Decarbonization goals may look similar, but pathways vary

What can we learn from Asia?

Bobby Noble
Program Manager, Gas Turbine R&D

11th International Gas Turbine Conference
October 11, 2023

Leading Collaborative Energy R&D Around the World

EPRI advances energy technologies and informs decision-making through ~$450M in collaborative annual research involving nearly 400 entities in ~40 countries - spanning the generation, delivery, and use of electricity.

ENGAGING

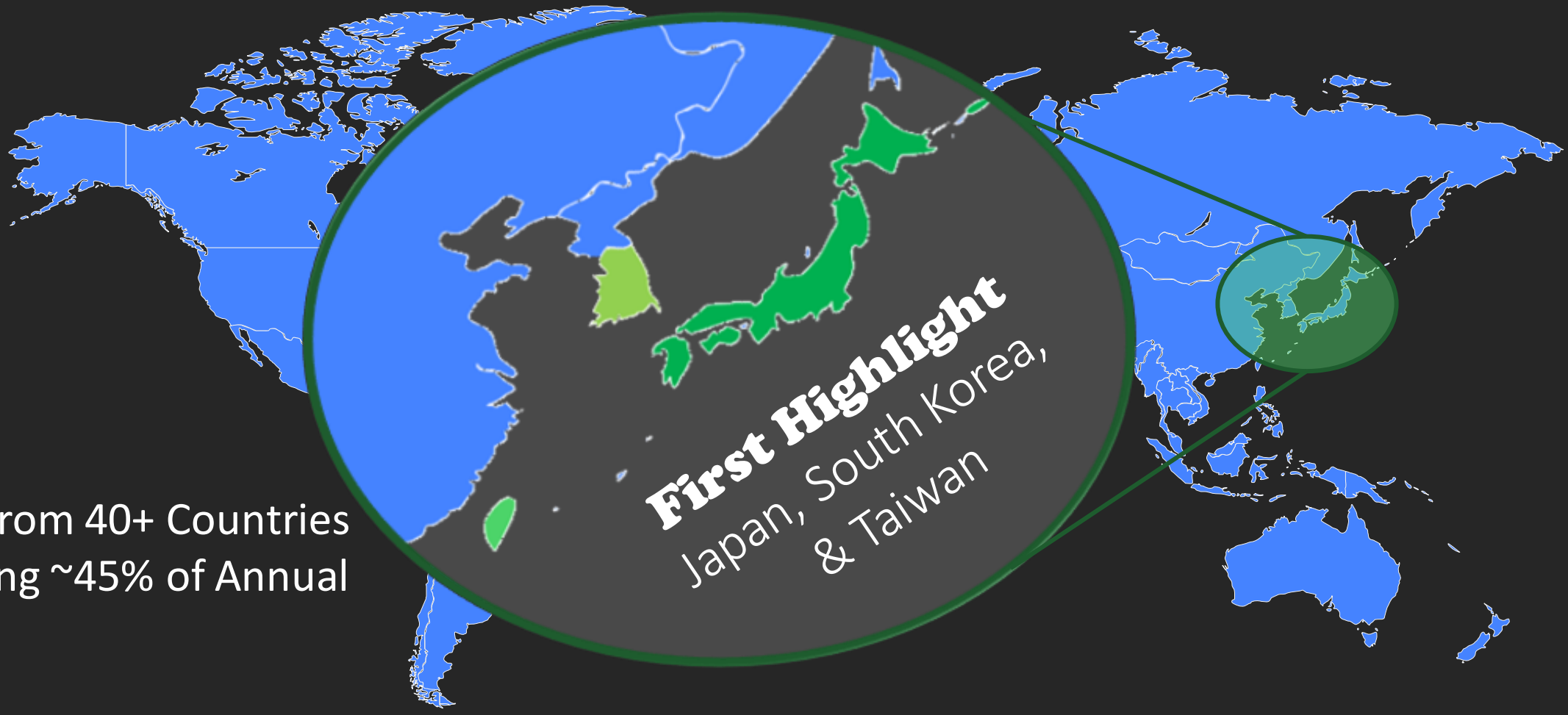
- Utilities
- Academia
- OEMs
- Regulators
- Financial Community
- Policy Makers
- Consumer Advocates
- Media

Together…Shaping the Future of Energy

A Perfect Storm

This Decade Represents a Perfect Storm of Challenges and Opportunities.

