

# **A Report on the Inception Workshop**

**“Decarbonisation of India’s Public  
Sector Enterprises (PSEs) and the  
Role of Green Hydrogen”**

*Submitted by*

**Standing Conference of Public Enterprises (SCOPE)**

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## 1. Acronyms and Abbreviations

AC	Air Conditioner
AMG	Avoid Minimize and Generate
ARAI	Automotive Research Association of India
ASF	Avaana Sustainability Fund
BATs	Best Available Technologies
BEE	Bureau of Energy Efficiency
BF-BOF	Blast Furnace-Basic Oxygen Furnace route
BHEL	Bharat Heavy Electricals Limited
BIS	Bureau of Indian standards
BLDC	Brushless Direct current
BPCL	Bharat Petroleum Corporation Limited
CAGR	Compound Annual Growth Rate
CBAM	Carbon Border Adjustment Mechanism
CBG	Compressed Biogas
CBG	Compressed Bio Gas
CCUS	Carbon Capture, Utilisation and Storage
CDRI	Coalition for Disaster Resilient Infrastructure
CE	Circular Economy
CEA	Central Electricity Authority
CMD	Chairman and Managing Director
CNG	Compressed Natural Gas
CO <sub>2</sub>	Carbon Dioxide
COD	Commercial Operation Date
COP	Conference of the Parties
CPSE	Central Public Sector Enterprises
CPWD	Central Public Works Department
CSR	Corporate Social Responsibility
DEFG	Distributed Energy Financial Group
DG	Director General
DRI	Direct Reduced Iron
ECA	Bureau of Educational and Cultural Affairs
ECSWG	Environment and Climate Sustainability Working Group
ED	Executive Director
EIB	European Investment Bank
EIL	Engineers India Limited
ESIA	Environmental and Social Impact Assessment
EU	European Union
FIs	Financial Institutions
FTA	Free Trade Agreement)
G20	Group of Twenty
GAIL	Gas Authority of India Limited
GCF	Green Climate Fund
GDP	Gross domestic product
GGI-OSOWOG	Green Grids Initiative – One Sun One World One Grid

GH2	Green Hydrogen
GHG	Greenhouse Gas
GIM	Green India Mission
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GM	General Managers
GSDP	Green and Sustainable Development Partnership
GW	Gigawatt
H <sub>2</sub>	Hydrogen Gas
HR	Human resources
HURL	Hindustan Urvarak & Rasayan Limited
IA	International Agenda
IAS	Indian Administrative Service
IGEF	Indo-German Energy Forum
IIFCL	India Infrastructure Finance Company Limited
IIT	Indian Institute of Technology
IOCL	Indian Oil Corporation LTD
IPCC	Intergovernmental Panel on Climate Change
IREDA	Indian Renewable Energy Development Agency Limited
IRIS	Infrastructure for Resilient Island States
IS	Indian Standard
ISA	International Solar Alliance
ISO	International Organization for Standardization
ITP	Industry Transition Platform
JDI	Joint Declaration of Intent
JS	Joint Secretary
KfW	KfW Development Bank
KTA	Kilotons Per Annum
KW	Kilowatt
KYC	Know Your Customer
LC <sup>3</sup>	Limestone Calcined Clay Cement
LCOE	Levelized Cost of Energy
LeadIT	Leadership for Industry Transition
LED	Light Emitting Diode
LiFE	Lifestyle for Environment'
LPG	Liquefied Petroleum Gas
LT-LEDS	Long-Term Low Emissions Development Strategy
MMT	Million Metric Ton
MMT	Million Metric Ton
MNRE	Ministry of New and Renewable Energy
MoEFCC	Ministry of Environment, Forest and Climate Change
MoP	Ministry of Power
MPA	Megapascal
MSME	Micro, Small & Medium Enterprises
MTPD	Metric Tonnes Per Day
MW	Megawatt

NAFCC	National Adaptation Fund for Climate Change
NAP	National Afforestation Programme
NAPCC	national action plan for climate change
NCR	National Capital Region
NDCs	Nationally Determined Contributions
NGHM	National Green Hydrogen Mission
NGO	Non-Governmental Organization
OPC	Ordinary Portland Cement
PESO	Petroleum & Explosives Safety Organization
PESO	Petroleum and Explosives Safety Organization
PhD	Doctor of Philosophy
PLI	Production Linked Incentive
PNG	Piped Natural Gas
POSOCO	Power System Operation Corporation Limited
PPA	Power Purchase Agreement
PPC	Portland Pozzolana Cement
PPM	Parts Per Million
PPP	Public-Private Partnership
PSEs	Public Sector Enterprises
PSUs	Public Sector Undertakings
PtX	Power to X
PWD	Public Works Department
Q&A	Question and Answer
QR	Quick Response
R&D	Research and Development
RE	Resource Efficiency
SAF	Sustainable Aviation Fuels
SAIL	Steel Authority of India Limited
SAPCC	State Action Plan on Climate Change
SBI	State Bank of India
SCOPE	Standing Conference of Public Sector Enterprises (SCOPE)
SECI	Solar Energy Corporation of India Limited
SIGHT	Strategic Interventions for Green Hydrogen Transition
SMART	Specific, Measurable, Achievable, Relevant, and Time-bound
SMR	Steam–Methane Reformation
SPM	Single Point Mooring
TRL	Technology Readiness Level
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollar
VGf	Viability Gap Funding
WAHA	Wrinkles Achhe Hain

## 2. Workshop Synopsis

Workshop Title	Decarbonisation of India's Public Sector Enterprises and the Role of Green Hydrogen
<b>Project Name</b>	Capacity Enhancement of Public Sector Enterprises (PSEs) in India on Climate Action
<b>Organised by</b>	Standing Conference of Public Sector Enterprises (SCOPE) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
<b>Duration / Date / Day / Time</b>	One day / 12-03-2024 / Tuesday / 09:30 to 17:30
<b>Location</b>	SCOPE Complex, New Delhi, India
<b>Workshop Mode</b>	Offline along with live telecast on SCOPE's YouTube Channel
<b>Target Audience</b>	Officers from Public Sector Enterprises (PSEs) in India
<b>Attendance</b>	305 officers (both offline & online) from 49 PSEs
<b>Workshop Objective</b>	<ul style="list-style-type: none"> <li>• Sensitize PSE officers about the ongoing SCOPE-GIZ project</li> <li>• Introduction to the climate co-benefit methodologies and their significance for PSEs in India</li> <li>• Building capacities of PSEs on climate action through knowledge and experience sharing on low-carbon technologies such as industry electrification, green hydrogen and its derivatives, etc. followed by discussion on their market expansion, and the financing options</li> </ul>
<b>Workshop Sessions</b>	<p><b>The workshop comprised four sessions:</b></p> <ol style="list-style-type: none"> <li>1. Inaugural Session</li> <li>2. Session on "Green Hydrogen and its role for India's Economy"</li> <li>3. Session on "Decarbonisation ways: Renewable energy, Green Hydrogen for PSEs (Technology Readiness &amp; Cost) &amp; use of Limestone Calcined Clay Cement (LC3) (Technology Readiness)"</li> <li>4. Session on "Financing for Green Hydrogen Projects of PSEs"</li> </ol>

<p><b>Dignitaries and Speakers</b></p>	<p>The workshop was graced by dignitaries and eminent speakers from –</p> <ul style="list-style-type: none"> <li>• Ministry of New and Renewable Energy (MNRE)</li> <li>• Ministry of Environment, Forest and Climate Change (MoEFCC)</li> <li>• German Embassy</li> <li>• Bureau of Energy Efficiency (BEE)</li> <li>• PSEs – NTPC Ltd., IOCL, IREDA, and GAIL (I) Ltd.</li> <li>• Grant Thornton LLP</li> <li>• IIT Bombay</li> <li>• IIT Delhi</li> <li>• KfW Development Bank</li> <li>• European Investment Bank (EIB)</li> <li>• World Bank</li> <li>• Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) India</li> <li>• Indo-German Energy Forum (IGEF)</li> <li>• Standing Conference of Public Sector Enterprises (SCOPE)</li> </ul>
<p><b>Methodology</b></p>	<ul style="list-style-type: none"> <li>• The inaugural session included addresses by dignitaries summarising the roles of PSEs and latest strides by Indian and German governments on climate action and also introduce participants to the ongoing SCOPE-GIZ project “Capacity Enhancement of Public Sector Enterprises (PSEs) in India on Climate Action”</li> <li>• Other sessions included both addresses and presentations followed by Q&amp;A sessions</li> </ul>
<p><b>Point of Contact</b></p>	<p><b>Mr. Shubh Ratna</b>  <b>Team Leader</b>  <b>GM (Tech &amp; HR)</b>  <b>SCOPE</b></p>

### 3. Background

Climate change has become a major threat to sustainable development, economic wellbeing, and, the life diversity. Multiple reports from Intergovernmental Panel on Climate Change (IPCC)<sup>1</sup> have revealed that while natural factors continue to play a role in shaping climate patterns but the global warming over the past century is primarily due to GHGs released by anthropogenic activities.

Recently, the “Global Carbon Budget 2023” report<sup>2</sup> published in the prestigious journal “Earth System Science Data” projected total global carbon dioxide (CO<sub>2</sub>) emissions arising out of fossil fuels to be 36.8 billion tonnes in 2023 which is 1.1% more than 2022. It had also projected that **carbon emissions in India witnessed a significant increase** of ~ 8.2% in 2023. Atmospheric CO<sub>2</sub> levels were projected to average 419.3 parts per million (PPM) in 2023, more than 50% above pre-industrial levels. Levels of atmospheric GHGs may further rise if industrial fossil fuel usage remains unchecked.

Understanding the urgent need to address climate change, countries across the world have been making sincere efforts in adopting mitigation strategies both at individual and corporate level. Industries across the world are adopting ways and methodologies so as to decarbonize their processes and reduce carbon footprint. In order to address the concerns of climate change, India is also taking decisive steps so as to ensure timely action to mitigate impact of climate change.

**India has been at the forefront by implementing several programmes and schemes** including the Energy Conservation Act (enacted in 2001 then amended in 2022), National Action Plan on Climate Change (NAPCC, launched in 2008), State Action Plan on Climate Change (SAPCC, launched in 2009), and by establishing National Clean Energy Fund (NCEF, launched in 2010), National Clean Energy Fund and National Adaptation Fund for Climate Change (NAFCC, launched in 2015) that support missions in specific areas of solar energy, energy efficiency, water, sustainable agriculture, Himalayan ecosystem, sustainable habitat, green India, and strategic knowledge for climate change. For transition towards a low-carbon economy and reduce dependence on fossil fuels, **India's leadership in renewable energy deployment has been particularly noteworthy** with initiatives like the Jawaharlal Nehru National Solar Mission (launched in 2010) and the National Wind Energy Mission (launched in 2015). Currently, India is also focusing on indigenous technology to optimize its resources and promote green energy to reduce carbon emissions. In this regard, the implementation of the National Green Hydrogen Mission (NGHM, implemented in 2023) is noteworthy.

**Apart from advancement in energy sector, India's focus is also on circular economy.** In India, the Circular Economy Cell (CE Cell) was constituted in NITI Aayog in September, 2022 as a dedicated unit to work around Circular Economy<sup>3</sup>. The 1<sup>st</sup> meeting of the Environment and Climate Sustainability Working Group (ECSWG) focusing on Promotion of

<sup>1</sup> <https://www.ipcc.ch/reports/>

<sup>2</sup> <https://essd.copernicus.org/articles/15/5301/2023/>

<sup>3</sup> <https://www.niti.gov.in/circular-economy-cell>

Blue Economy along with Coastal Sustainability, Restoration of Degraded Lands and Ecosystems, Enhancement of Biodiversity and Strengthening of Circular Economy, marked the beginning of constructive discussions within G20 countries for a sustainable future, led by India's G20 Presidency<sup>4</sup>. India has prioritized 'Resource Efficiency and Circular Economy' as one of the three core themes for deliberations in the G-20 forum<sup>5</sup> in the year 2023.

In the area of forestry, apart from efforts from Non-Government Organizations (NGOs), civil society, and corporate bodies; the **government of India has launched several forestry initiatives** such as the National Afforestation Programme (NAP, in year 2002), the Green India Mission (GIM, in year 2015), and Nagar Van Yojna (NVY, in year 2020), to increase in forest and tree cover in the country<sup>6</sup>. A Compensatory Afforestation Fund (CAMPA) is being utilized by States/UTs for taking up afforestation projects for compensating the loss of forest & tree cover due to diversion of forest land for developmental projects. In 2018, the MoEFCC has formulated the draft National Forest Policy and placed in public domain. The draft Policy recommends to integrate climate change mitigation and adaptation measures in forest management including resilience to climate change by forest dependent communities.

**Apart from addressing climate change domestically, India has launched some international coalitions** such as International Solar Alliance (ISA, in year 2015) and Coalition for Disaster Resilient Infrastructure (CDRI, in year 2019). Along with Sweden, India co-leads the Leadership Group for Industry Transition (LeadIT) for voluntary low carbon transition of hard to abate sectors since its inception in 2019. Recently at COP28 in 2023, the LeadIT initiated its second phase i.e., LeadIT 2.0, marking a joint commitment by member countries and companies to shape policy frameworks and international cooperation for an inclusive industry transition.

At COP26 in Glasgow in November 2021, besides launching new initiatives under CDRI and ISA i.e., Infrastructure for Resilient Island States (IRIS) and Green Grids Initiative – One Sun One World One Grid (GGI-OSOWOG), our Hon'ble PM, Shri Narendra Modi announced short- & long-term goals encapsulated as "**Panchamrit**" that also included goal to achieve **net-zero by 2070**. Aligning with the Paris Agreement, India submitted its first Intended Nationally Determined Contributions (INDCs) in 2015 and achieved few targets before committed time and then **resubmitted updated NDCs to the United Nations Framework Convention on Climate Change (UNFCCC)**<sup>7</sup> in 2022. The updated NDCs are –

1. Reduce emissions intensity of its GDP by 45 percent by 2030, from 2005 level
2. Achieve about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030
3. Create an additional carbon sink of 2.5 to 3 billion tonnes of CO<sub>2</sub>e through additional forest and tree cover by 2030
4. Mobilize domestic and new & additional funds from developed countries

<sup>4</sup> <https://pib.gov.in/PressReleasePage.aspx?PRID=1892661>

<sup>5</sup> <https://pib.gov.in/PressReleasePage.aspx?PRID=1943135>

<sup>6</sup> <https://pib.gov.in/PressReleasePage.aspx?PRID=1849867>

<sup>7</sup> <https://pib.gov.in/PressReleaselframePage.aspx?PRID=1847812>

5. Build capacities, create domestic framework and international architecture for quick diffusion of cutting-edge climate technology
6. Better adapt to climate change by enhancing investments in development programmes in sectors vulnerable to climate change
7. Adopt a climate friendly and a cleaner path
8. Propagate a healthy and sustainable way of living through a mass movement for 'LIFE' – 'Lifestyle for Environment'. Mission LiFE is an India-led global mass movement to nudge individual and community action to protect and preserve the environment.

