Centre for Energy Regulation
Department of Industrial and Management Engineering
Indian Institute of Technology Kanpur- 208016

Capacity Building Programme for Officers of CERC & JERCs
“Regulatory Perspectives on Network, Renewable Energy and Market Development”

Prospects for Green Energy Market and Green Hydrogen policy in India

04 Feb 2023

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ReNew Power
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Contents

• India – Changing fuel mix
• Electricity Transaction breakup
• Power Exchange Products
• Green Energy Market in India
• RE based RTC product – Load Following (Long term PPA)
• Power Exchange price discovery Curves
• Market Surveillance mechanism
  • CAISO market – Market Surveillance mechanism
• Independent System & Market Operator
  • CAISO example
• Green Hydrogen
India – Changing Fuel Mix

Source: CEA, IEX

- Total Installed Capacity: ~370 GW
- 2020:
  - Thermal: 62%
  - Hydro: 12%
  - Solar: 9%
  - Wind: 10%
  - Nuclear: 2%
  - Bio-Power: 3%
- Dec 2022:
  - Thermal: 236
  - Renewable: 121
  - Hydro: 47
  - Nuclear: 7
- 2030:
  - Thermal: 35%
  - Solar: 36%
  - Wind: 17%
  - Nuclear: 8%
  - Bio-Power: 1%
  - Small Hydro: 1%

Source: CEA, IEX
## India – How Electricity is transacted (FY ‘21)

<table>
<thead>
<tr>
<th>Long-term (90%)</th>
<th>Short-term (10%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1,381 BU (incl REN)</strong>*</td>
<td></td>
</tr>
<tr>
<td>Up to 25 years</td>
<td>Bilateral: Less than 1 year</td>
</tr>
<tr>
<td>1,244 BU</td>
<td>58 BU</td>
</tr>
<tr>
<td>90.0%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

- **Long-term PPA**
- **Bilateral & Banking Transactions**
- **Exchanges** (Only up to 11 days)
  - DAC
  - Daily
  - Weekly
  - Day Ahead Market
  - Real Time Market
- **Deviation Settlement/Unscheduled Interchange**

*Source: IEX, CERC*
# Power Exchange Products

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Day-Ahead Market**             | ➢ Delivery for next day; Includes cross border trade launched on 21st April 2021  
                                 ➢ Price discovery: Closed, Double-sided Auction                            |
| **Term-Ahead Contracts**         | ➢ For delivery up to 11 days                                               
                                 ➢ Intra-day, Day-ahead Contingency, Daily Contracts, Weekly Contracts      |
| **Real-Time Market**             | ➢ Delivery in an hour                                                       
                                 ➢ Price discovery: Closed, Double-sided Auction                            |
| **Green Market**                 | ➢ GTAM - Intra-day, DAC, Daily and Weekly                                   
                                 ➢ GDAM - Green Power Delivery for next day                                 |
| **Renewable Energy Certificates**| ➢ Green Attributes as Certificates:                                        
                                 ➢ Sellers: RE generators not under feed in tariffs                         
                                 ➢ Buyers: Obligated entities; 1MWh equivalent to 1 REC                     |
| **Energy Saving Certificates**   | ➢ 1 ESCert = 1 Mtoe (Metric Tonne Oil Equivalent)                           
                                 ➢ Trading session every Tuesday | Trading time 13:00 hrs. to 15:00 hrs.                                      |
# DAM vs RTM

