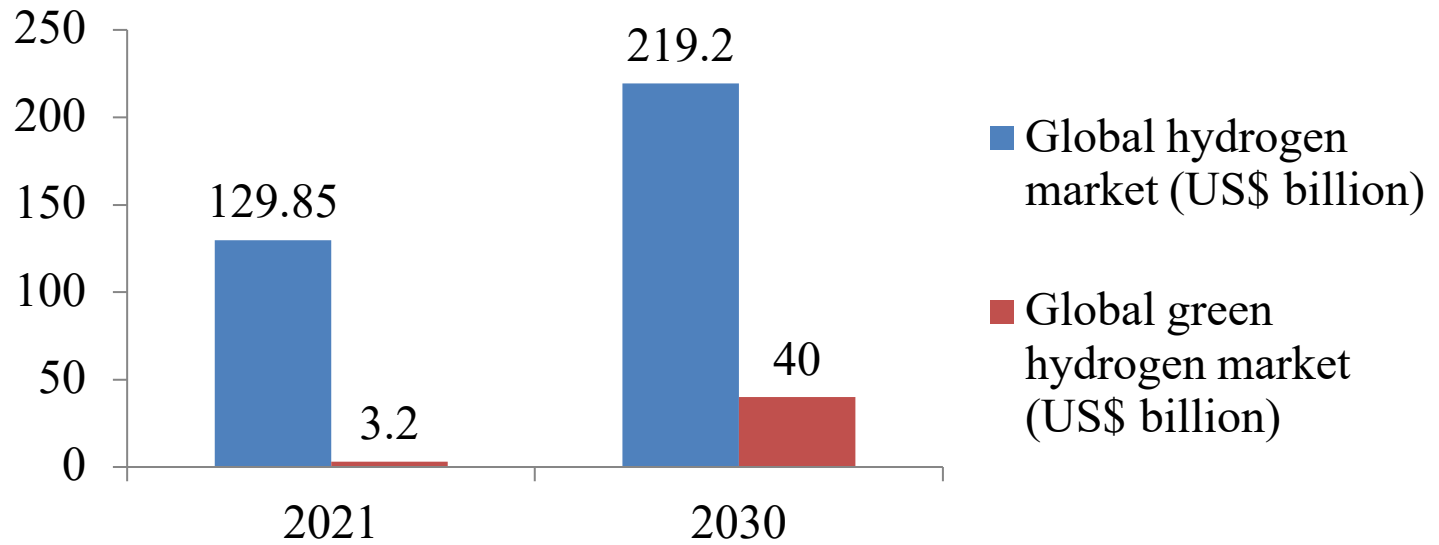
# Hydrogen Supply Chain

Figure 2: Hydrogen supply chain



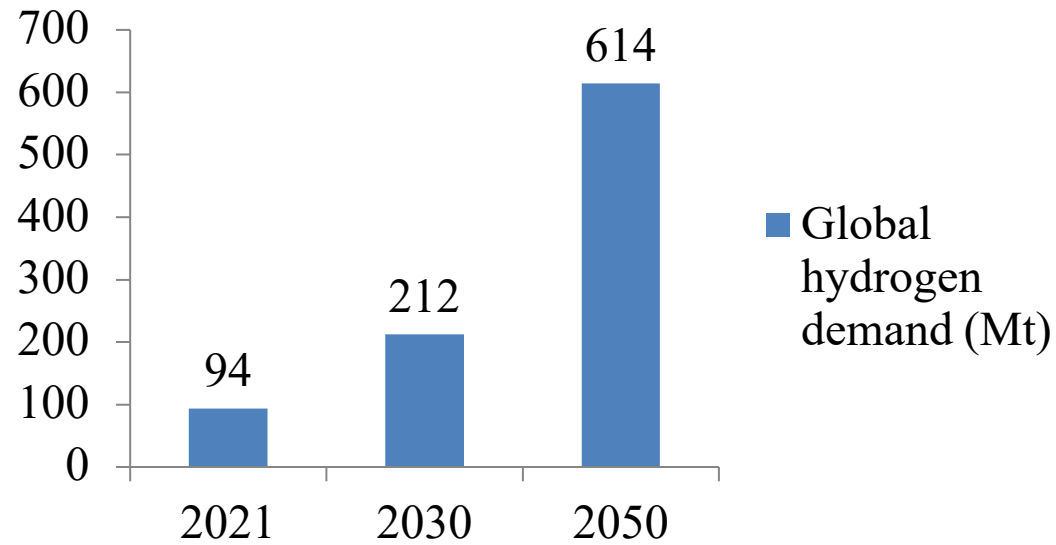
# Global Hydrogen Potential

Figure 3: Global hydrogen market size in 2021 and 2030 (US\$ billion)