At COP27 in 2022, **India released the “Long-Term Low Emissions Development Strategy (LT-LEDS)<sup>8</sup>”** document that reiterates all these commitments. During COP28 in the year 2023, apart from launching the **Green Credit Initiative** to create a participatory global platform for exchange of innovative environmental programs and instruments, India also showcased its achievements and promised new avenues<sup>9</sup> for its national climate action. Several other initiatives and policies on climate action and sustainable development are on way as evident by India’s investments in renewable energy, climate-resilient infrastructure, and adaptation measures.

While the Government is doing its bit, it’s imperative that the efforts to mitigate climate impact is made by all stakeholders and understanding this, **the corporates are also taking equal partnership so as to reduce carbon footprint**. As a result, today many corporates have declared net zero targets aligned to the country level achievement of carbon neutrality by 2070. While the corporate sector as a whole has been taking firm steps in this regard, Public Sector Enterprises (PSEs) are leading the way more sternly.

In India, **Public sector enterprises (PSEs) hold strategic importance** to the national economy, employment opportunities, and play prominent role in balancing socio-economic development. Currently, India has **254 operating PSEs that contribute nearly 14% to GDP in terms of turnover and providing employment to nearly 1.5 million people**. Presently, PSEs are net contributors to the Indian economy with a registered net profit of Rs 2.12 lakh crores and contribution to central exchequer of over Rs 4.5 lakh crores. These commercially prudent enterprises are present in all strategic sectors including petrochemical, oil & gas, fertilizer, minerals (e.g. coal, iron & steel), construction (e.g., cement) and other infrastructure sectors thereby playing a pivotal role in the development of the country., However, while the PSEs are present in key sectors of the economy, such sectors release significant amount of GHGs and hence are classified as **“hard to abate”** as the inherent nature of the sector/business together with their intransigent role in overall development of country makes it challenging for them to curb their carbon emissions. Given their strategic importance in the country combined with their need for the progress of the country, it is imperative to explore ways to decarbonise PSEs working in hard to abate sectors through increasing their energy and material efficiency so as to enable them to be a strong support to the national agenda of climate action.

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<sup>8</sup> <https://pib.gov.in/PressReleasePage.aspx?PRID=1881755>

<sup>9</sup> <https://pib.gov.in/PressReleaselframePage.aspx?PRID=1984434>

Understanding the need to facilitate PSEs to direct their efforts towards climate mitigation by **improving their energy efficiency and the renewable energy-based electrification of industries**. In the year 2019, Standing Conference of Public Enterprises (SCOPE), an apex body of PSEs, had collaborated with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, a German public-benefit federal enterprise, to work around climate change mitigation, sustainability, climate finance, and carbon market. In the journey of this partnership, SCOPE & GIZ undertook dedicated efforts to create awareness, handhold PSEs and also bring to light the dedicated efforts of PSEs to combat climate change. However, in the process it was revealed that while many PSEs are already venturing into using Best Available Technologies (BATs), alternative sources of energy, and other state-of-the-art technologies to reduce their emissions<sup>10</sup>, it is also true that many industries (sectors / PSEs) are still dependent majorly on conventional fuels. In addition, **challenges remain for the sectors that cannot be directly electrified**. Hence, it emerged that for the decarbonization of the PSEs within varied sectors, Green Hydrogen and its derivatives such as Green Ammonia and Green Methanol, produced from renewable energy sources have potential to be used as alternate fuels.

Green hydrogen production, heralded as a key solution in the fight against climate change, involves electrolyzing water using renewable energy sources like wind and solar power. This process splits water molecules into hydrogen and oxygen, with hydrogen being the primary product. Additionally, the oxygen produced can be utilized in industrial processes or released safely into the atmosphere. Unlike conventional hydrogen production methods, which rely on fossil fuels and emit carbon dioxide, green hydrogen derived from renewable sources like wind and solar, is poised to revolutionize our energy landscape which is also environmentally friendly and offers a sustainable alternative to fossil fuels.

Given its potential, today green hydrogen market size is valued at USD 6.26 billion in 2023 and is expected to reach over USD 165.84 billion by 2033, poised to grow at a Compound Annual Growth Rate (CAGR) of 38.77% from 2024 to 2033<sup>11</sup>. In this regard, on 4<sup>th</sup> January 2023, the Union Cabinet had approved the **“National Green Hydrogen Mission (NGHM)”<sup>12</sup>** that aims to make India a global hub for production, utilization and export of Green Hydrogen and its derivatives. In a significant move for the progress of the NGHM, the Ministry of New and Renewable Energy (MNRE), Government of India has recently issued the **Green Hydrogen Standard for India** (i.e., not more than 2 kg CO<sub>2</sub> equivalent / kg H<sub>2</sub> well-to-gate).

It is evident from above that we have never had better knowledge and technological solutions available to reduce GHG emissions and forestall the climate change crisis but challenges continue to remain for PSEs in hard to abate sectors. This challenge may be ascribed to the limited adoption of latest technologies in PSEs due to various techno-commercial constraints. Therefore, to engage PSEs on the subject, SCOPE and GIZ have ventured into a project “Capacity Enhancement of Public Sector Enterprises (PSEs) in India on Climate Action”. The basic aim of this project is to provide capacity enhancement for Indian PSEs to apply and

<sup>10</sup> <https://scopeonline.in/wp-content/uploads/2023/05/Technology-compendium-1.pdf>

<sup>11</sup> <https://www.precedenceresearch.com/green-hydrogen-market>

<sup>12</sup> <https://pib.gov.in/PressReleasePage.aspx?PRID=1888547>

institutionalize climate co-benefits methodologies for accounting and reporting the climate change mitigation and adaptation impacts, and for supporting low-carbon investments and pathways.

In general, climate co-benefit methodology recognizes that actions taken to combat climate change often have ancillary benefits beyond just reducing greenhouse gas emissions or adapting to climate impacts. Such co-benefits include cleaner air, green job creation, public health benefits, biodiversity improvement through expansion of green space, energy security, socioeconomic development, etc. By pursuing strategies that deliver multiple co-benefits, policymakers and stakeholders can maximize the effectiveness and acceptability of climate initiatives.

For the ongoing SCOPE-GIZ project, co-benefit methods that are being explored fall in two focus areas i.e., Circular Economy/Resource Efficiency (CE/RE) and Forestry/Biodiversity, which are well aligned with policy priorities of the Government of India. Major components of this project are –

1. Interaction among stakeholders (PSEs) to introduce the broad scope of the project and create awareness about various decarbonisation pathways for India including climate co-benefit methodologies, industry electrification, and use of alternative energy sources such as Green Hydrogen and its derivatives.
2. Regional workshops followed by focus group discussion to seek inputs from PSEs for developing PSE specific co-benefit methodology followed by pilot studies to understand the impact and effectiveness of the methodology. It also involves encouraging PSEs to exchange knowledge among peers, and also declare their climate actions.
3. Round table meetings with PSEs to get their suggestions for developing climate action index. Besides this, project also involves knowledge sharing on various climate change adaptation and mitigation strategies including climate co-benefits by creating an online knowledge platform and publishing articles.
4. Capacity building for PSE officers by facilitating their training on various adaptation & mitigation strategies, climate co-benefit methods, carbon market, etc. through an e-learning course.

Under the aegis of this project, **a workshop on “Decarbonisation of India’s Public Sector Enterprises and the Role of Green Hydrogen” was organised by SCOPE and GIZ on 12<sup>th</sup> March 2024 at SCOPE Complex, New Delhi.** The objectives of the workshop were –

- Sensitize PSE officers about the ongoing SCOPE-GIZ project “Capacity Enhancement of Public Sector Enterprises (PSEs) in India on Climate Action” and also introduce PSEs to climate co-benefit methodologies and their significance for PSEs in India
- Create awareness on the need and various ways of decarbonisation, related mission & scheme from the government, and technology readiness
- Building capacities of PSEs on climate action through knowledge and experience sharing on low-carbon technologies such as industry electrification, green hydrogen and its derivatives, etc. followed by discussion on their market expansion, and the financing options

## 4. Methodology

### 1. Define Objectives

The objectives and learning outcomes were discussed by SCOPE and GIZ teams so that these come under the aegis of the project as well as to make these objectives SMART (Specific, Measurable, Achievable, Relevant, and Time-bound).

### 2. Audience Analysis

As the SCOPE-GIZ project aims capacity enhancement of Public Sector Enterprises (PSEs), therefore, the Chief Executives of PSEs were requested to nominate relevant officials to attend the workshop. Majority of the nominated officers included middle and senior management (Senior Managers, General Managers, Executive Directors, etc.).

### 3. Curriculum (Agenda) Development

A well-structured agenda for the workshop was developed to break down the content into manageable sessions and allocate appropriate time for each (for detailed agenda, see annexure – I). The Workshop was divided into four sessions with each focusing on different topics as follows:

- Session 1: Inaugural of the Workshop and introduction to the climate co-benefit methodologies
- Session 2: Green Hydrogen and its role for India's Economy
- Session 3: Decarbonisation ways: Renewable energy, Green Hydrogen for PSEs (Technology Readiness & Cost) & use of Limestone Calcined Clay Cement (LC3) (Technology Readiness)
- Session 4: Financing for Green Hydrogen Projects of PSEs

### 4. Selection of dignitaries and speakers

- To ensure a balance of industry and global perspective dignitaries from German Embassy, GIZ India, and SCOPE were invited.
- The Government of India had recently launched National Green Hydrogen Mission and also released Indian Standard for Green Hydrogen. These topics were important parts of technical session of the workshop. Therefore, dignitaries from the concerned Ministries and organisations such as Ministry of Environment, Forest, and Climate Change (MoEFCC), Ministry of New and Renewable Energy (MNRE), Bureau of Energy Efficiency (BEE) were invited.
- Officials from the Indo-German Energy Forum (IGEF) to create awareness about the Forum and how they are working towards increasing decarbonization through innovative yet feasible ways. During the workshop, a study commissioned by IGEF was also unveiled.
- To talk technical knowledge on the subject including technology readiness in various sectors, officials from IIT Bombay, IIT Delhi, NTPC Ltd., and IOCL were invited to understand the practical solutions of the subject.

- To discuss financial options for Green Hydrogen and other low-carbon technologies for PSEs, speakers were invited from Indian Renewable Energy Development Agency Limited (IREDA), KfW Development Bank, European Investment Bank (EIB), and the World Bank.

## **5. Delivery Methodology**

- Interactive and participatory method was chosen to engage participants actively. Q&A sessions were included after each session to promote the interaction of participants with speakers / dignitaries.
- However, understanding the need for making the workshop as a reference for future and to reach the audience who could not mark their attendance in the workshop, the event was live telecasted on SCOPE's YouTube Channel (<https://www.youtube.com/watch?v=vd-L8flTjoc>) and other social media handles of SCOPE.

## **6. Logistics Planning**

To accommodate the large number of participants, the auditorium hall of the Convention Centre at SCOPE Complex was selected as the venue for the workshop. Other logistics such as catering was also well organised.

## **7. Prepare workshop merchandise**

Required merchandise such as folder, pad, pen, handouts, etc. were prepared and organized well in advance for smooth flow of the workshop.

## **8. Facilitation Plan**

Throughout workshop sessions, three facilitators / moderators played a central role in guiding the discussion, managing time effectively, ensuring that the objectives of the session are met, and summarising key takeaways.

- Ms. Samridhi Jain (Senior Manager – Corporate Affairs, SCOPE) facilitated session 1 & 2
- Mr. Tobias Winter (Director, IGEF) facilitated session 3
- Mr. Nisheet Srivastava (Advisor – Energy, KfW Development Bank) facilitated session 4

## **9. Energizers**

Short breaks between sessions were given to create a positive and lively atmosphere, foster connections among participants, and maintain energy levels.

## **10. Feedback Mechanism**

A feedback mechanism to gather input from participants was in place as a “feedback form” along with verbal feedbacks. These feedbacks will help in assessing the extent to which the learning outcomes were achieved as well as to refine future events.

## **11. Workshop resource sharing and follow-up plan**

Follow-up activity such as sharing of presentation materials (workshop resources) with participants was done to support them in applying their learnings after the workshop.

## 5. Nominations, Registration, and Attendance

For details of nominations and registration / attendance of officers from PSEs, please see annexure – II. A summary for the same is as follows:

<b>Online nominations (number of officers)</b>	<b>147</b>
Online nominations (number of PSEs)	46
Onsite registration (number of PSEs)	3
<b>Total PSEs</b>	<b>49</b>
Registration (out of 147 online nominated officers from PSEs)	116
Registration (officers from PSEs who were registered onsite)	14
Dignitaries / speakers	20
Dignitary associates	20
SCOPE and GIZ team	30
<b>Total offline attendance</b>	<b>200</b>
Online participants	105
<b>Total attendance (offline + online)</b>	<b>305</b>

## 6. Session Proceedings

### 6.1 Session 1 – Inaugural

#### 6.1.1 About the session

Overall, the inaugural session aimed to set a positive tone, build enthusiasm, and create a sense of community among participants. At first, all the dignitaries for the inaugural session were requested to take their respected seats on the stage. The moderator, on behalf of SCOPE and GIZ, welcomed all the participants and briefly introduced distinguished dignitaries present on the stage. The moderator then -

- explained how SCOPE & GIZ had been working together and assisting PSEs in exploring opportunities to align their climate action agenda with the national agenda
- applauded the overwhelming response that SCOPE got from the PSEs which was evident by the representation from around forty-five institutions
- informed that the event was being live-streamed for the benefit of those who could not mark their physical attendance for the Workshop
- directed welcoming of each dignitary with a token of respect and gratitude

Following this, the **Director General of Standing Conference of Public Enterprises (SCOPE), Shri. Atul Sobti** opened the first session with his address. Shri. Sobti is a Visionary leader having a versatile professional experience of nearly four decades and before leading scope as director General, he was CMD of BHEL, a Maharatna PSE and one of the largest heavy engineering organizations in India.