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Details/Function</th>
<th>Day/Term Ahead Market (DAM/TAM)</th>
<th>Real Time Market (RTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Trading Period</td>
<td>Previous Day from 10:00 to 12:00 Hrs. (1 Session only)</td>
<td>Every Alternate 15 Minutes (48 RTM sessions)</td>
</tr>
<tr>
<td>2</td>
<td>Delivery Time</td>
<td>Next day (After 12 Hrs from Bid Closure)</td>
<td>Same day (After 1 Hour from Bid Closure)</td>
</tr>
<tr>
<td>3</td>
<td>Contingency Feed</td>
<td>Not for Contingency requirement</td>
<td>Always available as a backup Source during Emergency</td>
</tr>
<tr>
<td>3</td>
<td>Bid approach</td>
<td>- Bid Planning required one day in advance</td>
<td>Based on Real time scenario (More accuracy can be planned)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Advance planning required</td>
<td>- Captures sudden demand from surplus power/ available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Unable to cover Incidental Risks</td>
<td>- Bid strategy can be changed as per the past session price trends For better economy/Sales realization</td>
</tr>
<tr>
<td>4</td>
<td>URS Power</td>
<td>Least Participation of URS/ Surrendered power (for ISGS)</td>
<td>URS power can be traded in RTM (Beneficiary consent not required)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>URS power comparatively Cheaper than other sources will result into lower Price discovery in RTM</td>
</tr>
<tr>
<td>5</td>
<td>Curtailment</td>
<td>Day Ahead Power will be curtailed prior to RTM</td>
<td>Curtailment Risk very low (DAM Power will be curtailed first, RTM later)</td>
</tr>
<tr>
<td>6</td>
<td>Supply Commitment (during Outage of captive Units)</td>
<td>- No schedule revision possible once bid is clear</td>
<td>Participation in upcoming bid session can be discontinued. (Hence, no bid, no-commitment/DSM/Under Injection penalty)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Heavy DSM Charges in case of Unit Outage</td>
<td>Also Generators may buy power under RTM under tripping/ reduced generation to avoid DSM penalty</td>
</tr>
</tbody>
</table>
Market Maturity Model

Source: IITK workshop
Power Market Growth in India

Source: CERC (www.cercind.gov.in)
Composition of short term power txn in India

Source: CERC (www.cercind.gov.in)
GDAM – Supply is constrained

Source: IEX
Wt. Avg. rates – Sep ‘22

Figure-6: Weighted Average Price of Short-term Transactions of Electricity, September 2022

Note: No electricity was transacted in DAM, G-DAM & RTM of HPX during September 2022.
* Simple average price of DSM of the month
GDAM Snapshot

Last 8 days

03-Feb-2023
GDAM – ACP Comparison

03 Feb 2023

30 June 2022
GDAM – MCV illustrations – Winter & Monsoon

03 Feb 2023

IC: Wind – 41.9 GW; Solar: 63.3 GW
(As on 31.12.22)

24 Aug 2022

IC: Wind – 41.2 GW; Solar: 59.3 GW
(As on 31.08.22)
Monthly MCP Trends (GDAM vs DAM)

Source: IEX
Increased liquidity (GDAM) – Key enablers

- Discom’s procurement beyond RPO compliance
- Increased merchant capacity
- Green Energy Open Access
- New Long term 100% RE construct – Load following
- Market Based Economic Despatch
Load following 100% RE – RTC construct

RE RTC Construct (Load Following)

Multi-location RE sources with diverse profiles help shape the load following RE profile

- Solar
- Wind + Solar co-located
- Wind
- Hydro – PSP & Storage

BESS – RE charged

Power Transmission Network

Discoms
(With complimentary demand profiles)

D1  D2  D3

Choice of RE sources shall be determined by Discom’s load profile for tariff optimization
RE based RTC power profiles (Load following)

• Multi location wind and solar power stations together with balancing hydro power and/or BESS can create load following & firm generation profile in MW (15 min time block).

• The day ahead & intra –day variability can be minimized by using assets as above

• State’s existing Hydro resources can be used to create RE-RTC profile with firm 25 yr tariff within (Rs 3-3.5 per kWh or less)

• Any residual variability can be met from Real Time Markets or Ancillary Services

• Customizable RE profiles can be created as per needs of States

• Flexibility & variability of RE can be turned into its strength of providing firm generation profile (with minimal variability managed from PX/AS)

RE-RTC power has a commercial case to replace coal stations – load centre or pit-head
RE based RTC generation profile – An Example

Storage Hydro can be used for peaking support to match demand

Minor variation managed thru’ PX/AS

Up to 1 hr gap

Similar Slot Wise analysis for entire year basis historical data and improved F&S of RE enable RE – RTC profile creation with lowest tariff

Source: How regional solar cooperation could be a solution for India’s energy crisis, Sapan Thapar & Seema Sharma
Energy Resource Map

Conventional Power Plants
- Coal
- Lignite
- Diesel
- Natural Gas
- Nuclear
- Hydro
- Pumped Storage Hydro