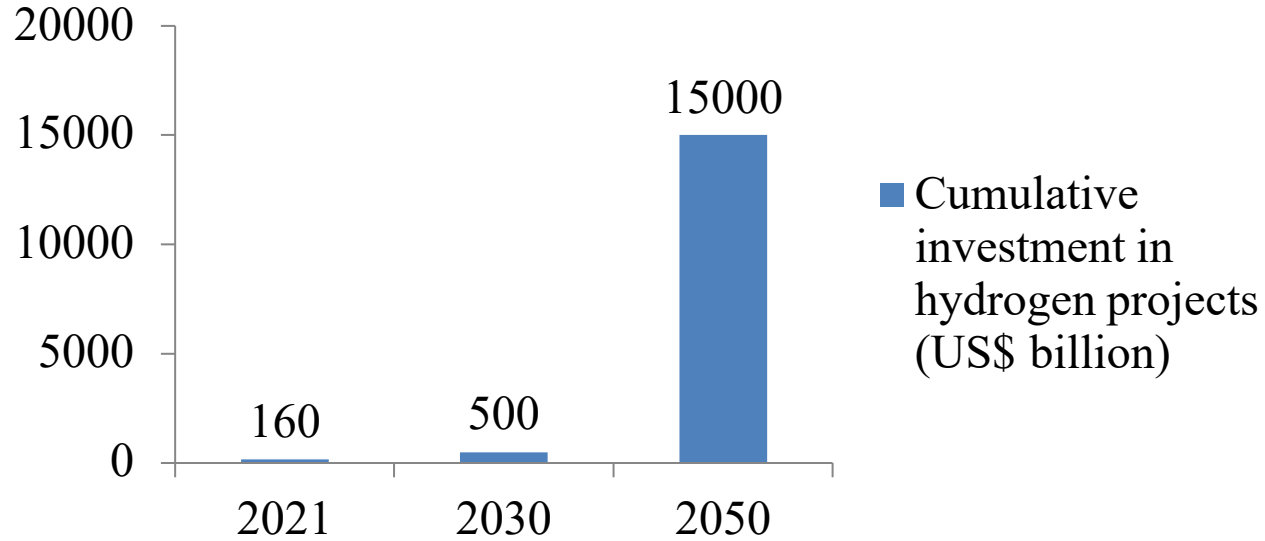
# Global Hydrogen Potential

Figure 4: Global hydrogen demand in 2021, 2030 and 2050 (Mt)



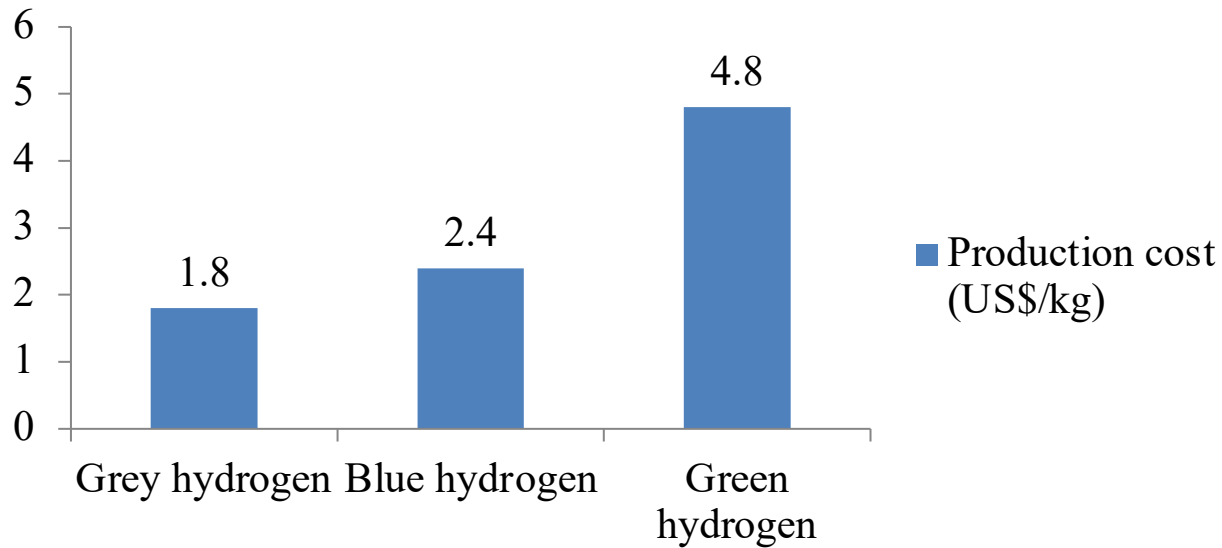
# Global Hydrogen Potential

Figure 5: Cumulative investment in hydrogen projects, 2021, 2030 and 2050  
(US\$ billion)