### 6.1.2 Opening Address by Shri. Atul Sobti

*What a day today! In fact, today all of us here to see the beginning of an ambitious and essential and important undertaking of Standing Conference of Public Enterprises in the area of environmental sustainability, a journey we started with the GIZ in 2019 and multiple MoUs have been signed in the recent past.*

*At SCOPE, in fact climate change is one of the very key areas where we are focusing. SCOPE, as u know is the apex body of PSEs and PSEs contribute close to 14% of the Indian economy, 451 billion USD turnover, 1.5 million employees there.*

*In scope we have got many verticals and one of the verticals which we have is on the “climate change” beside the Women Empowerment, Leadership, etc. As I mentioned that we started the journey in 2019 along with the GIZ and during this particular period we got the blessings of many dignitaries, a lot of work was done in this field and this partnership was very rewarding and very fruitful and in fact I am very happy to share, as Samridhi mentioned, the participants here are from 45 organizations. Initially when we had planned it, this is a sort of workshop and I request all of you whosoever participants are here, to make maximum use of it, whatsoever your query is there tried to get those addressed.*

*Initially we had planned in a very small room because we were expecting not more than 50 persons but I am very happy the kind of response we have got, only yesterday we took the decision of shifting to this Auditorium and I am thankful to all the organizations for nominating the people. I am thankful to the dignitaries on dais who are here and in fact you see that all the key areas are being represented here on the dais.*

*In fact, if you see the contribution of PSEs, as I mentioned, is huge and due to inherent nature of their operations they are also the positive emitters. I mean in majority of the areas they are operating for example coal 90% is by public sectors only, Power more than 50% by public sector, oil 60%, gas 20-30% and so on. So basically, if we have to address the issue of the climate action, I am very sure that public sectors have to contribute a lot in that particular regard and the kind of work which has been done by the public sectors you know if we think of something that can be implemented also.*

*Recently if you like to share with you, we had the SCOPE award ceremony in Vigyan Bhawan about a month back and where honorable Vice President was there, I would just like to mention, he quoted - public sector is the spine of the country and the PSEs Workforce is the spinal cord. That’s the kind of appreciation in fact public sectors are getting. Recently in the parliament also, honorable Prime Minister mentioned and applauded the exemplary performance of the PSEs and especially adding to the investor’s wealth.*

*Coming back to the climate action, a lot of work is being done for by Public Sector Enterprises and at SCOPE, in fact when we started working with the GIZ, basically a lot of work has been done in creating the awareness, creating the training, and handholding for the many organizations, and now we feel that although they are concentrating on many the green initiatives, they need to be exposed to the novel sources such as the Green Hydrogen because you know Green Hydrogen is one area which is very important and our Government of India has already launched a national hydrogen Mission with the aim to become the self-reliant for the production, use, and the export of the Green Hydrogen and it's derivatives and lead as an inspiration for the global clean energy transition.*

*Recently, even the interim budget 2024 also outlined 50% higher allocation to the schemes related to power sector including green hydrogen, solar power, and the green energy corridors. We know that there's a big impact of the green hydrogen, PSEs are already exploring this alternative source but we found that adoption in certain sector still remains unexplored. That is the reason we decided to have this particular Workshop so that all of you have the understanding and knowledge about this important subject and get aware about the policies. and also promote experience sharing.*

*Besides having the experts in this particular field, we are also having eminent global financiers e.g., Global Banks to share the green finance, industry experts to share their experiences of the process of the Green Hydrogen. I am sure that this would provide a fertile learning ground for all of you.*

*As I mentioned, the partnership with GIZ over the years, we had worked together on the capacity gap assessment study. We created a capacity gap assessment study which is available on our website. Based on the capacity gap study we organised training programs, regional Workshops and many awareness programs. The handholding of few companies such as GAIL and SAIL was also done in this particular field.*

*Now this particular project which is being launched together with the GIZ is one of its kind being done in SCOPE and in fact in India. During one of the sessions, you will be made aware about what is the coverage of this particular project which we are doing together but according to me, I am looking for three-four key areas where we will be working together over the journey of next two years.*

*The first is of course the knowledge platform, personnel training, and focus group discussions. The second most important thing which we are going to do is the development and institutionalization of the climate co-benefit methodologies in the selected PSEs. The third ambitious thing which we want to do is to develop a Climate Action Index. This is the first of its kind in the country, we will develop it and against that climate Action Index we will measure the performance of the public sector that how the performance is being done because what gets measured is what gets done, otherwise in isolation people will keep on doing so this is the third important thing which are doing. Another point during the discussions in the last three-four years, we found that there are no as specific micro credential courses or e-learning platform available in this field. So, one of the areas which*

*very close to my heart and I am sure that we will be able to develop, along with GIZ through this project, some e-learning platform certification courses in this particular field.*

*This is very important, very ambitious project and today we are achieving the first milestone. I am very happy to see that eminent panelists are there, so many guests are there, and I am sure that we will continue to have the blessings of all of you in the future also.*

*As I mentioned that this is a golden opportunity for all of you present here and I will encourage you to optimize it for your benefit, for your organization, for the society, and for our country as a whole. I believe that this project is going to pave the way for transition to low carbon economy while upholding the PSEs roles in India's economic landscape.*

*The SCOPE, I assure you, is committed to sustaining the planet and we seek your cooperation and continuous encouragement in this. Let us start today this particular process and optimize the opportunity. Thank you very much. Jai Bharat.*

The opening address was followed by the **'Program Perspective' by Mr. Farhad Vania, Senior Portfolio Manager, GIZ India.** Mr. Vania has over 15 years of experience with various projects related to CSR, Forest Wildlife Conservation, Environmental Management, and Social Development. He oversees the intent portfolio development for GIZ India including interfacing with all important and imperative Ministries and Departments of the Government of India and therefore, he was a relevant dignitary to provide the program perspective. He took the dais and first thanked the dignitaries on the stage and all attendees and then presented the program perspective.

### **6.1.3 Program Perspective by Mr. Farhad Vania**

*I actually stand before you on behalf of my country director who is on duty travel to Germany but I think I can also provide some program perspective as the organizers have asked us to do.*

*The issue is of course about climate change it's a topic that Germany is deeply committed to support India in its efforts to try and adapt and mitigate to the best of the abilities of the two countries. There is also an emerging global understanding as to what is causing it. You have the Intergovernmental Panel on Climate Change (IPCC) report which regularly comes out and points us in the direction of what the causes are.*

*And then we have NDCs which India has committed itself to and now has the duty to live up to what our NDCs are all about. We also have other international commitments for instance under the Paris Agreement you know we are going to reduce our emissions to the intensity of GDP by 45% by 2030 relative to 2005 levels, increase the share of non-fossil fuel capacity from 40 to 50% by 2030, not so far down the line, and additionally of course we have our Net Zero target for 2070. All of this if you think about, it is now being captured under the program that the Hon'ble Prime Minister has launched called 'Viksit Bharat 2047'.*

*The government of Germany has been quick to recognize this and said what is going to power India to 2047. It has to be something to do with energy and that's why energy remains one of the big areas of bilateral cooperation between India and Germany.*

*We have already heard from Mr. Sobti about the launch of the National Green Hydrogen Mission and which is what today's event is going to be all about. There is also the Strategic Interventions for Green Hydrogen Transition (SIGHT) program which has among its core components to provide an insight into the actions that India can take in pilot projects.*

*So, we can see and if you look at popular media not a day goes by when you won't hear something about Hydrogen or Green Hydrogen or the Hydrogen Mission, so obviously there's a gathering pace of interest in the topic.*

*But, what about today? What are we here for? Not so long back, as Mr. Sobti said, we started working with SCOPE around 2019. In 2021, we started the Climate Action Project with BMWK where Dr. Hesselmann represents and with the Ministry of Environment where Ms. Drall is, so these are the two political partners and then through that project we were allowed to come out and engage with SCOPE. We also have under the GIZ, something called the Indo German energy Forum (IGEF), one of my colleagues here is from the Energy Forum and we will be talking about that later in the day.*

*The idea is how do we get Public Sector Enterprises to transition towards a low carbon pathway. This is easier said than done, after all Public Sector Enterprises in India is a giant establishment / corporation with a lot of things going on. How does it transit to a low carbon pathway? Is that even possible to contemplate?*

*There is also an initiative called the Leadership for Industry Transition (LeadIT) of the Government of India and Sweden, and there's also the proposed European Union's (EU's) Carbon Border Adjustment Mechanism. So, all of this is driving India to do something with its energy issues and hydrogen presents possibly a way.*

*So, we have now under our Climate Action Project and with SCOPE we are collaborating on a study that we were able to conduct which is on "decarbonizing India potential for electrification across India's economy and assessment of electricity needs". This is something that we were able to facilitate, we will hear more about this in the course of the day today.*

*The Climate Action Project is actually something that we can work with partners of our choosing in collaboration with SCOPE and present evidence for what is actually possible. We have a discussion around it we can have many discussions but we also need to demonstrate pilots and this is again a possibility that the German government allows us to do along with the Indian government.*

*What about today's Workshop? Why are we here finally? So, we have the study, there will be somebody who will present its key findings and then come - time for action, what are going to be the next steps what is it that we can do and then what is the role of the different agencies and what is our role for instance as GIZ.*

*We have partnered in the past on different topics and we'll continue to be. I like your key areas of interest that you have already highlighted. My mind was already working how do I turn this into the next agreement with SCOPE. So, it'll always be of important to us and it's because of what SCOPE represents and we just heard in a little pre-discussion with the Chairman, what is the scope and the scale of the amount of outreach and coverage that an agency like SCOPE has, it's staggering! Somebody said it's bigger than half the countries in Europe. Yes, it's probably true. The amount of responsibility that comes to SCOPE with the extent of its coverage.*

*Thank you all very much for coming out for this. I don't have much more to say. I leave that to the experts but thank you sir for the opportunity for inviting us and also to the Embassy for enabling us to be part of a project like this and of course my GIZ colleagues who probably helped the SCOPE counterparts to help put this event together and please make the most of it.*

*Dr. Hesselmann is here from the other project, colleagues are here from different projects, use the time and the opportunity to engage with them and know more about Indo-German cooperation. Thank you very much.*

The next address was given by **Dr. Stephan Hesselmann, Minister Counsellor - Economic Affairs, German Embassy**. Dr. Hesselmann is a long-serving official from the German Federal Ministry for Economic Affairs and Climate Action, heading divisions in the industry department and has served as senior advisor in the economics and energy committee as well as in the finance committee in the German National Parliament in his previous role. A CPA and a PhD in economics, he has played an instrumental role in identifying issues and crystallizing the same in the IA (International Agenda) in Paris. At first, he appreciated and thanked distinguished representatives from MoEFCC, MNRE, SCOPE, PSEs, and colleagues from the GIZ and then presented his address.

#### **6.1.4 Address by Dr. Stephan Hesselmann**

*I would like thank the Standing Conference of Public Enterprises (SCOPE) and GIZ for organizing this event on this very important topic for both India and Germany. There is an increase in consensus around the word that the concerted efforts need to be taken to reduce the global warming to levels less than 2 degree Celsius and if possible, to cap it to 1.5 degrees higher than the preindustrial levels. This underpins the urgency of now.*

*We need collective efforts to tackle climate change and we need to do them right now. Various countries have pledged to their Nationally Determined Contributions to ensure energy transition and reduce emission. India is one of the few G20 countries whose climate actions are in line to achieve its NDC targets. India has also taken a leap forward by updating its NDC thus committing to reduce the emission intensity of the Gross Domestic Products to 45% below 2005 levels by 2030 and to achieve 50% of electricity generation capacity from non-fossil fuels by 2030.*

*The government of India has acknowledged and highlighted the role of Green Hydrogen towards achieving these goals. Addressing the nation on 75<sup>th</sup> Independence Day, Prime Minister Sh. Narendra Modi announced the National Green Hydrogen Mission with an aim of making India a Hub for production and also export of Green Hydrogen. Recent trends and analysis indicate that driven by technology advancements by reduction in cost of renewable energy and electrolyzes and aggressiveness of the strategy some of the major economies.*

*Green hydrogen is likely to become cost competitive in applications across industry, across mobility, and across other sectors within a very short span. India's National Green Hydrogen Mission is indeed is a very promising step in this direction. The mission will build capabilities to produce at least 5 million metric ton (MMT) of Green Hydrogen per annum by 2030 with potential to reach 10 MMT per annum with growth of export markets. The mission will support the replacement of fossil fuels and fossil fuel-based feedstocks with renewable fuels and feedstocks based on Green Hydrogen.*

*This will include replacement of Hydrogen produced from fossil fuels sources from green hydrogen and ammonia production and petroleum refining. Blending Green hydrogen in city gas distribution systems, production of steel with Green Hydrogen and use of Green Hydrogen derived synthetic fuels including green ammonia, green methanol and so on to replace the use of fossil fuels in various sectors including mobility, shipping and aviation. These commitments show that India is serious about the much-needed low carbon transition. As Mr. Atul Sobti mentioned, in this transition India's public sector enterprises (PSEs) are of strategic importance to Indian economy as they contribute to capital formation, contribution to employment generation about 1.5 million people, they have contributed to regional development and promotion of research. SCOPE is always trying to achieve state-of-the-art excellence as I see the sign back there "promoting excellence" and that also applies to the renewable energy sector and to climate action.*

*Thus, PSEs contribute 13% to Indian GDP and work in most important sectors as mentioned like coal, oil, and gas, energy metals, and minerals. In doing so, they represent a very high proportion of India's CO<sub>2</sub> equivalent emission contributing significantly to climate change but at the same time they are very important for country's development goals as a whole.*

*Therefore, it is paramount to have India's giant PSEs onboard for low carbon transition i.e., just that creates green jobs, to train green skills, to accelerate research and technology development and thereby contributing to all the efforts made by India to meet its climate targets.*

*Several PSEs are taking actions to reduce their carbon emission and support communities in adapting to changing climate. Some of the PSEs have spearheaded innovations in their sectors with new proprieties, technologies, and processes that reduces emissions and enhance resource efficiency.*

*These actions by India's PSEs reflects a fact that companies all over the world are realizing now what is good for climate is also good for business and this will be even more so in the*

*future. Thus, taking action to tackle climate change will positively impact the triple bottom line of businesses in terms of the economic social and environmental aspects.*

*Germany stands ready to collaborate even more with India and addressing climate change and building a sustainable future. Environment and climate are priority areas of Indo-German cooperation and this focus got the highest notification by prime minister Shri Modi and German Chancellor Scholz who signed the Indo-German green and sustainable development partnership in 2022 at cabinet consultations in Berlin.*

*Germany and India pursue the common intention of advancing the energy transition in both countries with the aim of achieving a socially just ecologically and economically sustainable, secure, and affordable energy supply to reduce their dependence on Imports of fossil fuels, very important for both of our countries and decarbonizing our economies.*

*Both of our countries value the productive and close political dialogue that takes place under the green and sustainable development partnership GSDP. Green hydrogen is among the priority areas between the two countries as was highlighted during the signing of the Joint Declaration of Intent (JDI) on Indo-German green hydrogen task force signed during the sixth Indo-German intergovernmental consultations between the MNRE and the German Ministry of economic Affairs and climate action in May 2022 to strengthen mutual cooperation in production in utilization in storage and in distribution of Green Hydrogen.*