Renewable Energy Power Plants
- Small Hydro Power (2018-2020)
- District-wise RE Power Plants
- Solar
- Wind
- Biomass
- Small Hydro
- Waste to Energy
- Installed Capacity (MW)
  - 5000
  - 4000
  - 3000
  - 2000
  - 1000

Coal Reserves
- Coal Mines
- Lignite Mines
- Captive Coal Mines
- Coal Washeries
- Coal Blocks
- Coal Field

Petroleum & Natural Gas Sector
- Oil & Gas Wells
- LNG Terminals
- Refineries
- LPG Bottling Plants
- Ethanol Plants
- POL Terminals
- Natural Gas Pipeline
- Petroleum Products Pipeline

Wind potential (W/m²)

HEP
Enablers for Mega Aggregated RE stations

- Portfolio approach to evaluate CUF and not site specific
- Increase in balancing area through regional pooling (proposed in Draft IEGC)
- General Network Access Regulations (GNA) – Copperplate transmission system
- Demand response as a resource (proposed in draft IEGC regulations and AS regulations 2022)
- RE stations to provide ancillary services (proposed in draft IEGC – primary reserves)
- Suitable market mechanism for AS (notified in AS Regulations ‘22)
- Guidelines for Load following RE based RTC power station – Aggregated stations (MOP guidelines likely soon)
# Market Based Economic Despatch

## Details vs. Particulars

<table>
<thead>
<tr>
<th>Details</th>
<th>Particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pooling of buy / sell bids</td>
<td>Sellers and buyers submit their offers and bids on a day ahead basis</td>
</tr>
<tr>
<td></td>
<td>Offers and bids (quantum and price) are pooled</td>
</tr>
<tr>
<td>Price discovery, scheduling &amp; dispatch</td>
<td>National merit order stack is prepared</td>
</tr>
<tr>
<td></td>
<td>Market Clearing Price (MCP) is discovered as per common merit order for each time block of upcoming day</td>
</tr>
<tr>
<td>Payments and settlement</td>
<td>Cleared buyers would pay MCP to the Power exchange which will in turn pay the MCP to the cleared sellers</td>
</tr>
<tr>
<td></td>
<td>Final settlement would be as per contract for the portion of demand cleared in relation to contracted MW. Gains realized due to URS sale will be shared with beneficiaries as stipulated by the Commission</td>
</tr>
<tr>
<td></td>
<td>The buyers would still continue to pay the fixed costs outside the market.</td>
</tr>
</tbody>
</table>

- The proposed mechanism would be a key step in enabling uniform clearing price for procurement of power and transitioning towards the concept of "One Nation, One Grid, One Price".

Phase 1 of MBED – Applicable to NTPC stations only

Source: MOP Draft paper, Jun ‘21
### PX (RTM) rate discovery curves

<table>
<thead>
<tr>
<th>Time period</th>
<th>Clearing price (MCP)</th>
<th>MCV</th>
<th>Seller bid price before sharp move</th>
<th>Seller bid volume before sharp move</th>
<th>Shape of curve</th>
<th>% seller bid volume before sharp move against MCV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rs/Mwh</td>
<td>MW</td>
<td>Rs/Mwh</td>
<td>MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F = D/C</td>
</tr>
<tr>
<td>18:30 - 18:45</td>
<td>20000</td>
<td>2164.1</td>
<td>6000</td>
<td>2100</td>
<td>Vertical</td>
<td>97%</td>
</tr>
<tr>
<td>18:45 - 19:00</td>
<td>20000</td>
<td>2269.1</td>
<td>9000</td>
<td>2100</td>
<td>Vertical</td>
<td>93%</td>
</tr>
<tr>
<td>19:00 - 19:15</td>
<td>20000</td>
<td>2448.4</td>
<td>9000</td>
<td>2350</td>
<td>Vertical</td>
<td>96%</td>
</tr>
<tr>
<td>19:15 - 19:30</td>
<td>20000</td>
<td>2743.4</td>
<td>9000</td>
<td>2600</td>
<td>Vertical</td>
<td>95%</td>
</tr>
<tr>
<td>19:30 - 19:45</td>
<td>20000</td>
<td>3066.6</td>
<td>9000</td>
<td>2900</td>
<td>Vertical</td>
<td>95%</td>
</tr>
<tr>
<td>19:45 - 20:00</td>
<td>20000</td>
<td>3091.6</td>
<td>9000</td>
<td>2900</td>
<td>Vertical</td>
<td>94%</td>
</tr>
</tbody>
</table>
Rate Discovery curves
Rate Discovery Curve