# Hydrogen Potential in Europe and East Asia

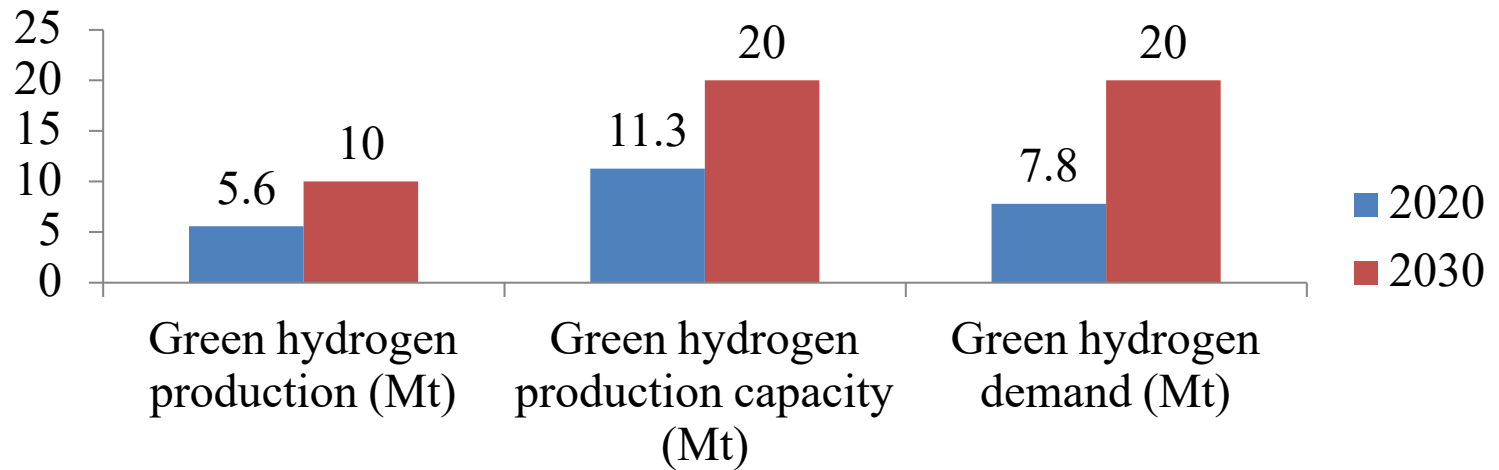
Figure 6: Production Cost of Hydrogen (US\$/kg)





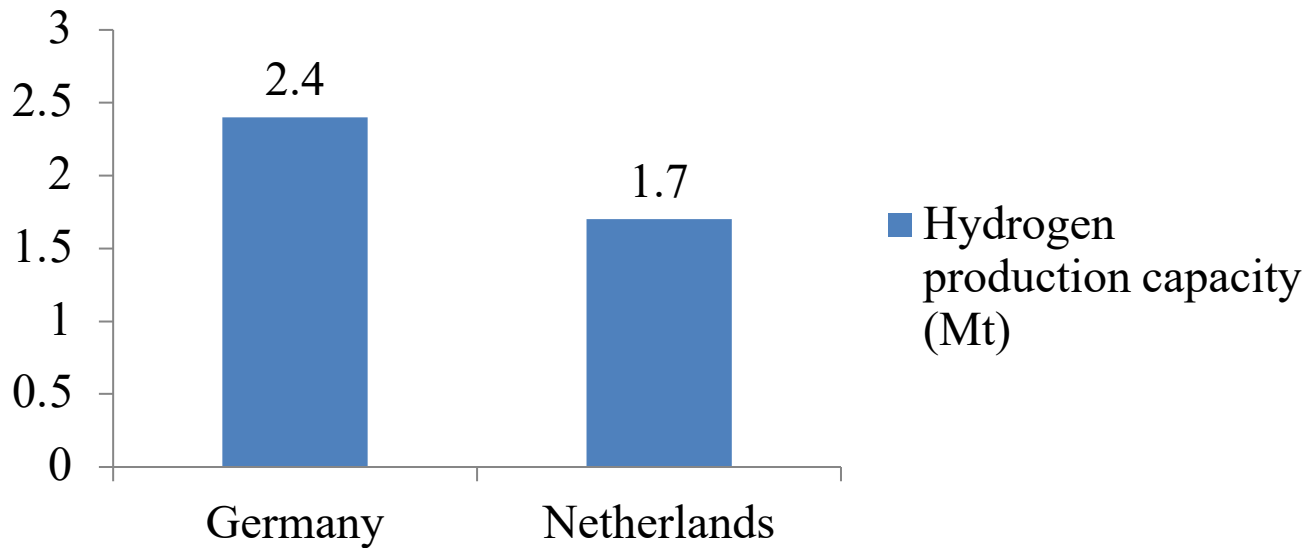
# Hydrogen Potential in Europe and East Asia