EPRI Global Partners



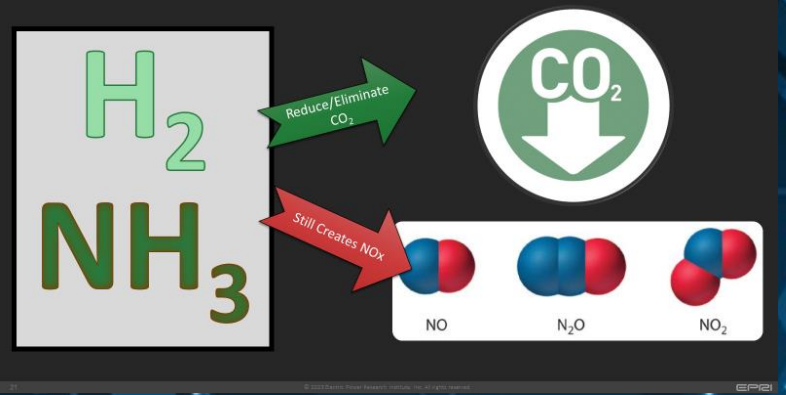
Members from 40+ Countries
Representing ~45% of Annual Funding

Specifically for Gas Turbines
~25% of Funding from Asia

Decarbonization Plans

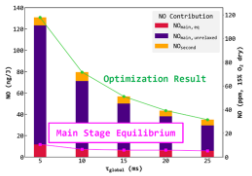
Focus on Renewables & Low-Carbon Fuels

Focus on Low-NOx Technology Development



Ammonia Fuel: NOx Considerations (2023 Turbo Expo Paper)

- Ammonia also a promising carbon-free fuel
- NOx emissions a key challenge
- Calculations suggest viable emissions with RQL-style combustor
  - Rich main stage with low equilibrium NOx
  - Lean secondary stage for ammonia burnout
- Georgia Tech/EPRI/GTI to conduct NH_3 combustor design/experiments
- Emissions reporting nuances with NH_3
  - Just like with H_2
- What about H_2/NH_3 blends?

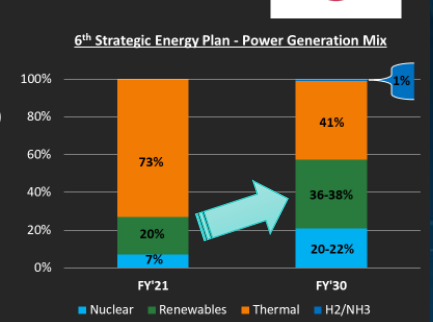


Minimum NO at various global residence times for
TIT = 1900 K
P = 10 bar

EPRI, Georgia Tech, KEPCO/KEPRI, TEPCO/JERA, & TPC/TPRI Partnering to Explore Low-NOx Options for NH_3

Japan Decarbonization Targets

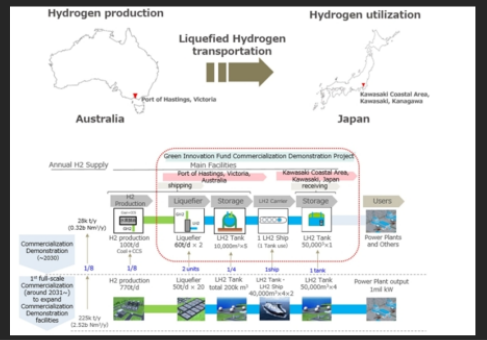
- **The Japanese government targets to reduce GHG emissions by 46% relative to '13 in '30 and achieve carbon neutrality in '50.**
- **METI (Ministry of Energy, Industry and Trade) published 6th Strategic Energy Plan**
  - Renewables and Nuclear to grow and supply 56% - 60% of electricity in '30.
  - H_2 (30%v) and NH_3 (20%v) to be blended in gas turbine and boiler respectively and generate 1% of electricity in '30.



Where will low-carbon fuels be sourced?