*The common long-term goal is to make Green Hydrogen economically viable this has to be stressed this requires a global expansion of green hydrogen production and sales Germany and India therefore support the development of a global green hydrogen economy to facilitate the achievement of the goals of the Paris Agreement. Green Hydrogen was also an important topic of discussion between the two countries at last year's G20 proceedings under the Indian presidency.*

*At the 28<sup>th</sup> Conference of the Parties, Prime Minister Narendra Modi also initiated the second phase of the leadership group for industry transition (LeadIT 2.0) that brings together countries companies and Industries to achieve Net Zero emissions from heavy industries that Germany is also part of.*

*This workshop on the decarbonization of Indian PSEs and the role of Green Hydrogen being organized under the Indo-German support project for climate action in India therefore comes at a very opportune time. Discussions on evolving Technologies, their Readiness levels, and financing structures are extremely critical at this juncture to ensure on ground action.*

*As you can see India and Germany have deep relationships and both countries are committed to work together on sustainable green development. I can see that these issues are also very close to Indian PSEs, judging by the high-level participation today and audience here and the attention SCOPE is giving to this topic. I am convinced that by adopting sustainable practices, embracing Innovation, and leveraging on India and Germany's partnership PSEs can become champions of climate action and contribute to a greener, more resilient India.*

*So, ladies and gentlemen, let me conclude by reiterating the German ambassador's words from a few months ago – “In all our efforts against climate change, one thing is clear in fighting climate change the world cannot do without India and India cannot do without its Public Sector Enterprises.”*

*Thank you for your attention and best wishes to SCOPE, GIZ, and all the eminent officials present today for accelerating the partnership on climate action by India's most important PSEs and constructively engaging on a topic of prominence in this regard, decarbonization and the role of Green Hydrogen. I would also like to once again thank the Ministries here and look forward to today's Workshop. Thank you.*

It was followed by the address of **Shri Sandeep Kumar Gupta, Chairman, SCOPE; CMD, GAIL (India) Limited**. Shri Gupta has a wide experience of over three decades of oil and gas industry and has held different positions in leading PSEs in India. Presently he is heading GAIL (India) Limited as Chairman and Managing Director (CMD), which is India's leading natural gas company with diversified interest across the natural gas value chain. He has also held important positions in IOCL which is a global 500 company. He started with the greeting dignitaries and all attendees and his address is as follows –

#### **6.1.5 Address by Shri Sandeep Kumar Gupta**

*It is with great pleasure and a sense of profound responsibility that I extend a warm welcome to every one of you to this important gathering focused on the decarbonization of India's Public Sector Enterprises and the indispensable role of Green Hydrogen in this endeavor.*

*As chairman SCOPE, I am privileged to host this gathering as it aligns perfectly with our core mission and values. For years, we have been steadfast in our dedication to advancing sustainable practices and fostering innovation within the public sector. In the era of decarbonization and gaining momentum for Net Zero organizations, climate change has been a focus area for SCOPE.*

*Several climate action initiatives in the past have been taken for Public Sector Enterprises such as building green skills for PSEs, training sessions on climate resilient pathways for PSEs, PSEs role in nation's climate agenda, etc.*

*Climate change is a major threat to sustainable development, economic well-being, and the life diversity. Besides having a moral obligation, the urgency to address the climate change is of prime importance to all of us. India has already shown its dedication towards the subject by showcasing commitments at domestic and international platforms to strive to mitigate climate change and reach Net Zero by 2070.*

*Now it is the time for corporates to follow a streamlined path so that we as corporate citizens of the country can contribute effectively to the national goal. Today's discourse on decarbonization and the role of green hydrogen epitomizes our organization's commitment*

*to spearheading transformative initiatives that have a lasting impact on society and the environment.*

*The cabinet of Government of India has approved India's ambitious National Green Hydrogen Mission which aims to establish a Green Hydrogen ecosystem and leverage its potential for decarbonization and energy security. It is expected to lead to the development of 5 million metric ton per annum of green hydrogen production capacity while also reducing the quantum of imported fossil fuels by approximately rupees 1 lakh crore by 2030. Green Hydrogen usage in industries such as fertilizer production, petroleum refining, steel shipping, etc. is being promoted thus reducing carbon.*

*We as CPSEs are working to facilitate demand creation through domestic utilization. This has been duly supported by the Strategic Interventions for Green Hydrogen Transition program i.e., SIGHT which includes incentives for manufacturing of electrolyzers and production of Green Hydrogen. Pilot project guidelines have been issued for using Green Hydrogen for steel, mobility, shipping, decentralized energy applications, hydrogen production from biomass, hydrogen storage etc. Public Sector Enterprises in India are showcasing role of PSEs in reducing carbon footprint despite operating in hard to abate sectors. PSEs have been taking lead in this direction.*

*I am happy to share that GAIL has started India's maiden project of blending hydrogen in city gas distribution grid. Two percent by volume of Hydrogen is being blended in CNG network and five percent by volume of Hydrogen is being blended into PNG network at city gas stations of Avantika Gas Limited, Indore, in the state of Madhya Pradesh. GAIL is setting up one of the largest proton exchange membranes electrolyzers of 10-megawatt capacity at Bijapur. The project would be completed by mid of the current year itself and it will be powered definitely by renewable power.*

*NTPC limited has initiated blending of Green Hydrogen up to 8% volume in PNG network at NTPC Kawas township, Surat, in Gujarat from January 2023. Hydrogen based fuel cell electric vehicle buses in Leh and Greater NOIDA have also been started by NTPC.*

*Oil India Limited has developed a 60-kilowatt capacity hydrogen fuel cell bus which is a hybrid of an electric drive and a fuel cell.*

*Demonstration pilot plants for production of Green Hydrogen through water electrolysis using solar power, biomass oxy stream gasification, and CBG reforming for refilling 15 number of hydrogen fuel cell buses have been done by Indian oil and I believe that these are only illustrative and there are many other initiatives which are being taken by various PSEs.*

*While it is true that we have never had better knowledge and technological solutions available to forestall the climate change crisis and create opportunities for better life for people all over the world but challenge continues to remain for hard to abate sectors. This challenge may be ascribed to the limited adoption of latest technologies in PSEs due to various techno-commercial constraints.*

*As we continue to be in pursuit of suitable techniques to limit these emissions, using green electricity and alternative fuels such as Green Hydrogen are sustainable solutions. I am glad that SCOPE has recognized this concern and collaborated with the GIZ for this important project with the aim to identify sustainable decarbonization efforts thereby providing PSEs with practical solutions.*

*I understand, today's Workshop is a step towards this and forms the basis for working on more comprehensive and sustainable solutions in the future as well and from the program I note that there are very interesting sessions going forward which not only deal with the concept with Green Hydrogen with the use cases but also on the financing aspects of this entire subject.*

*Throughout the course of this event, we will have the privilege of delving into substantive discussions, sharing insights, and exchanging ideas that will undoubtedly shape the future trajectory of our nation's energy landscape. Moreover, we will have the opportunity to showcase the remarkable strides achieved so far in the industry both in terms of research and practical applications in advancing sustainable practices within the public sector.*

*May the insights gained serve as catalysts for meaningful change propelling us towards a future defined by environmental stewardship, innovation, and prosperity.*

*Thank you all.*

Next, **Shri Ajay Yadav (IAS), Joint Secretary, Ministry of New and Renewable Energy (MNRE)** through his address provided the Government of India's perspective on this important subject. Shri Yadav is an IAS officer from 2005 batch of Bihar cadre and he has been working in the field of climate change mitigation by promoting renewable energy. He has been contributing to many important works in the ministry which is been translated in the form of many new initiatives. Shri Yadav expressed gratitude to the dignitaries on the stage and welcomed all participants from both offline and online platforms and delivered his address.

#### **6.1.6 Address by Shri Ajay Yadav (IAS)**

*First of all, let me congratulate SCOPE and GIZ for organizing this Workshop which covers three broad areas. The key areas, decarbonization, the role of Public Sector Undertakings and the role of green hydrogen.*

*As we know decarbonization is the theme of the current century, if I can say along with digitalization. Our carbon budgets are limited by the projected limit to rise of global temperature by 1.5° Celsius or even to 2°C.*

*Different countries around the world have come out with their own decarbonization strategies and their own policies. In India, our policies are guided by the Panchamrit, the five principles as initiated by Hon'ble Prime Minister at COP26 in Glassgow.*

*The first one is to have 500 gigawatts of installed capacity from non-fossil sources by 2030, then to have 50% of our energy needs to be met through renewable energy. A 45% reduction in emission intensity of GDP over 2005 Levels by year 2030. We aim to basically reduce the carbon dioxide emissions by 1 billion ton by year 2030 and the long-term horizon the target is Net Zero by year 2070.*

*These are the basic principles. All our policies are aligned towards achieving these principles. In India, we launched our National Green Hydrogen Mission and in last year.*

*If we talk of decarbonization then basically there are two pathways that I can think of when we can move towards decarbonization?*

*The first one is to electrify whatever is possible – the industries, the vehicles, the cooking, everything else whatever can be possible, let us electrify that but then again, this electricity has to be greater percentage of renewable energy in this mix. So, we will have to decarbonize our generation of electricity - so that's one part. Currently our electricity consumption from renewable energy sources is 22% and through Energy Conservation Act we have mandated that we will take it up to 43-44% by year 2030. So, this is a step towards demand creation of renewable energy. Our current generation of renewable energy (non-fossil) is around 190 gigawatts out of a total for 430 gigawatts. Going forward, by 2030 we will reach 500 gigawatts (renewable energy) out of a projected generation of 777 gigawatts. So, this is one pathway.*

*The second pathway - there are certain industries where we cannot electrify to the extent possible. So, there hydrogen has now emerged as a very promising solution. It's now being also called as fuel of the future. There are industries like refineries, fertilizers, steel, heavy duty mobility, shipping, aviation, etc. where there is a limit to electrification and where the fossil fuels are used as feed stocks.*

*So, towards that end, I think more than 50 countries have announced their hydrogen strategies. In India, we launched our mission last year. The mission targets around 5 million tons of production per annum by 2030 and it would require 125 gigawatts of renewable energy, around 80 gigawatts of electrolyzer capacity to be set up in the country, and it will lead to creation of six lakh jobs. A total investment that is required would be around 8 lakh crores of rupees. It will also lead to import substitution, so we will be able to save on the foreign exchange to the tune of around 1 lakh crores of rupees and the carbon emission it would save to the tune of 50 million tons per annum.*

*As has been told, a major component of this mission is the SIGHT program i.e., Strategic Intervention for Green Hydrogen Transition. Here we provide incentives for manufacturing of electrolyzers and for production of Green Hydrogen. In the initial round, we carried out the first round of bidding and we identified & awarded 412,000 tons of capacity of Green Hydrogen to 8-10 entities and we awarded 1500 megawatt of electrolyzer manufacturing capacity to 8 entities. We will support electrolyzer manufacturing for over a period of five years and for green hydrogen production we will support for a period of three years.*

*This is the first tranche. We will be coming out with other tranches as well. In addition, we have launched pilot projects on steel, shipping, mobility etc. and these are in coordination and consultation with the respective industries and the respective ministries.*

*For example, for mobility the call for proposal is out and here we are looking at providing Viability Gap Funding (VGF) for running of the fuel cell vehicles or the hydrogen ice vehicles and for setting up of dispensing stations. For shipping sector, we are looking that Shipping Corporation of India would retrofit at least two ships to run on green methanol and we will also be setting up the facility for bunkering. In the steel sector, we are looking at both the processes for manufacturing of steel - the DRI process and the Blast Furnace process, and how we can use hydrogen there.*

*In addition to this, we have schemes in R&D. We launched our R&D road map and we are coming out very shortly with a scheme for supporting R&D projects. We are also coming out with the scheme for supporting of testing infrastructure, like electrolyzer testing, like testing of type-4 cylinders, then we are also coming up with a scheme for skilling of the manpower which is also in pipeline, and also for setting up of two hydrogen hubs.*

*So, the idea here is to do whatever is possible to reduce the cost of Green Hydrogen. There are certain incentives which are being provided under NGHM i.e., National Green Hydrogen Mission. Then certain incentives are also being provided by different states.*

*A large number of activities are being done by our Public Sector Enterprises. As CMD GAIL has said, the major intervention has been demand-creation. All our refineries and fertilizer units are now moving towards usage of Green Hydrogen and its derivatives. We have come out with a separate scheme for the petroleum sector and for the fertilizer sector. We have allocated 2 lakh tons of Green Hydrogen production to the refineries (petroleum sector) and we have also allocated 550,000 tons of Green Ammonia to the fertilizer sector. These bits will now be out and called in the next few months, so the process is on.*

*I would also like to say that there are large number of activities that our Public Sector Enterprises have undertaken. The CMD (GAIL) said that they are blending hydrogen in city gas distribution, in pipe natural gas, they also setting up of an electrolyzer facility in Bijapur. IOC has set up an electrolyzer facility, a dispensing station in Faridabad, and running 15 buses (on Green Hydrogen). NTPC has taken a large number of steps, they are setting up of a Hydrogen Hub in Pudimadaka in Andhra Pradesh, they are doing projects in Rajasthan, and they are also setting up of a dispensing station at Leh and running I think, five hydrogen buses there. NHPC is setting up dispensing station at Chamba and at Kargil. BHEL is setting up its own Center of Excellence for Green Hydrogen. THDC has set up its electrolyzer in Rishikesh. Oil India Limited has set up its electrolyzer in Jorhat (Assam). Cochin Shipyard has manufactured India's first Hydrogen ferry. Cochin Airport and BPCL are now planning to set up a Green Hydrogen unit at the airport.*

*So, a large number of activities are being carried out by a various PSE. These activities cover the length and breadth of the country. There are activities up the mountains (North) to South and East to West. Almost every area is covered and this would lead to creation*

*of an ecosystem across the country. These are some of the novel areas and locations which probably only Public Sector could do.*

*I think if we see the overall perspective then public sector will play a very crucial role in the adaptation of Green Hydrogen and its derivatives in the economy. The ministries here would like to support. I extend whatever support the ministry can provide to the Public Sector Enterprises across the board. Our enterprises now have taken up this decarbonization strategy to their heart. Many sectors e.g., the oil sector units, the power sector units, the heavy Industries units, the Indian Railways, etc. are entering the green energy space and green hydrogen space.*

*In the last, I would like to thank SCOPE and GIZ. We have a very longstanding and robust program with the German Government. We have a Green Hydrogen taskforce and over last few weeks we have such an intense level of engagement with our German counterparts. I see two of countries collaborating and cooperating in this exciting phase. So, thank you again. I wish you all the best for the sessions ahead.*

The last address of the session was provided by **Ms. Ruchika Drall, Deputy Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC)**. Ms. Drall is an environment and sustainability professional working on environmental and social safeguards for renewable energy projects with extensive consultancy and consulting experience in climate change, carbon accounting, and energy efficiency. She began with expressing gratitude to learned dignitaries and greeting participants and then delivered her address.