01/02/2021, 08:45-09:00 hr
Independent Market Surveillance Mechanism

- In India, CERC has a market monitoring cell
- The Cell publishes analysis of rates and volumes, players through monthly & yearly reports
- However, given the recent very high prices discovered on RTM & DAM since Oct’21, there is a need to go beyond the surface and identify root cause
- Pattern in high purchase or sell bids by players
- Resource Adequacy and prediction of unnecessary high dependence on energy markets (PX) with capacity on bar not monitored (due to various reasons)
- **There is a need for independent market surveillance mechanism.**
- Example can be seen from California ISO, which established independent market surveillance committee comprising of 3 or more independent & recognized experts.
- ISO staff to provide data & admin support

Independent Market Surveillance Mechanism

- The functions of the Market Surveillance Committee include:
  - Provide independent review of market performance and market power problems
  - Develop a record of structural problems and propose corrective action
  - Review rule changes, penalties, and sanctions
- Current members in CAISO MSC include
  - James Bushnell - email: jbbushnell@ucdavis.edu
  - Scott Harvey - email: scott.harvey@fticonsulting.com
  - Benjamin Hobbs, Chair - email: bhobbs@jhu.edu

Source:
http://www.caiso.com/informed/Pages/BoardCommittees/MarketSurveillanceCommittee/MarketSurveillanceCommitteeDescription.aspx
http://www.caiso.com/informed/Pages/BoardCommittees/MarketSurveillanceCommittee/Default.aspx
Need for Non-profit Market Operator

• With increasing penetration of ST markets and the proposed move to MBED mechanism, it is imperative to ensure robustness of PX platform as well its independence.

• The current PX mechanism ensures earning of the PX by means of trading margin.

• There may be conflict of interest between the market participants and promoters of PX which may result into inefficient market operation.

• The transition to single combined system + market operator with non-profit objectives shall serve the objective.

• Example is California Independent System Operator (CAISO) market.

• Suitable study and thought in this regard as applicable to Indian scenario shall be helpful in ensuring a robust and reliable market (energy, capacity, ancillary etc).
Green Hydrogen - Overview
Solar potential – Key to Green H2

India has highest solar energy security
365 days of solar photovoltaic (PV) generation in India, Germany and USA in the year 2020
### The Hydrogen Colour Spectrum

<table>
<thead>
<tr>
<th>Colour</th>
<th>Technology</th>
<th>Primary Energy / Source of Electricity</th>
<th>Carbon Footprint</th>
<th>Termology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Hydrogen</td>
<td>Thermolysis</td>
<td>Biomass</td>
<td>Low (&lt; 3 kg CO₂eq / kg H₂)</td>
<td>Renewable Hydrogen</td>
</tr>
<tr>
<td>Yellow Hydrogen</td>
<td>Steam Reforming</td>
<td>Biomethane</td>
<td>Low (&lt; 3 kg CO₂eq / kg H₂)</td>
<td>Renewable Hydrogen</td>
</tr>
<tr>
<td>Blue Hydrogen</td>
<td>Water Electrolysis</td>
<td>Renewable Energies (Solar, Wind, Hydro etc)</td>
<td>Minimal (&lt; 2 kg CO₂eq / kg H₂)</td>
<td>Renewable Hydrogen</td>
</tr>
<tr>
<td>Brown Hydrogen</td>
<td>Steam Reforming Gasification</td>
<td>Natural Gas, Coal + Carbon Capture Sequestration (CCS)</td>
<td>Low (&lt; 3 kg CO₂eq / kg H₂)</td>
<td>Low-carbon Hydrogen</td>
</tr>
<tr>
<td>Black Hydrogen</td>
<td>Pyrolysis</td>
<td>Natural Gas</td>
<td>Low (&lt; 3 kg CO₂eq / kg H₂ + Carbon Black (CB))</td>
<td>-</td>
</tr>
<tr>
<td>Grey Hydrogen</td>
<td>Steam Reforming</td>
<td>Lignite</td>
<td>High (~ 11 kg CO₂eq / kg H₂)</td>
<td>High-carbon Hydrogen</td>
</tr>
<tr>
<td>Pink Hydrogen</td>
<td>Electrical Network</td>
<td>Nuclear</td>
<td>Minimal (&lt; 2 kg CO₂eq / kg H₂)</td>
<td>Low-carbon Hydrogen</td>
</tr>
<tr>
<td>White Hydrogen</td>
<td>Gasification</td>
<td>Bituminous Coal</td>
<td>Very High (&gt; 20 kg CO₂eq / kg H₂)</td>
<td>High-carbon Hydrogen</td>
</tr>
</tbody>
</table>
Hydrogen – Supply chain
Global Hydrogen Demand