Figure 7: Green hydrogen production, production capacity and demand in Europe, 2020 and 2030 (Mt)



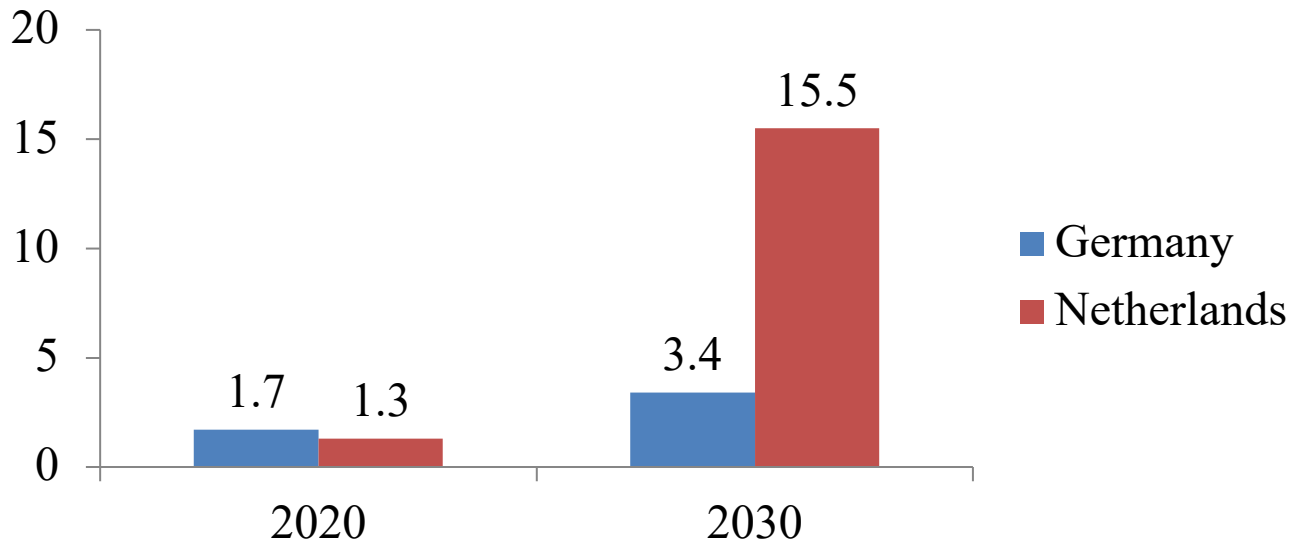
# Hydrogen Potential in Europe and East Asia

Figure 8: Hydrogen production capacity in Germany and Netherlands in 2020 (Mt)