#### **6.1.7 Address by Ms. Ruchika Drall**

*Let me begin by congratulating SCOPE and GIZ, who have put together such an intense and diverse agenda for the day talking about the Green Hydrogen which is one of the key things that India has been working on right now and it is my absolute honor to be talking at this workshop on “Decarbonization of the India's Public Sector Enterprises and the Role of Green Hydrogen”, a gathering of some of the brightest minds and leading organizations dedicated to shaping a sustainable and equitable future.*

*Before I begin my address, I would say that a lot has been already talked about Green Hydrogen on this dais today and the colleagues from the Public Sector Enterprises have highlighted what role they can play, and Yadav sir has very beautifully brought about what different initiatives different PSEs are taking across the country covering the length and breadth of the country. So, with my address, I hope to add some value to it.*

*I would like to begin by saying that developing countries like India basically face dual challenge. We face dual challenge of meeting the development aspirations of our people at the same time mitigating and adapting to some of the climate changes that we have been experiencing across the world and to combat this challenge India has very responsibly embarked on ambitious transition Journey with commitment to reduce the emissions intensity of its GDP by 45% and ultimately achieve the goal of Net Zero by 2070.*

*PSEs, I would say particularly those in the heavy industries like power and steel have a very significant role to play or contribute to this particular journey owing to their enormous contribution to the greenhouse gas emissions of the country, which has already been highlighted by Mr. Sobti in his opening address and their transition to clean technologies and processes is going to be very vital for meeting India's climate goals and tackling climate change.*

*At the same time, it has very significant economic and social impacts and these implications can actually be termed as co-benefits. It has several co-benefits that include increasing resilience to the changes in the climate, enhanced energy security for the country, innovation socioeconomic development, and job creation.*

*India as a developing country is currently at a very crucial juncture in terms of the energy landscape as it is evolving. Due to its growing energy needs which is required to fuel its developmental activities being the fifth largest economy in the world and all geared up to become the third largest by 2030. So, from this number itself we can imagine the kind of energy demand that we can expect going forward.*

*Now Green Hydrogen has a very crucial role to play to make the nation self-reliant and energy independent. As already highlighted by the previous speakers, India has launched the very ambitious National Green Hydrogen Mission to become Aatmanirbhar through clean energy and serve as an inspiration to the global clean energy transition.*

*The target under the National Green Hydrogen Mission is to have the capacity of 5 million metric tons per annum by 2030 with an associated renewable energy capacity of 125 gigawatts because here we are talking about Green Hydrogen that is coming from the renewable energy sources. This target is actually associated with a lot of employment creation, new additional investments, and reduction of greenhouse gas emissions at the same time the numbers have already been talked about by Yadav Sir and the role of PSEs in this particular endeavor cannot be overstated.*

*I would say as a key driver for the nation's growth and economy, PSEs have a unique opportunity and the responsibility at the same time to lead by example because we all know that a lot of sectors which are not traditionally established as economically returning, PSEs have always taken a forefront in investing in those sectors looking at the associated social and economic benefits for the larger country.*

*Now by adopting Green Hydrogen for power generation, for transportation, for industrial processes, PSEs can actually set example for rest of the sectors. They can catalyze widespread adoption of these technologies across different industries. It presents a strategic opportunity for the PSEs themselves to grow. The investments into these upcoming and I would say niche sectors will actually strengthen the position of PSEs by increasing their competitiveness in the market, increasing their resilience to the changing climate, and also providing them a long-term viability in an increasingly carbon constrained world, I would say.*

*We talk about carbon budget, there is a very limited amount of carbon that this atmosphere can hold for us humans to survive the way we have been. So, in this upcoming or growing carbon constraint world, PSEs have actually this opportunity and strategy to their resilience and ensure their competitiveness going forward.*

*Now this is going to be very expensive. We require huge investments to be able to bring about the transitions that we really intend to and while doing so there is a risk of making some of the existing assets obsolete or what we call stranded assets in financial terms but let me assure you that the cost of this transition or the amount of investment needed in these particular transitions will be far less than the cost of any inaction for this transition. So, we need to do a very robust cost benefit analysis and we would realize that the cost of action is far less than the cost of inaction that is the reason we are having this conversation today.*

*I will give you an example on how these costs can actually be met in a collective manner. There is a recent initiative called Avaana Sustainability Fund (ASF) which has been supported by Green Climate Fund and this particular fund aims to invest in early-stage climate technology companies in the country which will be waving across different sectors such as sustainable resource management, mobility, supply chains, sustainable agriculture, and food chains, for that matter.*

*Now PSEs can actually target such facilities or funds to fuel the required transitions in their businesses and try to tap into the collective resources that are available domestically as well as globally and realizing this strength of collective and collaborative action, India had launched the Leadership Group for Industry Transition in 2019. This particular group we call LeadIT, is basically a group of countries and companies which are committed to achieve Net Zero from heavy Industries. The first phase of LeadIT was concluded last year i.e., in December 2023 and our Hon'ble Prime Minister Shri Narendra Modi had launched the second phase LeadIT 2.0 in Dubai last year along with the Swedish Prime Minister Mr. Ulf Kristersson and this particular phase of LeadIT 2.0 is basically focusing on the action on the ground through very structured framework and three basic pillars.*

*The first pillar is about providing a global forum for dialogue which LeadIT has already been doing for last couple of years. The second pillar is the technology transfer and co-development pillar which will focus on the development of the low carbon technologies jointly by the members of LeadIT. The third pillar is the industry transition platform which is basically trying to bring together people or countries or companies who are committed to a particular technology or a particular sector. I will give you one example under this third pillar of industry transition platform. India and Sweden have launched the India-Sweden industry transition platform and again this platform was also launched by the two Prime Ministers of the country and it basically aims to provide a tailored support to India's specific needs.*

*This particular ITP between India and Sweden is designed considering the requirements of the hard to abate sectors in India and it aims to catalyze collaboration, foster knowledge exchange, facilitate technology development or joint development, facilitate technology*

*transfer, and promote joint research and development endeavors. This platform as of now focus on hard to abate sectors and the current focus within those hard to abate sectors is steel and cement for India and it very well aligns with the urgent need to address the significant emissions that are generated from these industries and as they have a significant contribution to the overall greenhouse gas emissions from the country.*

*So, this particular forum today, I would encourage the Public Sector Enterprises to join international initiatives and particularly those who are in to the hard to abate sectors can consider joining the LeadIT group i.e., Leadership Group for Industry Transition to foster low carbon transition and to know more about the process of joining and what are the benefits of being a member to this particular group.*

*Please feel free to write to either MoEFCC or the LeadIT secretariate which is hosted by Stockholm Environment Institute in Sweden. You can reach out to us through any of these modes and we will be happy to assist you and highlight what all opportunities exist for collaboration for the members of this particular group.*

*As we embark together on this journey towards a greener, more sustainable future, let us reaffirm our commitment to collaboration, innovation, and collective action. The agenda for this event today has been very beautiful designed and it touches upon some of the very crucial aspects for making the Green Hydrogen a reality from the ambition and together different PSEs, Government, Private Sector Enterprises, Research Institutions, and all the stakeholders in this particular ecosystem, have power to shape the better tomorrow for ourselves and future generations.*

*So, with this hope I stop here for today and wish you a very fruitful and engaging discussion going forward. Thank you very much for your patient hearing.*

After this comprehensive address, the moderator thanked Ms. Drall for highlighting the various initiatives by the MoEFCC. She acknowledged that Ms. Drall have highlighted a very important concept of climate co-benefit methodology which is actually the core of the SCOPE-GIZ project while going forward in the next two years.

### **6.1.8 Unveiling of Study “Decarbonising India – Potential for Electrification across India’s Economy & Assessment of Electricity Needs”**

The moderator then announced that the GIZ India and Indo German Energy Forum (IGEF) have recently designed, conceptualized, and come out with a study on “**Decarbonising India - Potential for Electrification across India’s Economy & Assessment of Electricity Needs**” which can be a guiding force for the future of decarbonisation in India. She said that today’s workshop will be a good platform to release the study for a better use of all of the attendees (representing various PSEs). Then, she requested the dignitaries to kindly unveil the study. A total of six dignitaries, present on the stage for the inaugural session, launched the study. Further, she informed that the study can be downloaded from the IGEF website link – [https://www.energyforum.in/fileadmin/user\\_upload/india/media\\_elements/publications/20240310\\_Decarbonising\\_India/Max\\_electrification\\_India.pdf](https://www.energyforum.in/fileadmin/user_upload/india/media_elements/publications/20240310_Decarbonising_India/Max_electrification_India.pdf)

### 6.1.9 Vote of thanks – Inaugural session

After the unveiling of the study, the moderator announced the end of the inaugural session and spoke words of gratitude for all the dignitaries, which is as follows:

*On behalf of SCOPE and GIZ, I would like to extend a heartfelt thanks to all the dignitaries present on the dais and off the dais for taking time out from their busy schedules to join us for this very critical program. I would like to extend our heartfelt thanks to Mr. Ajay Yadav sir for his time and guidance today. We are also very grateful to Dr. Stefan Hesselmann for his time and sharing of thoughts today. I understand so you have a meeting with the Ambassador yet you have accommodated this program, thank you so much. We are also thankful to Sandeep Sir for always guiding us and also being with us today. We also convey our heartfelt thanks to Madam Ruchika Drall for being here and guiding us today and informing us about the various initiatives of MoEFCC. We are thankful to the collaborators Mr. Farhad Vania and Atul Sobti Ji for being with us and all always guiding us ahead. Of course, how can I forget to thank all the participants, all the Chief Executives who have nominated their officers for this program, thank you so much. Thank you to the SCOPE team and GIZ team for organizing this seamless program. With this, we come to the end of the inaugural session and I request the dignitaries to please join us for the technical sessions ahead Thank you once again all of you.*

It was followed by a brief tea-break. Immediately after the tea break, the moderator requested **Shri E. Nand Gopal, Director Grant Thornton LLP** and **Mr. Vaibhav Rathi, Technical Advisor-Climate Change, GIZ India** to take their seats on the stage. The moderator requested Mr. Gopal to briefly explain key findings of the unveiled study. Mr. Gopal, has more than a decade of experience of managing multiple, small to large, local and international project and addressing the distinct needs of each client. His forte consists of clean energy and climate change through conceptualization development and implementation of projects and programs on energy efficiency, climate change mitigation, NDC assessment, decarbonisation, and net zero strategy. The narration of Mr. Gopal's presentation is as follows.

### 6.1.10 Presentation by Mr. E. Nand Gopal

#### **Slide 1 (cover slide)**

*Very good afternoon to all. It is tough after such an esteemed panel has done the inauguration and you didn't get much break. So, I will not take much time. I would want to give you a high-level overview of the study. As you read, the task given to us by GIZ was largely on how do you decarbonize India by giving a much higher emphasis on electrification. Look at every sector and sub-sector and see up to what extent can we electrify it and when I see up to what extent we were given free hand to not just look at technologies which is present today but technologies which are kind of under development or piloted or could play a major role in future as well.*

## **Slide 2**

*So, with this objective, our approach for the study was - we had a German partner 'HEAT' who was assisting us with identification of technologies. The idea was that you map all possible available technologies at present which are not piloted, which are maybe under R&D, which have been announced but there are lab scale projects but also look at projects which have been commercially adopted in various other countries but not yet flourished in India. So, with that background, we did extensive research - connecting in with lot of R&D institutes, connecting through our German partners with European institutions and understanding in each sector how the technologies are going to play out in the coming decade and two and beyond. Based on this we mapped out sector-wise technologies, created a road map for 2030, 2050, and 2070. The three timelines are quite unique as you know, 2030 focuses on NDC, 2050 align with the 1.5-degree target, and 2070 of course India's net zero target.*

*With this what we did was - we looked at every sector i.e., industry, agriculture, transport, buildings, and appliance. Within sectors we further bifurcated down to sub sectors like when I say industries, iron and steel, aluminum, refineries, cement, every sector was looked at as a standalone perspective that how can they go all out electrified. How can I electrify say an iron and steel primary plant, which looks absurd, but it is possible there are technologies out there. Then we did economic modeling of how India would grow beyond 2030 till 2070 and various scenarios were developed. A high growth scenario – a scenario which aligns with India 2047 targets and then there is a scenario which was given as ambitious which is goes beyond 2047 targets, and we developed excel based tool which was given to GIZ and this tool is something where you can play around with technologies and see how each technology, if let's say, I pick a technology and say it becomes mainstream by 2030 or 2035 or 2036, how would it impact the sector and the overall GHG emissions of the sector.*

## **Slide 3**

*With this pretext, let me give you a very high-level overview. So, what the study identified is that in order to achieve net zero electrification will definitely play a major role, not just because electrification is important, also because electrification also brings and improves the efficiency. If you look at this graph, you will see that roughly 56% of emissions due to energy consumption can be brought down by direct electrification. When you electrify a technology, for example, you have a simple cook (gas) stove – you go for induction cook top, the efficiency doubles. This is a small example of an appliance but if I move a notch up to an industry, let's say I have a coal fired 10 ton per hour boiler in an industry which is which has efficiency in tune of 80% - I go for electric boiler, I get efficiencies in tune of 98-99%. So, you see the electrification is also bringing in energy efficiency, so that can lead to roughly 37% of efficiency the GHG reductions. What's remaining is the thermal needs which can't be electrified. Now you look at indirect means to electrify that which is of course the theme of the day i.e., Green Hydrogen and Green Ammonia and other sustainable fuels. The study focused on the emissions because of energy use, there are fugitive emissions like due to refrigerant leakage in buildings or say process emissions like in*

cement plant, calcination will lead to a CO<sub>2</sub> release, so those emissions are not part of the study. Those are exclusions, it is understood that they would be either captured or off-settled in the future process so the emissions are looked at.

#### **Slide 4**

Now having painted this picture, how do we achieve there? We looked at step by step – firstly looking at the technologies based on sector. So, by which year do you think can a sector be fully electrified? We tried to map that. There are various ways to look at it. Apart from the consultations and the desk research which was done, we also looked at various corporates and industrial groups and their commitments – how are they committing to become net zero? What technologies are they relying on? If you look at this graph, Railways as you know, will be all electric by 2030, same for the cold storage, and building & appliance sector. This is something which is quite easily achievable but on the other end of the spectrum you have sectors like brick where electric kilns are available but these electric kilns have not been adopted fully even in the developed world yet. So, we need some time for it to mature in the developed world then make its way. Also, bricks are something which are largely with the MSME sectors in India, so you can't push the MSME sectors very early. Hence that goes to the far extreme and there are other sectors in between which you see here - fertilizers pump set, agricultural pump sets, which are running on diesel could be electrified, and so on and so forth. Now, if you electrify each one of these sectors, electrification is as good as the grid is. Right? If you don't have a clean grid, then electrification will not lead to the GHG reduction.