**Global hydrogen demand by sector (Mt H₂/year)**

- **2020**: 89 Mt H₂/year
- **2025**: 134 Mt H₂/year
- **2030**: 211 Mt H₂/year

**Global hydrogen electrolyser market share (2020)**

- Germany: 19.0
- Japan: 17.1
- Thailand: 16.0
- China: 15.2
- USA: 6.5
- Italy: 4.1
- Korea: 3.3
- Czech Republic: 3.0
- Canada: 1.8
- UK: 1.4

**Source:** IEA, 2020

**Source:** Clean Energy Wire 2020
**METHANOL AS A HYDROGEN CARRIER**

1. Carbon intensity of the grid determines the carbon intensity of electrified applications.
   - Most grids have low integration of renewable energy capacity.

2. Renewable energy generation has to be X3 or X4 larger than electricity demand to address intermittency.
   - Cost to integrate fully renewable grids:
     - >USD 4.5 trillion
     - >USD 3.6 trillion
     - >USD 11 trillion

3. Rising cost of electricity brings cost of H₂ to >USD 3.5/kg (based on price of the industrial method).

4. Electrolysis of water requires 50 – 55 kWh/kg of H₂.
   - H₂ produced is green with a carbon intensity of 21 kgCO₂eq/kg of H₂ (based on carbon credits for H₂ and electrolysis).

5. Methanol has a low carbon intensity and can be carbon-neutral when produced from sustainable feedstocks such as municipal solid waste (MSW), agricultural waste, and captured CO₂.

6. Bio-methanol produced from MSW can produce H₂ at a carbon intensity of 2.15 kgCO₂eq/kg of H₂ = 90% GHG SAVINGS compared to electrolysis.

7. As the most effective hydrogen carrier, methanol is:
   - Simple – Stored and transported as a liquid
   - Efficient – Highest hydrogen to carbon ratio of fuelled fuels
   - Green – A pathway to carbon-neutral transport
   - Now – Immediate solution for the adoption of hydrogen

8. Vehicles with onboard methanol reforming occur LOWER CAPEX and OPEX for LONGER RANGE, SHORTER REFILL TIME and LOWER EMISSIONS.

Source: Methanol Institute
Gas turbine experience with Hydrogen

Figure 10: Timeline of selected projects with hydrogen fuels.

Source: GE
Gas turbine experience with Hydrogen

NYPA, GE Successfully Pilot Hydrogen Retrofit at Aeroderivative Gas Turbine

A pioneering GE aeroderivative gas turbine project to demonstrate hydrogen combustion as part of a retrofit at an existing U.S. natural gas power plant has successfully utilized blends of 5% to 44% hydrogen with natural gas—some of the highest volumes of hydrogen blended into a commercially operating gas turbine.

NYPA, GE Successfully Pilot Hydrogen Retrofit at Aeroderivative Gas Turbine (powermag.com)
DOE, US’s target 1:1:1 for GH

**Hydrogen Shot**

In June 2021, the DOE launched the first in a series of Energy Earthshots to accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade. This “Hydrogen Shot” – “111” – aims to reduce the cost of clean hydrogen to $1 per kilogram in just a decade.