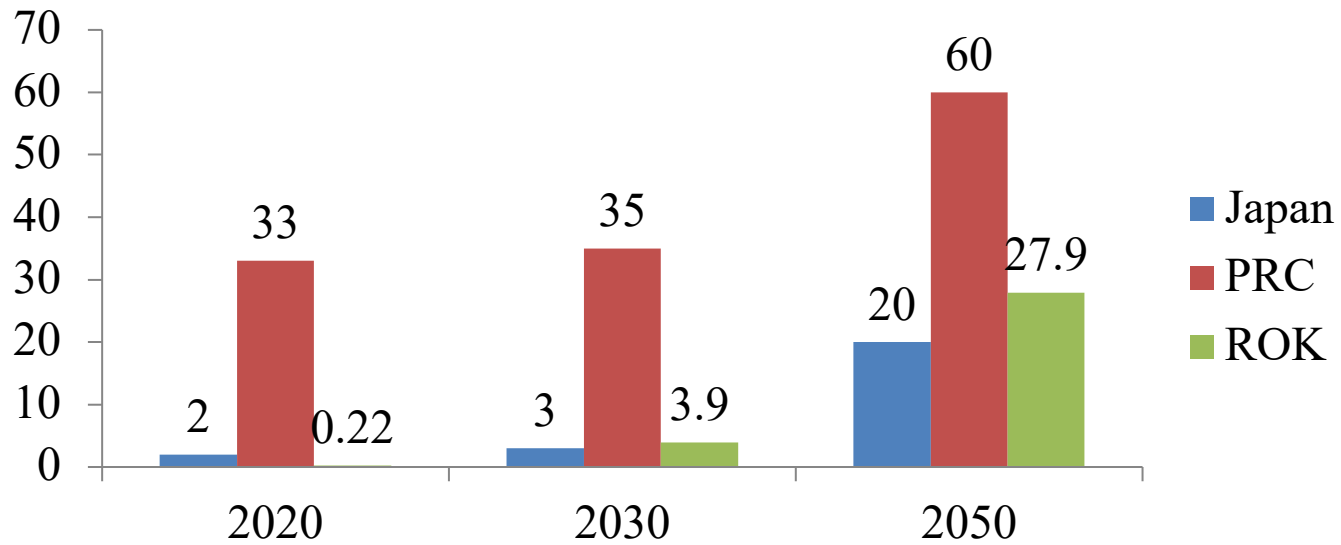
# Hydrogen Potential in Europe and East Asia

Figure 9: Hydrogen production in Germany and Netherlands, 2020 and 2030 (Mt)



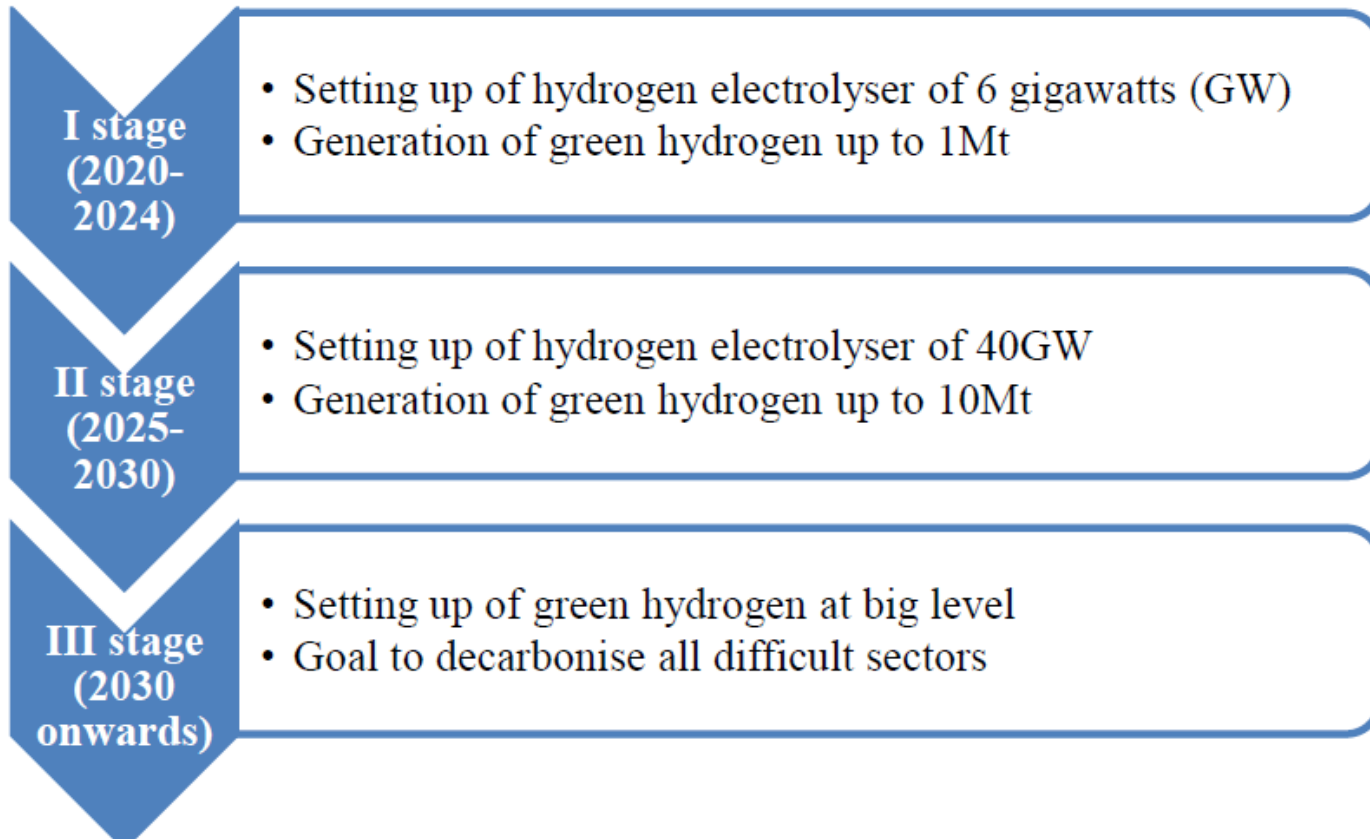
# Hydrogen Potential in Europe and East Asia