Demonstration Projects – Hydrogen Supply Chain

Large scale clean liquefied hydrogen supply chain project ('21- '30) funded by GI (JPY 220B/USD 1.6B)



Goal: Build and commercialize 225,000t/year of carbon free hydrogen supply chain from Australia to Japan in '30 with target price of JPY30/Nm3

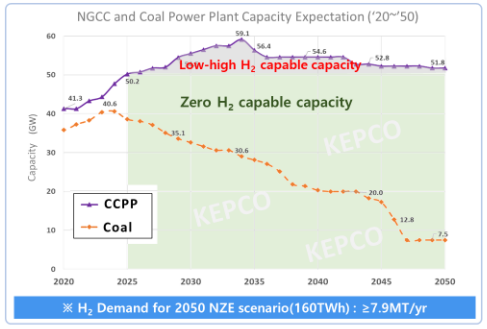
Project Scope:
- Hydrogen Production: 770t/d
- Liquefaction: 50t/d x 20 units
- LH2 carrier: 40,000m3 x 4 tanks x 2 ships
- Storage: 50,000m3 x 4 tanks

Source: NEDO

Energy Policy for Net Zero

2022 Fall EPRI Advisory Meeting

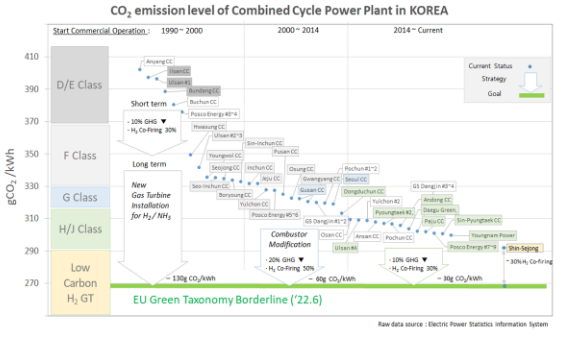
❖ **Responsibility of clean gas turbine in KOREA**



Energy Policy for Net Zero

2022 Fall EPRI Advisory Meeting

❖ **How to accomplish the CO_2 reduction**



General Trends:

Reduce Coal
Maintain/Increase GTs
Use Low-Carbon Fuels
Increase Renewables

Regional Top Research & Demonstrations Priorities

- **Ammonia: transitional low carbon fuel and hydrogen carrier**
  - Ammonia co-firing in boiler and gas turbine
  - Ammonia cracking technology (as a hydrogen carrier)

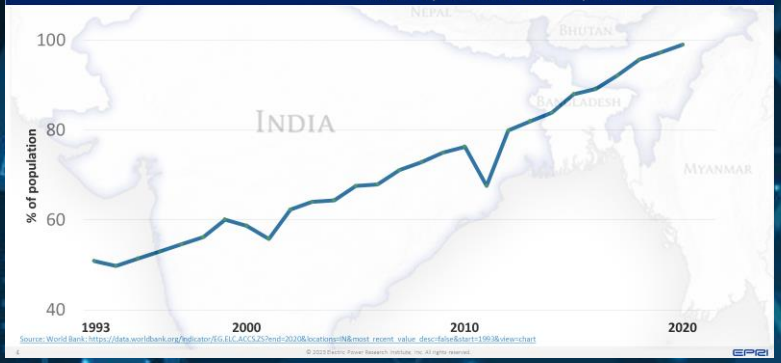
- **Hydrogen Supply Chain: dependency on imported hydrogen**
  - Hydrogen liquefaction technology with high efficiency
  - Large scale liquefied hydrogen carrier & storage tank