#### **Slide 5**

So, it's very important that we look at how the grid is decarbonizing itself, how the Grid's emission factor is coming down. You all know that CEA (Central Electricity Authority) has done a projection couple of years ago where it says the grid emission factor would be somewhere around 0.61 but that was before the 500 gigawatts target. If you look at 500 gigawatts plus the Green Hydrogen Mission and everything that should be coming down far lower than that study – what's important is that a very massive deployment of renewable energy technologies is required. We need to look at storage in a big way. As I said, we had three different scenarios – one more of a conservative, one moderate, and an ambitious scenario. What's important to look is, in all of this scenario, the requirement of renewable energy by 2030 if you see it's coming more than 500; when first 500 gigawatt was announced, it was seen as a landmark number, something which can't be achieved. But when we do scenario modeling that okay, these are the technologies which are at a TRL-9 (Technology Readiness Level 9), they can be deployed immediately and if I want to deploy them, I need this much electricity. That means, to achieve that level of decarbonization, 500 (gigawatts) is not sufficient, you need to go beyond 500 (gigawatts) and this 500 (gigawatts) does not include your Green Hydrogen at all. The honorable spokesperson in the morning from MNRE said that you need additional 125 gigawatts for the Green Hydrogen, so add to that of our projection, we are looking at in excess of 800 gigawatts, that's very important. We are seeing a very sturdy phase out of fossil fuel from 2030 and beyond, the exclusions here is that no announcements of nucleus have been

*included. The study was conceptualized and done about a year ago and what we have assumed is that all the announced nuclear projects will see it end of life and then we shift towards renewables completely, that's something which I thought I should highlight. If you look at net zero scenario where roughly 70% of electrical energy requirement would be coming from solar, the number seems daunting – close to 5,800 gigawatts. But if you look at that, that's equivalent to less than 4% of India's wasteland, which is not being utilized presently, can achieve that sort of number but the investments required is not just towards renewable but also towards the robustness of the network.*

### **Slide 6**

*Once we establish that renewable requirement, the next step was to understand how much each sector can be electrified directly and how much can be electrified indirectly. So, for direct electrification the idea was that all those technologies which are TRL 7-9, which have been demonstrated anywhere in the world, we bring them and we make them mainstream in the country over the next six years as of now by 2030. The next phase which is 2031-2050, we looked at present TRL 4-6. For example, if you look at molten oxide technology or electrowinning technology for iron and steel plants, these are 100% electrical options which would replace your blast furnaces as we know today. There are already pilots which are announced – by 2027 will see the results out of them, actual steel coming out of full electrical systems. So, these could be upscaled in India.*

*We are not looking at those to be adopted by 2030 because we want to see the results by 2030 and beyond 2035-2040, those to be adopted, which means a large part of expansion in the steel sector beyond 2030, we should be looking at these technologies rather than the present focus of 2030 which is largely on BF-BOF (Blast Furnace-Basic Oxygen Furnace) route. The other advantage as I spoke was the inherent efficiency advantage which you get with electrification.*

*The graph in the center – it highlights some of the technologies and what level of efficiency improvement you get beyond the conventional counterparts. I will take an example of electric kilns. Cement plants have coal fired kilns but there are technologies which are proven, installed, demonstrated, and are being replicated already which are electrical kilns and they give you multiple co-benefits beyond GHG reduction as well – they give you capability to capture CO<sub>2</sub> unlike in a conventional cement plant where the flu gas steam has lot of particulate matter and you require a substantial cleaning system. Over top of all these benefits you're getting 30% efficiency improvement as well, so that's very niche technology. There is discussion with a lot of global vendors (Australian and Sweden vendors) in India, as well we have handholded many such discussions and we see that by 2030 we will be seeing some of these coming through.*

*Now with the intermittency of renewables, it's important that we have a very good storage system in place. For this storage system we have done an equivalence calculation. You might say that there might be pumped hydro storage as well there might be other forms of storage but what we did was - okay this is my total energy requirement which is coming from renewables and I need to store it to in order to be able to use it over a 24-hour period*

*and we converted to equivalent battery storage requirement, and that's presented here. If you look at those numbers and what the government wants to achieve through their PLI (Production Linked Incentive) that's hardly 10% of what you're seeing for 2030. So, again emphasizing on the part that we all speak that batteries are expensive today or pump storage is just taking off but it's at that curve of 'S' curve where it's going to explode quite soon – next two three years are going to be important for storage.*

### **Slide 7**

*Next couple of slides are the final things on indirect electrification. If you look at industry as a sector, even by 2050 and 2070 you will not achieve 100% electrification because they're going to be many processes which would require heat, which would require steam, and you will have to look at alternate options for achieving that thermal energy and that will be done through Green Hydrogen in large part of the industries and as spoken by a couple of speakers in the Inaugural session, Green Hydrogen will not only be required as a fuel but also as a feed stock. Some of our estimates show that by 2030 you would need 6.7 million metric ton of Green Hydrogen. Our target of Green Hydrogen Mission is about 5 million metric tons so that means the requirement is going to be far higher than our target. If PSEs and large corporates are taking step towards Green Hydrogen then definitely the ecosystem will evolve there and the total need is close to 42 million metric ton for energy needs. For feed stock needs we considered iron, steel, and fertilizer sector. Refinery sector is not added here if you add that then the feed stock requirements will jump up multifold.*

### **Slide 8 & 9**

*The final sector I want to touch upon is transport which is something which can't be 100% electrified. You need to have other sustainable fuel options there. Already up to 1100-kilometer flights have been electrified, demonstrated, and running successfully, so that is something which can be electrified but if you look at India, roughly 85% of the domestic aviation market is beyond that 1100 kilometer so that would be met by sustainable aviation fuels, where we can use renewable electricity or hydrogen for catalytic reactions to produce a sustainable aviation fuel. Shipping sector is very important domestically. The small distance fishery boats can be electrified. There are a lot of case examples globally which are running on electrical options. Roughly 20% of the shipping which goes to the outer seas would need Green Methanol for this purpose and the Green Methanol requirement along with the SAF (Sustainable Aviation Fuels) requirement is also estimated. So, this is a very high-level overview. If any of you are interested to deep dive in any particular sector, we would be happy to connect offline. Thank you very much.*

After this, the moderator thanked Mr. Gopal for his insight into the study. She then requested **Mr. Vaibhav Rathi, Technical Advisor-Climate Change, GIZ India** to highlight the scope of project under which the Workshop was organised. Mr. Rathi is an expert in circular economy and climate change and has an experience of over 13 years in development sector. He has worked on sustainability assessments and implementation of innovative low carbon technologies and construction sector. The narration of Mr. Rathi's presentation is as follows.

## 6.1.11 Presentation by Mr. Vaibhav Rathi

### **Slide 1 (cover slide)**

*Good morning, everyone. I believe you have heard this term called 'co-benefits' since the morning by the dignitaries in the inaugural session. I would like to deep down on what is it all about and the project that now we have in collaboration with SCOPE, what are we going to do in it for public sector Enterprises through SCOPE.*

*So, the project is termed as "Indo German Support Project for Climate Action in India". It is supported by BMWK which is the Ministry of Economic Affairs and Climate Action, government of Germany and our political partner is the Ministry of Environment Forest and Climate Change in India, and in this particular case SCOPE is one of our partners where we work with all the PSEs on decarbonization, developing climate co-benefit methodologies, and capacity building on climate change. So, I am just going to talk a bit more about that - what are we going to do in this project? The core question that this project is trying to answer is how development and climate can work together and you have heard and you know PSEs are at the forefront for the development in India. They contribute a lot to development in India.*

### **Slide 2**

*Through this project, we are trying to develop methodologies which is climate co-benefit methodologies. What do we mean by climate co-benefit methodologies is – Public Sector Enterprises take a lot of initiatives either in the core businesses or through CSR measures. There are core businesses initiatives such as reducing energy and reducing fuel; CSR measures such as planting forest and supporting the community, but they all are done with a particular objective. If there is a forestry initiative, it is done with an objective of planting trees – greening the area, if it is done with a core business objective of reducing energy / reducing fuel – it is one of the core objectives is to reduce cost and also reduce energy demands but are these initiatives looked from the lens of climate? Sometimes it is, sometimes it is not. But it is not like a mainstream lens through which PSEs look at and enter into an initiative with a core objective of climate change and this is what we are trying to address by developing climate co-benefit methodologies for programs and initiatives which does not have climate as its core objective but when implemented on the ground, it does impact climate mitigation or adaptation. But do we have a methodology through which PSEs can quantify – How much carbon am I mitigating by planting say X hectares of forest? How much carbon I am mitigating if I am installing a heat exchanger? How much carbon I am mitigating if I am trying to preheat my Limestone before it goes into the Limestone kiln for making a clinker? Sometimes you do, sometimes you don't but there is no methodology which is mainstreamed which can help you assess that. What can be quantified, can be used for approving a lot of things which are available in the market. You have heard, there are a lot of financing mechanism which are available in the market. Every PSE comes out with a sustainability report. A lot of things which are not quantified yet, can be quantified using this methodology. So, this is what this project's core objective is – to support you and work with you in developing these climate co-benefit methodologies*

for programs and policies, for maybe not entering into the climate focus but they do have a climate impact either in the terms of mitigation or also more importantly in terms of adaptation because adaptation impacts are very often not being quantified. With this co-benefit methodologies, GIZ and SCOPE can work with you (PSEs) in addressing this climate action by Public and Private Sector Enterprises which is also Prime Minister Modi's call that how do you basically support in climate action. So, a lot is already going. Where we want to come in and support is through the co-benefit methodologies help you quantify – what you are doing, also mainstream climate in your future policies, in your future programs, in your future initiatives, so that you already have readymade available tool which you can use right at the beginning of inception of a business plan which basically may be used to reduce your energy or maybe a CSR plan which basically is intended towards planting forest. So, you can enter into those objectives and planning with a climate lens. That's what climate co-benefit methodology means and it also means to support PSEs through this collaboration.

### **Slide 3**

Why do we need to engage with PSEs? You have heard PSEs basically are at the forefront of supporting India's development goals, they contribute a lot to GDP, but on the contrary, there are also many PSEs working in hard to abate sectors which means, sectors contributing a lot to the development of the country but that is also hard for them to decarbonize because of the inherent nature of the business they are in, so that's how they are defined as hard to abate sectors. Ruchika Drall, in the inaugural session already mentioned what are the priority sectors for government of India. There is a list of hard to abate sectors. In this list, cement and steel are two prime hard to abate sectors which we are focusing on. Also, we live in a globalized world. PSEs just not do business in country but they also do business globally. The global policies and global outlook on climate action is changing. Very recently (yesterday), India signed the FTA agreement, though the CBAM (Carbon Border Adjustment Mechanism) was not discussed in the FTA agreement. But now we have EU-FTA coming soon, we have other FTAs coming soon, CBAM might be discussed there. What I am trying to put out is that these CBAM or other initiatives from the world which is beyond India, might kick in for the Indian industries as well and we need to prepare ourselves now. Maybe, they don't impact us (PSEs) now but they are going to impact us by 2030-2034 and we need to prepare ourselves and that's why we need to engage with PSEs, that's why we need to have tools that are assessing climate impacts of what you're already doing. You need to know what is that Delta, you are not calculating and that where we come in – to provide a methodology to calculate the Delta for you, both in terms of mitigation and in terms of adaptation. So, climate co-benefit is basically is a tool to support you in raising ambition or maybe achieving your target, with what you already have as of now. So, that is why we need to engage with PSEs, that is why we need to build capacities, and that is why we have projects like this and this collaboration with SCOPE which prepares PSEs for what is coming nationally and what is also coming in the globalized world with which the PSEs do business with. So, we need tools and mechanisms for PSEs to assess climate co-benefits of their existing initiatives.

#### **Slide 4**

*How can the Climate Action Project and this collaboration with SCOPE support the PSEs? First one is – we develop methodologies but we don't do it in silo. During the course of two years of engagement with SCOPE, we are going to reach out to you (PSEs) to hold consultations in getting feedback from you on how do we develop these methodologies for you because ultimately you are going to be the users of this methodology. So, we want to have a feedback loop while we are developing these methodologies with you. We basically assess and report the climate achievements and targets which can support further the climate action. PSEs, as I said, as an example, might be conducting a lot of forestry initiatives but maybe the objective is to reclaim the mines which are already abandoned as of now. But is climate a core focus? Is the objective to assess how much carbon I am mitigating if I plant X hectares of trees in my reclaimed mine? Maybe or maybe not. So, that is what we want to discuss with you, to consult with you – how do we develop methodologies with you so that you can use it. They can also strengthen the outputs of this methodology such as carbon mitigation, impacts on adaptation, to strengthen your sustainability practice reporting. A lot of data goes into the sustainability reporting that you do but it can be strengthened further through these methodologies. Also, through quantified climate impact either in terms of carbon mitigation, you can use this as carbon credits to access climate finance from the market, access the funds such as GCF (Green Climate Fund) which was mentioned by Ruchika Drall in the morning that your initiatives can be used to access Green Climate Funds and climate co-benefit methodologies can be one of the tools for you to assess how much carbon will you mitigate with your initiative that you are going to implement say two years down the line or what are you already mitigating through initiative which is going on for the past two years so that is where the importance of climate co-benefit methodologies comes for you in terms of accessing climate finance.*

#### **Slide 5**

*We have already developed an online training module on climate change and climate mitigation/adaptation. We would launch it very soon along with SCOPE. It is an online self-paced learning module. You all can have access to it and certificates will be generated so that's one of the measures that project is doing to build capacities of PSEs on climate change. There will be also a lot of knowledge exchange initiatives which will be done within PSEs because PSEs can also learn from each other but also from stakeholders outside the country and outside public sector universe which is the private sector, which are doing similar carbon neutral or carbon positive practices which PSEs can learn from. So, there will be a lot of capacity building in terms of trainings, in terms of knowledge exchange that the project will be supporting and reaching out to you through SCOPE. The project can also support this collaboration with public and private sector because as of now I don't see a lot of active collaboration between public and private sector but both of these sectors work in similar areas of interest and both of these sectors are taking a lot of initiatives on climate action. We also support more focused assessment of technical and commercial feasibility of low carbon technologies with specific PSEs. We have already started an*

*initiative with SAIL on assessing – What is commercially feasible for a particular steel plant? What is technically feasible for a steel plant on climate positive technologies? So that as a business you can take a decision to invest in these technologies. Using this techno-commercial feasibility analysis, you may ask for financial support from outside (financing organisations) based on the robust analysis of what works and what doesn't work, and where do you need support? So, this is basically a tool for the planning process and implementation process that we are going to support and this one bit of it we are already started with SAIL.*

### **Slide 6**

*The next step in the proposed engagement is that we need your inputs on development of climate co-benefit methodologies. We need your support in institutionalizing these methodologies within your own reporting mechanisms. We don't want to create additional work (therefore) we would like to know how are you already reporting for your sustainability reports and we want to integrate that into your existing work and not add another layer of tool / process for you to work upon. So, that is the approach that we are going to follow. We also want to take up and make use of the online training modules that are being developed on climate change and also a potential collaborative climate declaration from the PSEs - What are we going to do in the next 30 years or until 2047. That is what our aim is – to help you come up with a climate declaration from all the PSEs.*

*I would like to end with a recent fact that I know and this is basically a bit of out of context. In 1960s, Indian Hockey team was invincible. There was no one in the world that could defeat Indian Hockey team but post 1970s India took 41 years to win a silver medal recently in Tokyo Olympics. It took us 41 years post 1970s to win a silver medal for a team which was invincible in 1960s. Why did that happen? There was one change that happened in 1970s. The turf on which Hockey is played changed from a natural green grass turf to an artificial turf and the Hockey team maybe was not able to keep up with it and it took us 40 years to catch up. Now just to put it into context, in India the turf of climate action is changing. There is a change in the turf and together we need to keep up with the turf to keep up with the competition and also the turf which is now changing on climate action. That is very much visible in CBAM, that is very much visible what government of India is doing, and that is very well visible on why we are sitting here. We are here to support you with all other activities that you're doing within our scope, what we can do to help you keep up with the changing turf of climate action and that's how I will end. Thank you so much.*

After the presentation, the moderator mentioned that the interest and inputs from the public sector and corporate fraternity is extremely important to take the project forward and benefit PSEs. Both speakers were then felicitated with a token of gratitude. It marked the end of the inaugural session of the Workshop.