Figure 10: Hydrogen production potential in Japan, PRC and ROK (Mt)



# Hydrogen Strategy in Europe and East Asia

Figure 11: EU hydrogen strategy and transition stages



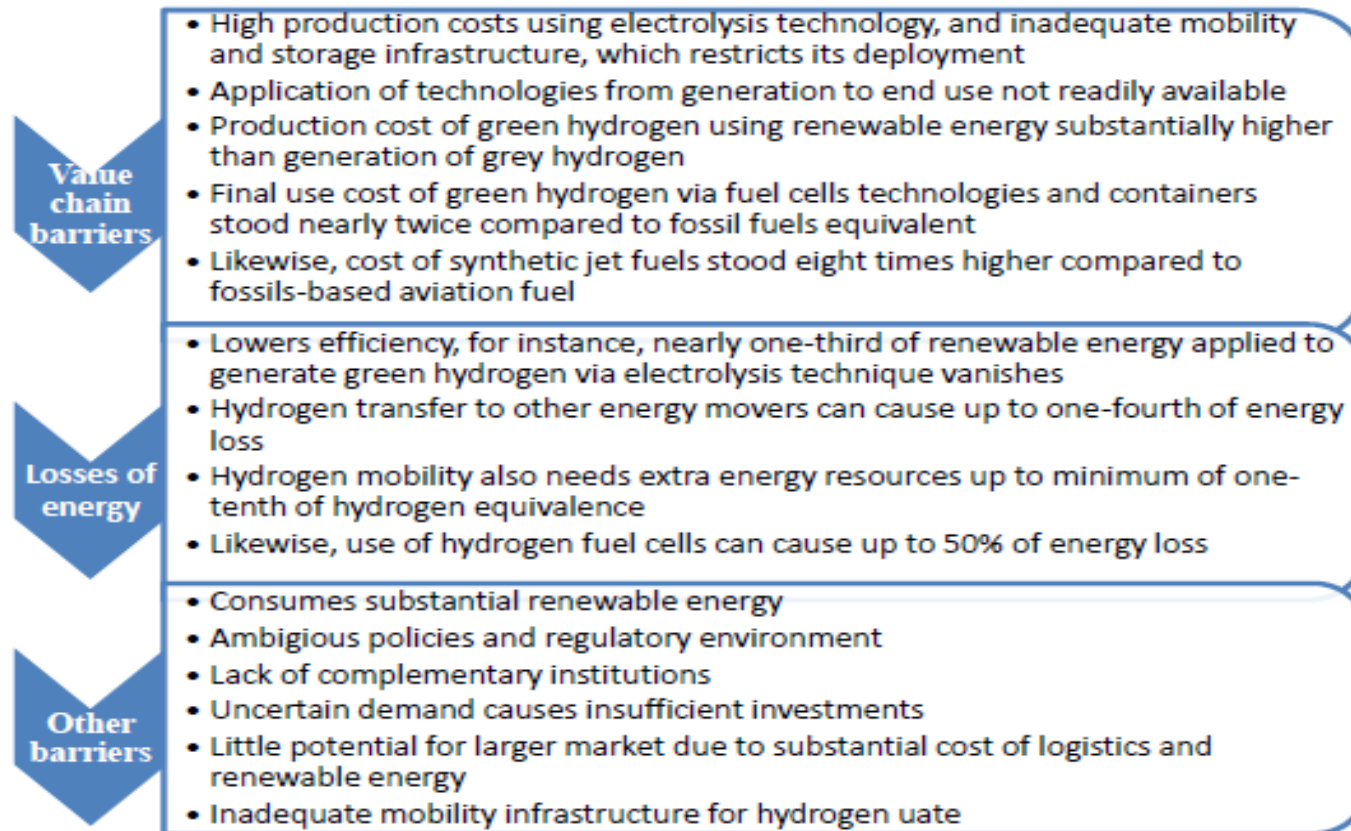
# Hydrogen Strategy in Europe and East Asia