1 Dollar 1 Kilogram 1 Decade

DOE is also working closely with industry to expand low-carbon hydrogen production capacity, including through grants, loans, and other tools and incentives. We will support multiple production routes with potential to achieve the Hydrogen Shot, to stimulate competition, innovation, investment, and commercialization, to catalyze sharp declines in cost, across the value chain.
India – Hydrogen story

Potential locations identified by Govt of India for Green Hydrogen capacity installation:

- Rajasthan
- Madhya Pradesh
- Gujarat
- Maharashtra
- West Bengal
- Odisha
- Andhra Pradesh
- Karnataka
- Tamil Nadu

Govt has held initial talks with the industry and at least 25 Million tonnes of hydrogen capacity in India is confirmed.

Union power minister RK Singh, however, expects this to touch 35 million tonnes at the start itself.

Source: DGCA, Moneycontrol

Estimated GH Production Costs pre- and post- India H₂ Policy:

- 2022 Pre policy: 320-330
- 2022 post policy: 230-240
- Grey hydrogen costs 2022: 160-200

~20-30%.
~25-30%

Source: KPMG India Analysis

Electrolyzers
RE
Transmission
Water
Opportunity for Hydrogen Intake in India – Refineries & Fertilizer Plants

Spread of number of Urea Plants in India as of March’2022

Spread of number of Refineries in India as of March’2022

Spread of number of Chemical & Chemical Products in India as of March’2022

Potential demand hubs for hydrogen across the urea producing clusters

Potential demand hubs for hydrogen across the refineries clusters

Urea Production Scale (LMT) 20-50 5-10 0-5
Refining capacity (MMTPA) 10-50 5-8 0-5

Source: Eninrac Report on Hydrogen Market & Opportunity in India, MoPNG, MoC&F, Channel Checks
Regional analysis of existing and upcoming LNG terminals in India: First mover advantage for hydrogen and ammonia bunkering facilities.
# National Green Hydrogen Mission

## Demand Creation
- **Export Markets**
  - Capturing Global Demand
- **Substituting Imports**
  - Fossil Fuels and Fertilizers
- **Domestic Demand**
  - Multiple Sectors

## Incentivising Supply
- **Strategic Interventions for GH2 Transition**
  - Direct Financial Incentives for:
    - Electrolyzer Manufacturing
    - Green Hydrogen Production

## Key Enablers
- **Resources**
  - Finance, renewable energy (banking & storage, transmission, land, water)
- **R&D**
  - Result oriented, time-bound, including through PPP, grand challenges
- **Ease of doing business**
  - Simpler procedures, taxation, SEZ, commercial issues
- **Infrastructure & Supply Chain**
  - Ports, Re-fueling, Hydrogen Hubs, pipelines
- **Regulations & Standards**
  - Testing facilities, standards, regulations, safety & certification
- **Skill Development, Public Awareness**
  - Coordinated Skilling programme, online portal

*Source: MNRE, Govt of India*
NGHM 2023 – Expected outcomes

<table>
<thead>
<tr>
<th>Expected Outcomes of the Mission by 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>India’s Green Hydrogen Production</strong></td>
</tr>
<tr>
<td>Capacity will Reach at Least</td>
</tr>
<tr>
<td><strong>5 MMT Per Annum</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Renewable Energy</strong></td>
</tr>
<tr>
<td>Capacity Addition of</td>
</tr>
<tr>
<td><strong>~125 GW</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Over</strong></td>
</tr>
<tr>
<td><strong>₹8 lakh crore</strong></td>
</tr>
<tr>
<td>in Total Investments</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Create Over</strong></td>
</tr>
<tr>
<td><strong>6 lakh</strong></td>
</tr>
<tr>
<td>Full Time Jobs</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>50 MMT per annum</strong></td>
</tr>
<tr>
<td>of CO2 Emissions are Expected to be Averted</td>
</tr>
</tbody>
</table>
Summary

• PLI supported Electrolyser manufacturing in India – Key to target $1/kg GH
• Massive deployment of RE a must (Load following RE RTC a key)
• Demand mandates for key sectors in a phased manner
• Carbon Market – Domestic & Global
• Mechanism for M&V of green Hydrogen – Active role to be played by India in Global discussions
Thank You

cer.iitk.ac.in
eal.iitk.ac.in