### 6.1.12 Key outcomes of the session

- Shri Atul Sobti opened the inaugural session and highlighted the role and potential of PSEs in contributing to the national agenda on climate action. He also briefed participants about the latest SCOPE-GIZ endeavor for the capacity enhancement of PSEs.
- Mr. Farhad Vania provided program perspective that not only highlighted complex issues related to climate change and the urgency of collective climate action but also inculcated participants about what they could expect from the workshop. The importance of PSEs highlighted by him along with their strategic role in mitigating climate change was noteworthy.
- Shri Sandeep Kumar Gupta through his comprehensive address highlighted initiatives from several PSEs in the area of sustainable energy sources especially green Hydrogen. He also pointed out the need of understating techno-commercial studies by PSEs operating in hard-to-abate sectors of the economy.
- Shri Ajay Yadav provided a very insightful address that highlighted the importance of electrification and demand creation for renewable and alternate sources of energy including Green Hydrogen. He also enlightening participants about the future plan and various schemes of the Government of India for PSEs which would go a long way in creating an ecosystem across the country for the successful implementation of the National Green Hydrogen Mission. His eloquence in articulating his vision for the green future has left a lasting impression on all attendees.
- Ms. Ruchika Drall through her enlightening address highlighted the importance of the adoption of climate co-benefit methodologies and transition to clean technologies and processes including Green Hydrogen as crucial components to address climate change. She also very well-articulated understanding and awareness about India's international coalitions to tackle climate change.
- Mr. E. Nand Gopal had reflected the idea of behind the study "Decarbonising India - Potential for Electrification across India's Economy & Assessment of Electricity Needs". He explained that realizing deep decarbonization will require massive technological leaps into every economic sector to achieve complete electrification of industries. Electricity generated from renewable sources will serve as a cornerstone in decarbonization efforts. The inevitable residual thermal energy demand from electricity incompatible sectors may get fulfilled by Green Hydrogen & its derivatives and other cross-cutting technologies.
- Mr. Vaibhav Rathi briefly described various component of the project "Capacity Enhancement of Public Sector Enterprises (PSEs) in India on Climate Action". He explained – how can PSEs accelerate their climate actions by applying and institutionalizing climate co-benefits methodologies for mitigation and adoption impact accounting and reporting, and also how can they take help in supporting them for low-carbon investments and pathways in two chosen focus areas for this project i.e., Circular Economy/Resource Efficiency (CE/RE) and Forestry/Biodiversity.

## 6.2 Session 2 – Green Hydrogen and its role for India’s Economy

### 6.2.1 About the session

With an aim to make India the Global Hub for production, usage and export of Green Hydrogen and its derivatives, the “Nation Green Hydrogen Mission (NGHM)<sup>13</sup>” was implemented by the Ministry of New and Renewable Energy (MNRE) after its approval by the Union Cabinet on 4<sup>th</sup> January, 2023. The Green Hydrogen is being envisaged to have tremendous potential as an alternate fuel in near future, nonetheless, it has few limitations such as its high cost and its nascent stage across globe. After discussions with multiple stakeholders, the MNRE has issued the Green Hydrogen Standard<sup>14</sup> for India on 18<sup>th</sup> August 2023 that outlines the emission thresholds for the production of Green Hydrogen. It was also notified<sup>15</sup> that the Bureau of Energy Efficiency (BEE), Ministry of Power (MoP) shall be the Nodal Authority for accreditation of agencies for the monitoring, verification and certification for Green Hydrogen production projects. At present, some PSEs in India such as the NTPC Limited, Oil India Limited, etc. have already started adopting the Green Hydrogen as alternate fuel. However, many PSEs are yet to begin on this endeavor.

The fundamental aim of the second session was to sensitize participants about the Green Hydrogen, National Green hydrogen mission, and its role in contributing to the India’s economy through first realizing its potential and then by creating a niche among PSEs, especially those working in hard-to-abate sectors of economy. To make the session relevant and impactful, four eminent panelists from the MNRE, BEE (MoP) along with an international Forum i.e., Indo-German Energy Forum (IGEF) were invited to speak on “Green Hydrogen and its role for India’s Economy” so that participants get a chance to listen to field experts from the relevant Indian ministries and international institutions.

The first panelist for the session 2 was **Dr. Prasad Arvind Chaphekar, Deputy Secretary, MNRE**. Dr. Chaphekar has a wide experience in revenue and climate change areas, both very diverse in nature. Presently he is working in firming up the National Green Hydrogen Mission of India.

### 6.2.2 Address by Dr. Prasad Arvind Chaphekar

*Hello. So, I will just give a brief overview of when the mission was launched and what have we done so far and what can you expect in the coming months. The mission was launched on 4<sup>th</sup> of January, 2023. The overall budgetary outlay was 19744 crores. The mission comprises many areas but the bulk of the budget was in the SIGHT program. The SIGHT program is a program which incentivizes production of Green Hydrogen in India and promote manufacturing in India. So, we have a subsidy per kg of hydrogen, three years and per kilowatt of electrolyzers for five years. This is the bulk of the mission budget. The*

<sup>13</sup> <https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2023/01/2023012338.pdf>

<sup>14</sup> <https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/aug/doc2023819241201.pdf>

<sup>15</sup> <https://pib.gov.in/PressReleaselframePage.aspx?PRID=1950421#:~:text=Green%20Hydrogen%20Standard%20for%20India,H2%20as%2012%2Dmonth%20average>

*total mission budget is around \$2.4 billion, around \$2.1 billion is for the SIGHT program. The other component – we have projects which you do in steel, shipping, and transport; that's the second most bulky part of the budget. We also have separate budgets for R&D, for skill development, and others.*

*So, let me start with the SIGHT program. The SIGHT program has two parts – (1) it is to incentivize hydrogen production in India. So, the scheme guidelines were out in June 2023 and the first bids were out on 7<sup>th</sup> of July and the first bids were finally awarded in the month of January (2024). So, we auctioned out or the capacity which we are giving our incentives, the first tranche was for 4,12,000 tons of production. We ordered to around 10 companies and the time for commencement of the plant is 3 years. So, we will be expecting the first molecules at scale in three years that is February 2027. The second component that is the part - we did an auction of 1.5 gigawatts capacity per annum. We will be giving incentives for five years and the incentives will be tapering down every year. We awarded the incentives based upon two categories (the selection was done in two parts) – one, how efficient is your stack? and two, how much of it are you making in India? So, the bidding was only on the quality and indigenous nature of the of the stack. So, the field was made more, even any startups may also compete. So that we awarded to around eight companies. The time which we have given to commission the plant is two and half years but many of them were already in the process of setting up their plant so you may see capacity is coming up much sooner than two and a half years. Some of the plants may even commission at least partly even this year. So, this is the bulk of the SIGHT budget.*

*The second is as I said goes to the projects in different areas (such as) steel, shipping, and mobility. So, all the three guidelines for the disbursement of funds for projects in these three sectors were notified in the month of February (2024) and Ministry of Transport through its agency ARAI (Automotive Research Association of India) are already out with the call for proposals. The last day of submitting is I think 24<sup>th</sup> March. They will take a month or month and half to evaluate the proposals and probably after elections (probably in June or July) we hope to award the winners of projects in the sector of Mobility. Side by side, you also see the call for proposals for steel and shipping also come through in the meantime. We hope to award all the projects as soon as possible, within a few months from the date when election is over. We also have a separate scheme for R&D. That's a separate budget and the scheme is under submission and I hope it will be approved shortly. So, there will be also call for proposal for R&D which will be launched along with the scheme and those will be mission mode projects. So, I have given a brief overview of what we have done so far and I would now like to hand over the mic back to you. Thank you.*

The moderator thanked Mr. Chaphekar and requested **Dr. Ashok Kumar, Deputy Director General, Bureau of Energy Efficiency (BEE)** to kindly present on the Green Hydrogen Standards of India. Dr. Kumar presently leads the implementation of national mission of enhanced energy efficiency which is a part of national action plan for climate change

(NAPCC). Before joining BEE, he worked as a scientist in National Physical Laboratory and also the Bureau of Educational and Cultural Affairs (ECA).

### 6.2.3 Address by Shri Ashok Kumar

*Good afternoon. I think after Dr. Chaphekar intervention, I would be doing the fill in the blanks particularly because MNRE is leading the Hydrogen Mission and under the mission, Bureau of Energy Efficiency is given the responsibility to create standards for hydrogen and also the accreditation process for the verifiers. So, those are the responsibility, within that I would like to have some of the comments. As you know, the ministry's notification of hydrogen standard of August 2023 where there is a certain benchmark that has already been indicated that what would be the carbon footprint of a 1 kg of hydrogen, that would be considered as "green hydrogen" in India. Along with that the process of engaging agencies those would be doing the verification of such projects, those processes are on Bureau (BEE) under the guidance from the Ministry of New and Renewable Energy. We are in the process of framing the broader contours of the certification process itself and also taking a stakeholder consultation and also looking at various components of the hydrogen production and fixing boundaries – fix how the various monitoring, verification, reporting, all processes and protocols that could be developed or needed to be.*

*Also, as the India is going full throttle on the hydrogen so there may be possibility that we would be adopting some of the internationally available protocols or procedures to help us in the whole process of developing the procedures and the methodologies. So, these are some of the activities that Bureau (BEE) is doing and as you know that the level of carbon intensity that has been identified or that has been fixed in India is quite ambitious which kind of forgives us a lead in the whole game so the public sector units would be taking up in this journey. I think if we can maintain that level of carbon footprint, certainly that's going to be a big plus for our production or our products.*

*So, just to repeat myself from the Bureau (BEE) side, we are in the process of framing all the certification process because the accreditation of the agencies who is going to verify the projects that would be done by Bureau of Energy Efficiency as you know at many of you are party to Indian carbon market where we have done extensive consultation for creating a cadre of what we call Accredited Carbon Verifiers (ACVs). So, a lot of ground has already been covered. The same set of (pool of) professionals having the level of competency, we should be doing the verification in the carbon market which we find that same kind of people would be able to do that. If at all needed, certain credentials for specific to the hydrogen that would be added or that would be looked into. So. that is I think where we are. So, I would stop with this initial remarks. Thank you.*

The last panelist was **Mr. Tobias Winter, Director, Indo-German Energy Forum (IGEF)**. Mr. Winter has gained professional experience in renewable energy and energy efficiency projects and the corresponding legislation in various countries like Germany, India, Argentina, Uruguay, and Paraguay. He has worked extensively in the area of solar energy and has been

promoting energy security, efficiency, and renewable synergies. The narration of Mr. Winter's presentation is as follows.

#### **6.2.4 Presentation by Mr. Tobias Winter**

##### **Slide 1 (cover)**

*Thank you very much, Samridhi Ji. With your permission, I will do a PowerPoint presentation. Namaskar everyone! I will try to keep it short.*

*Any idea how many gigawatts of electrolyzer capacity have been installed globally in 2023? I see some experts here in the room.*

*Let me maybe begin, first of all thank you very much to SCOPE and to my colleagues from GIZ for having agreed to organize this session. We were very much thrilled when we heard that you wanted to do this and you said hydrogen has to be prominent within this event and I am really delighted that I am able to sit on the same panel with Dr. Chaphekar Ji and Shri Ashok Kumar. You are the ones which actually are into the design of the Green Hydrogen Mission of the country. So, whenever Prime Minister asks something about Green Hydrogen it goes down to the Minister, the Minister brings it down to the Secretary, and then JS, and at the end Director level, and Deputy Director General. You are the ones actually on the forefront of the Green Hydrogen Mission. So, very much honored to be here today.*

##### **Slide 2**

*Fifty-two countries as per the Bloomberg strategy tracker have actually now put their Green Hydrogen strategies in place. All major economies across the globe are betting on Green Hydrogen, 29 in preparation, 31 not assessed.*

##### **Slide 3-4**

*India is at the forefront as per Bloomberg New Energy Finance country comparison. They see that actually Green Hydrogen from renewables will be competitive at least with blue hydrogen from natural gas in 2025. So, this is maybe also one of the reasons why in India we don't even talk about blue hydrogen too much because green hydrogen already makes sense so much in the near future in India that we rather look into making green hydrogen competitive with gray hydrogen and many see this as maybe a little bit too optimistic but there are people which say that 2027 is possible to make green hydrogen competitive with gray hydrogen and India again at the forefront. Why is that?*

##### **Slide 5**

*Thanks to Shri Sahai Ji (Shri Sanjiv N. Sahai), former Secretary, Minister of Power. He actually then became the president of the power foundation. He actually convinced Bloomberg New Energy Finance to not only give the data to the subscribers, to the big corporates, to the big banks, but also to the foundation so Bloomberg New Energy Finance actually came out with the levelized cost comparison for solar in different countries and*

*made it available to the public. So, this graph is public and doesn't have any restrictions in publishing it and here you see that actually India is able to harvest the Sun at the lowest cost globally. So, we know that India may not have the sunshine as some other states like the south of Chile but India is able to harvest the Sun at the lowest cost and that's what it's all about.*