Figure 12: Hydrogen strategy of Japan, the ROK and the PRC



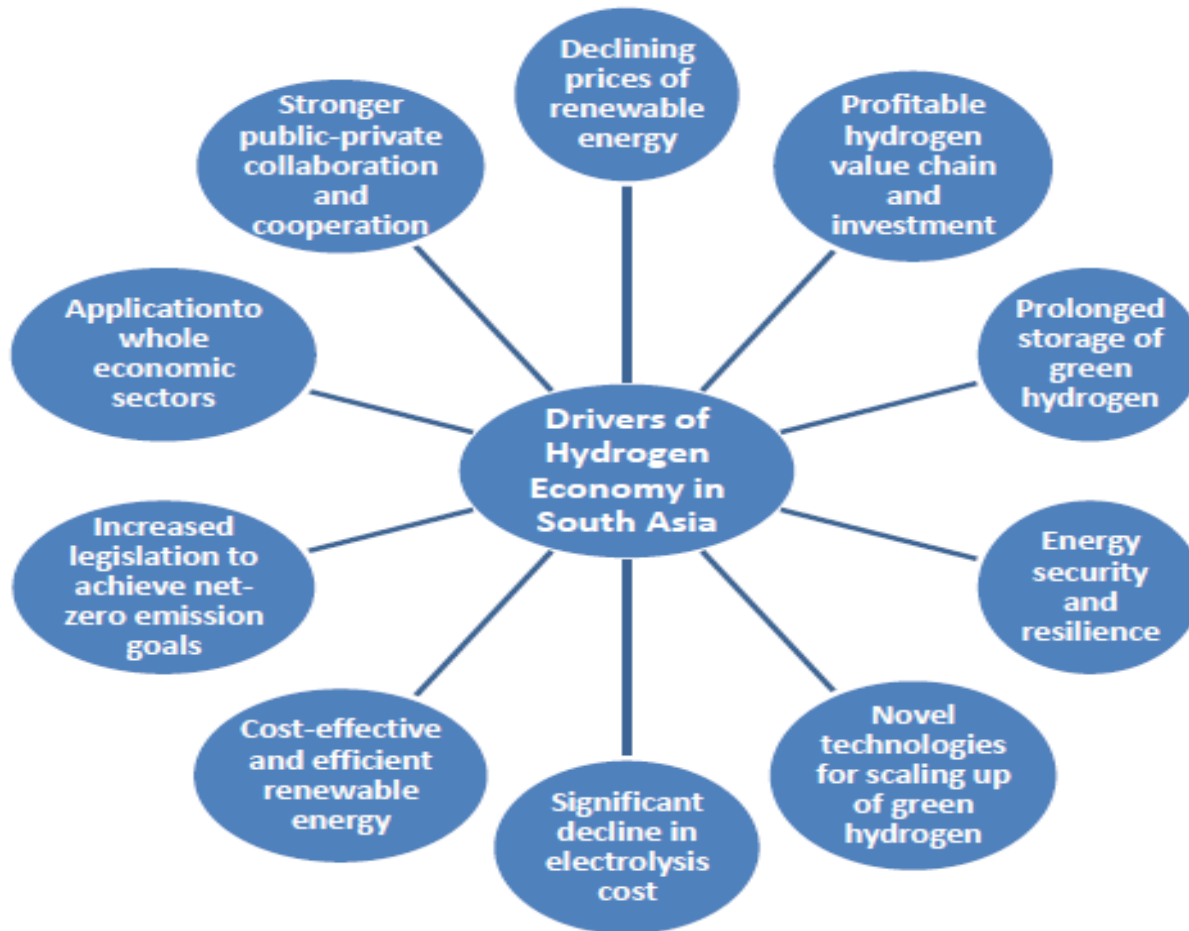
# Barriers to Green Hydrogen Development in South Asia

Figure 13: Barriers to green hydrogen development in South Asia



# Drivers of Hydrogen Economy in South Asia

Figure 14: Drivers of hydrogen economy in South Asia





# Policies to Leverage Green Hydrogen Economy in South Asia

- In 2021, India announced its National Hydrogen Mission focusing on
  - both short-term (4-10 years) and
  - long-term (above 10 years) plans for hydrogen economy
- National Hydrogen Mission aims to
  - promote green hydrogen economy
  - develop renewable energy to improve hydrogen storage
  - boost hydrogen supply to
    - meet industrial energy needs
    - lower fossil fuels dependency and
    - meet energy requirements of mobility sector