Source: KHI

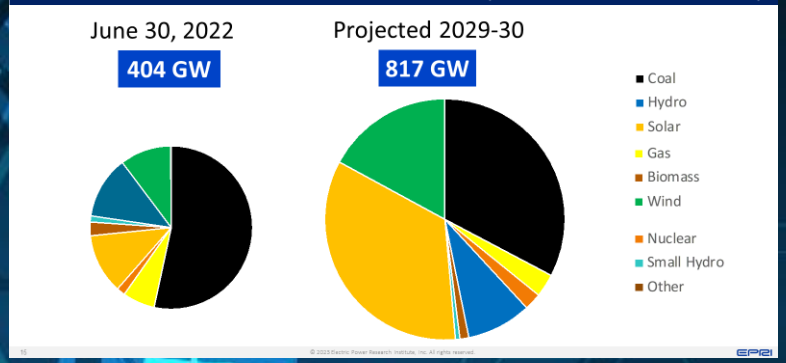
Decarbonization Plans

Focus on Renewables & Carbon Capture

Access to Electricity Growing
Nearly doubled in past 3 decades

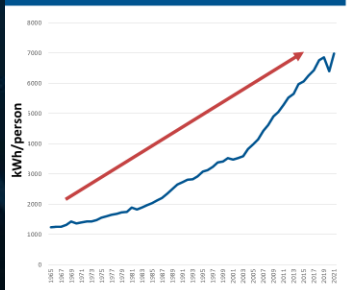


Response to Climate Change
pivotal them for country

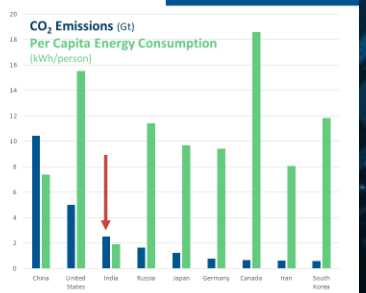


3rd-largest Global CO_2 Emitter
low per capita energy consumption

PRIMARY ENERGY CONSUMPTION



A GLOBAL VIEW



Goals and Commitments
through 2070

500 GW by 2030	45% by 2030	50% by 2030	Net-zero by 2070
Non-fossil energy capacity	*Economy-wide carbon intensity*	*Renewable energy*	*Economy-wide emissions*

- Flexible, conventional steam generators play a key role in ensuring grid stability

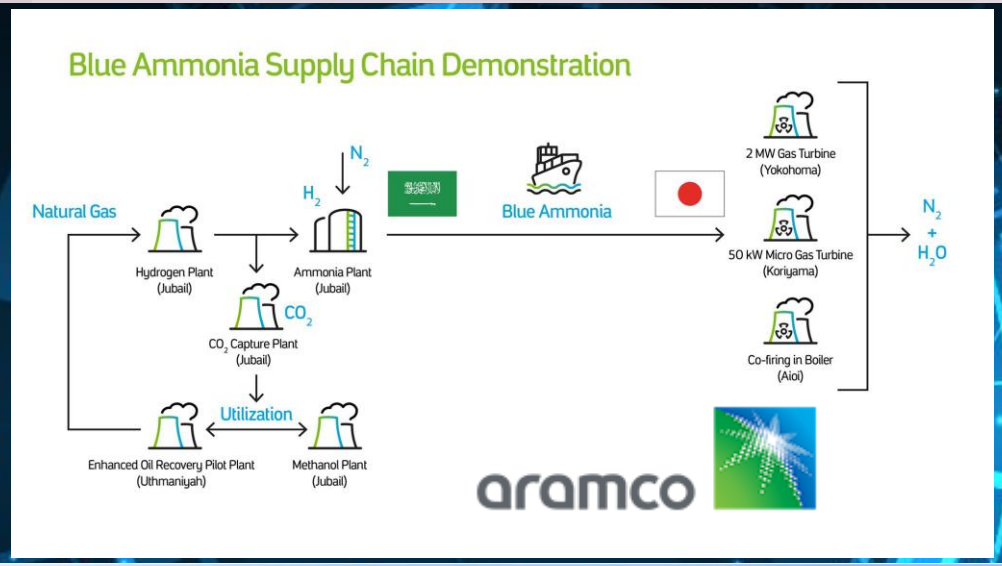
General Trends:

- **Carbon Capture**
- **Increase Renewables**

Possible Low-Carbon Fuels

Decarbonization Plans

Focus on Renewables & Producing Low-Carbon Fuels



مؤسسة الإمارات للطاقة النووية
Emirates Nuclear Energy Corporation

General Trends:

- **Producing/Exporting Low-Carbon Fuels**
- **Increase Renewables**

Examining Carbon Capture
Examining Nuclear