# Policies to Leverage Green Hydrogen Economy in South Asia

- India aspires to become a global centre of
  - hydrogen production and
  - novel hydrogen technologies
- India also targets to
  - boost hydrogen demand and application in
    - refineries and fertilizers and steel industry
- R&D has also been promoted in
  - hydrogen value chain
- However, substantial hydrogen production requires
  - greater application of renewable energy
    - to achieve emission reduction goals
      - which require suitable policy support mechanisms

# Policies to Leverage Green Hydrogen Economy in South Asia

- Experiences of the European and East Asian countries and their strategies can be
  - significant for transition to green hydrogen economy in South Asia
- Policies to support transition to green hydrogen economy in South Asia can be broadly grouped into two parts
  - first, supporting fossil fuel producers during initial transition phase and
  - second, developing novel institutions, regulations and regional collaboration centered on development and application of novel technologies including market diffusion and expansion in second phase and subsequent phases

# Policies to Leverage Green Hydrogen Economy in South Asia

- **Aiding fossil fuel producers**
- Transition to green hydrogen aids
  - fossils-based energy exporters to switch to net-zero emissions using
    - existing infrastructure, talented manpower, and trade linkages
- Novel technologies have been developed speedily to provide net-zero emissions in
  - cost-effective pathways to achieve hydrogen economy
- Some economies have developed numerous innovations in recent years
  - which can be replicated in South Asian countries

# Policies to Leverage Green Hydrogen Economy in South Asia

- **Aiding fossil fuel producers**
- Transition to clean hydrogen economy
  - potentially change the outlook of energy trade
    - novel technologies for green hydrogen generation
      - decline of trade in fossils-based energy
- Ports in industrial zones to be leveraged
  - increase hydrogen trade
    - boost green hydrogen value chain along transport corridors
- Transition to hydrogen economy
  - reorient potential trade relations along maritime routes

# Policies to Leverage Green Hydrogen Economy in South Asia

- **Policies to support transition to hydrogen economy**
- Switching to hydrogen economy
  - novel institutions, regulations and international cooperation
- Need to establish global green hydrogen standard
  - ensure supply chain sustainability
- Development of hydrogen trade links can promote
  - regional cooperation for acquisition of novel technology, skills, and finance to
    - develop hydrogen value chains
    - develop industries and
    - generate employment in renewable energy sector

# Policies to Leverage Green Hydrogen Economy in South Asia

- **Policies to support transition to hydrogen economy**
- Policy support necessary to leverage green hydrogen economy
  - novel technologies adoption and
  - market diffusion and expansion
- Public and private funding including public-private collaboration
  - bridge the investment gaps and reduce capital cost
  - ensure techno-economic feasibility and
  - sustainability along hydrogen value chain in South Asia

# Policies to Leverage Green Hydrogen Economy in South Asia

- **Policies to support transition to hydrogen economy**
- Market diffusion of novel technologies can help
  - reap economies of scale
  - lower costs and
  - increase profitability of green hydrogen production and its commercialization
- Hydrogen corridors should be bolstered in the South Asian countries
  - blessed with low-cost renewable energy and
  - developing industrial clusters near ports and end users
- Existing natural gas pipeline infrastructure should be tapped for development of hydrogen trade
- Market expansion is needed to
  - utilize the full capability of the hydrogen value chain



# Policies to Leverage Green Hydrogen Economy in South Asia

- **Policies to support transition to hydrogen economy**
- Private players should complement public agencies to
  - leverage green hydrogen economy for reaching net-zero emissions in South Asia in near future
- Private and institutional investors should be given lasting public assurance to
  - attract their dedication towards long-term allegiance for transition to hydrogen economy
- Regional collaboration and cooperation should be bolstered to
  - leverage R&D in novel technologies and
  - develop compatible infrastructure to reduce cost for robust hydrogen value chain and ensure energy security
- Regional collaboration and cooperation is also needed to
  - institute strong safety and standards

# Policies to Leverage Green Hydrogen Economy in South Asia

- **Policies to support transition to hydrogen economy**
- Need to collate hydrogen data and information in energy databases in South Asia
  - which can cover all phases of hydrogen value chain
- This can cover data and information on
  - hydrogen flows
  - hydrogen demand
  - costs, prices, and trade
- Regional cooperation is necessary to
  - develop sound methodology and guarantee shared knowledge and application
- Regional collaboration and cooperation in hydrogen research and innovation is essential
  - to find out technological gaps
- Public-private collaboration in developing novel technologies is not over-emphasized
  - to develop robust hydrogen value chain and
  - transit to sustainable hydrogen economy

**Thank  
You**