### **Slide 6**

*Then, there is one factor which us Germans look at India and we really become one could say a bit jealous because your sunshine. We always hear 300 days of sunshine in India. It's not true. It's 365 days. It's maybe 300 days in one point, in one geographical location but all over India – Monsoon is not everywhere in India at the same time. So, one can say that actually you are so much blessed with the sunshine and the Sun is always shining in India.*

*So, your worst day and that's really difficult for us to believe in Germany, your worst day of solar radiation and generation as per POSOCO data is actually 50% of the best day throughout the year. That's amazing. In Germany we go down to maybe 1-3% of generation and then go up to 100% in summer.*

*So, we need to talk about long-term storage but in India being assured that the sun is shining that's a big advantage to let those electrolyzers run and produce Green Hydrogen at competitive cost.*

### **Slide 7**

*Same with wind, there India is playing in the global league and though wind may be 20-30% more expensive than solar, it's having the benefit of actually blowing mainly in the morning and in the evening complimentary to solar and India again being well positioned globally under the top 10 in terms of being able to harvest the wind at the lowest cost globally.*

### **Slide 8**

*Electrolyzers that's the topic. Electrolyzers have been amongst us for a very-very long time. I had asked initially how many gigawatts you believe have been installed in 2023? Any idea? Maybe megawatt not gigawatt? We are at gigawatt scale.*

### **Slide 9**

*So, it's 1.7 gigawatt, shipments at least, that's the statistics that are out in 2023 and high growth rates of around 100% at low levels. So, we are talking about 3.6 gigawatt that's going to be shipped and certainly installed in 2024. If we compare this to battery, just to put this a little bit in perspective, any idea how much gigawatt of capacity battery or storage has been installed? Not talking about pump storage really talking about mainly battery (lithium-ion batteries) in large scale projects, not those small backup power batteries, we are talking about batteries above 2 megawatts.*

### **Slide 10**

*That's the statistics. Forty-two gigawatts and in average two and a half hours of storage capacity - so 99 gigawatt hours. That's globally and annual growth is around 40% but coming back to the picture I have shown (slide 8), that is a photo from India and I am always amazed when I hear that actually India was once and may become again in the forefront of Green Hydrogen production in the world. India had how much green hydrogen electrolyzer capacity installed already or how much electrolyzer capacity for green hydrogen production do we have installed today in India? Any idea, Dr. Chaphekar? I think estimates are more like 5-10 megawatt.*

### **Slide 11/12**

*Are you aware that more than (I think) 50 years ago, India actually had installed 180 megawatts already at Nangal fertilizer plant and I think the green electricity came from Bhakra Dam and you see one of those stacks is huge – 3 megawatts. That was installed in India by Italian company which was bought by the German company Thyssenkrupp Nucera and it was later then replaced actually by natural gas-based hydrogen production because one saw that the electricity was really costly and it was switched to natural gas. So, now we are trying to get back to where we were in 1962 and it will take some time to get back to 180 megawatts, but certainly. What we wanted to demonstrate is that India knows very well what green hydrogen production means and that India once had one of the biggest green hydrogen production capacities installed in the world.*

### **Slide 13**

*I know some people say, Mr. winter please not again this slide. I see my friends from NTPC, I see many people saying – okay maybe he is a little bit too strict on us when it comes to the use cases for green hydrogen, but why is this so important? If we talk about green hydrogen, we hear a lot about manufacturing of electrolyzers, we hear a lot about production of green hydrogen, but at the end the big question is, who will buy the green hydrogen and who will maybe buy the green hydrogen also at a premium because if we reach competitiveness maybe in the best case it was shown 2027 but most people actually agree it maybe 2030 onwards, I mean it depends, with the gas prices being up there was a time already when green ammonia production was competitive but now gas price is going down a little bit again so it may take some time. So, the question is, who are the off-takers? who are the buyers?*

*I am fortunate to be German so our government put out those H2 Global input tenders and also attracting Indian attention of PSUs and private sector companies to actually form consortia and to at least bit and demonstrate willingness to actually deliver green hydrogen, but at the end and who will buy it? Because the H2 Global mechanism by Germany is actually a two-fold mechanism. One is telling all the world outside Europe who would like to deliver green hydrogen in the form of green ammonia, green methanol or sustainable aviation fuel, who would like to deliver to us but the second part of this mechanism is that German industry is being asked how much are you actually willing to pay for green? And then the German taxpayer so to say is paying the difference between what German industry is willing to pay and what it cost for example to deliver green*

hydrogen at Harbor in Germany from India and there one can actually see that the sectors here which are more like on the green side, on this hydrogen ladder, those are the ones where one can actually see that there is hardly any alternative or there is no alternative.

We saw the study being presented by Gopal Ji (Mr. E. Nand Gopal) saying that almost everything can be electrified, even steel. We have heard next generation hydrogen based (steel) but next-to-next generation, he was using a word I don't know if everyone was really hearing it, he was speaking about Electrowinning. So, the next-to-next generation of green steel is already steel which doesn't need hydrogen anymore. It is super green steel by green electricity only. But yes, that is a technology readiness levels he had also mentioned which are not mature.

For green hydrogen steel we need a certain development, maybe that is 2050 beyond till 2070 but climate change is happening today so we need solutions today but if we look at this one should maybe see those alternatives to green hydrogen at least as alternatives that would need to be checked. If I say, okay I would like to go into green hydrogen, where does my sector here fit on this ladder? Is it actually more towards 'A' or more towards 'G' and then is there alternatives actually? and then at least do a calculation if those kinds of alternatives make sense? If you then still decide to go for green hydrogen, that's your decision. But at least we like to listen to the critics and at least consider it as an alternative.

So, steel again – Mr. Liebreich had put that steel long-term could be done for example entirely by electricity but certainly right now it's all about converting to green hydrogen based. Shipping, Jet, Aviation, all those sectors that will be Power to X (PtX), so they are very high on the ladder but may depend a lot on actually biomass and bioenergy-based fuels. At the end, fertilizer, hydrogenation, let's say all 'AB' is considered strongly to be off-take green hydrogen, for 'C' then 'DEFG', one would have to see, certainly US or UK where this man comes from is different so that does not mean that this has to be applied one by one on India, but yeah fruitful thought.

#### **Slide 14**

Coming back to the study which was just released. I just listened and we putdown like the main factors – 90% electrification of India's entire economy is possible already with known technologies with high technology readiness levels; 40% emission reduction alone through energy efficiency gains mostly because of electrification of sectors. If thermal power plants, there's a lot of heat which is not being used so there's a lot of waste. We don't need to replace all the primary energy. Even in Germany, I hear this mistake very often. So much primary energy we have to replace by renewable, only half of it because there is no or very little losses involved when we talk about direct use of Sun and wind. Then yes it says 40 million tons of green hydrogen required in 2050. I don't know, Dr. Chaphekar, I think government of India estimates 125 gigawatts for 5 million tons, around that? Yeah! So, if we say like easily maybe 100 gigawatts for 40 million tons, so that would be 1,000 gigawatts for green hydrogen production to decarbonize India.

### **Slide 15**

*I think with this, I will stop. My colleagues have asked me to put a QR code so that everyone can actually also download the study. It's a soft launch. We are still awaiting comments so this maybe have to be relooked in. Please do so. I would request everyone to just scan the QR code and download the study and yes, any valuable comments (shall be welcomed). I think my colleagues were in favor of having anyone commenting on the study, being put as official reviewer of the study, so your name and organization may be mentioned in the final print out version.*

### **Slide 16**

*Thank you very much. Looking forward to further discussions, one sector which was mentioned – shipping, maybe as a last (slide). Dr. Chaphekar knows I am promoting this a lot because we see this as an excellent opportunity. So, EU apart from CBAM, which maybe one comment out of this slide just like to remember ourselves. German Minister Habeck (Dr. Robert Habeck) for Economic Affairs and Climate Action, he is also the vice chancellor of Germany. He is the boss of the Ministry that was presented here, which also Dr. Hesselmann comes from, he came to India last June and he spoke to the big bosses, to the PSUs, but also to the Reliance, and the Tata's and Adani's and German companies and he said one sentence which really first I really didn't get it. He was telling everyone – friends, commercial affairs (trade) are more and more becoming power affairs. Then, I was thinking is that a bad translation? what does he mean with power? Certainly, the most powerful country will also have power over trade. But he meant electricity. So, what he was saying is that the country which is able to harvest the Sun and the wind at the lowest cost globally will be also able to convert the green electrons into green products cheaper than any other country in the world, and that makes India the global manufacturing hub for the world. Congratulations and thank you very much.*

*Then, Mr. Sobti reminded Mr. Winter that they had met earlier and discussed on this subject. Mr. Winter further explained 'why did he select shipping for today's presentation'. He said – Why it is (shipping) so interesting because this is something which is coming up already tomorrow. The EU came out with a legislation that all big ships above 5,000 tons which are entering the EU or which are leaving the EU they can choose where to refuel. Green airplanes, they did a different legislation only in Europe refueling counts towards emission reduction; Ships, they can refuel everywhere in the world. So, if India is able to create export terminals (as Shri Ajay Yadav Ji said that they are looking for green ammonia export terminals), those export terminals will also have the possibility to actually fuel the engines of those ships, be it methanol or ammonia. New ammonia engines coming up as different governments are working on this such as Japan and Germany. If bunkering in India can be done at a lower cost than anywhere else, India can become the green fueling station of the world and sell everyone who wants to pay a premium for green ammonia. That's something which is an offtake market which does not even involve exports. It's happening here in India. Thank you very much.*

After this, **Mr. Abhay Bakre, Director General, Bureau of Energy Efficiency (BEE)** joined the dignitaries. Mr. Tobias Winter commented that he (Mr. Bakre) is actually the one behind the green hydrogen standard and certification, and we are really honored that he joined us for the precious event. The moderator then directed a formal welcome of Mr. Bakre with a token of gratitude and requested him to share his perspective on this subject.

### 6.2.5 Address by Mr. Abhay Bakre

*Thank you, Mr. Sobti, for organizing this workshop and my apologies (for joining late). I (my address) will be very brief. See, the Green Hydrogen Mission is going to offer many opportunities, I will not go into detail. In fact, I am just coming from the NITI Aayog's workshop and round table. India is in the cusp of energy transition now. What do we really talk about the energy transition?*

*Mostly we talk about the renewables so that that's only one fifth of part. The economy needs energy and now 95% of energy comes from fossil fuel in the economy. Now on the demand side, only 20% is electricity. So, if you want to clean up or make it more and more towards non-fossil, the electrification is one aspect in that but again there is a limit. Even the best of the developed countries the electrification ratio is something around 38%, today in India we have 20% electrification of our demand sector so that means 80% demand consumption of energy is coming from non-electric purposes. We can at the best go to 30% by 2035 or so that we are aiming for 27%.*

*Now what happens to those sectors which you cannot do electrification. So, green hydrogen offers an alternate route for electrification in an indirect method. That means all good amount of sunshine, wind, hydro, and everything which is available in our country in every sector – how can we take it and when it is not possible to take it through wire (or) through transformer, the other option is to use Green Hydrogen. So, that's in nutshell. All PSUs are working there. It's again a kind of ecosystem. (In) transport sector, we are switching to electric mobility, that's a direct thing. Practically we will be switching from petrol/diesel to electricity. Now electricity will come from coal, it will be slowly shifted to the wind and solar but processes like cement, steel or many other areas like fertilizer, pulp & paper, etc. To decarbonize them either we have to use those technology which work on electricity, which is practically not possible because of the processes because they need a lot of high heat. You can generate heat up to 150°-180° or maximum 200° through solar or wind. So, to have a high temperatures like 800°-900° which is required in steel or 650° in cement, you need to have other sources and green hydrogen offers actually an indirect way of converting electricity using the electricity and converting into a green fuel which can actually run our processes.*

*So, that's how the energy transition in India will be hugely benefited by two-pronged strategy – (1) direct electrification and (2) indirect electrification in the form of green hydrogen. So, that's where the opportunity lies and I am actually glad that most of the major CPSUs (are working in this direction) and let me thank SCOPE also for taking this lead that we need to step up to make sure that energy transition for our India's economy*

*happens in a low carbon trajectory, in a much more affordable manner, and we need to take leverage of the opportunities available in our India. Thank you for inviting me.*

## **6.2.6 Question & Answer Session**

The moderator thanked panelists for their insightful talks and opened the Q&A session.

**Mr. Varun Sharma (Engineers India Limited) to Dr. Prasad Arvind Chaphekar (MNRE) –**

*Basically, this green hydrogen definition which MNRE has come up with that 2 kg carbon equivalent. So, you cover compression also in that? To what extent are we talking about hydrogen compression? Say I am generating hydrogen in an electrolyzer at say 25 bar and then let us say I am refueling it into certain cylinders at 200 bars so does this power which I am using for compression from 25 to 200 bar, is it included in that definition?*

**Dr. Chaphekar –**

*We will come up with the details on how we are measuring it. As of now, I can just say that we are in discussion with BEE (Bureau of Energy Efficiency) for the proper mechanism of how to measure but the model is generally well to gate. So, what is happening within your premises will be counted, more or less.*

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**Mr. Nisheet Srivastava (KfW Development Bank) to Mr. Ashok Kumar (BEE, MoP) –**

*You were mentioning about standards and you mentioned that the government wants to come up with national standards and then you also mentioned about international standards. Especially when you talk about international funds, they work on the international standard basis. When you talk about financing, they only look with reference to international standards. So, I just wanted to know what kind of a differences would be seeing in national standards versus international standards and how much alignment would you be looking into to make it through international standards so that the projects are easily financeable by international organizations. Thank you.*

**Mr. Ashok Kumar (BEE, MoP) –**

*I would limit my standard related discussion on the accreditation process for the verifying agencies. So, there are for instance there are ISO 19870 of 2023 and for the verification ISO 14065 (of 2020) and so on. So, we would start with possibly, if we are not able to come up with our own IS (Indian Standard), we would be adopting to the ISOs (International Organization for Standardization) and based on the nuances of our own context certainly we cannot beforehand assume or kind of visualize all the possibility of customization what all needed but of course for a working to the extent of the requirement for a verification process that is acceptable across the board that will be done. So, for the time being we would only limit to that much of a comment that we are going to do extensive consultation, we would develop, if possible, our own standard, if not, we will adapt to the*

ISO, that is what I was referring to. So, again I think the delegate who have asked the question about the pressure that also as in when it is needed what pressure we are transporting you know the level of transportation to what extent are we drawing the boundary and what are the parameters of the concentration, compression or various stages of whether you are including the compression only or the transportation usage. So, all this will be clearly defined and for the verifier it would be set protocol that for a particular section what needs to be done as many of you very will know it. So, we would be following that with the wide range of consultation and MNRE is already in the process of doing that and we will come out with that. To start with we have a benchmark that already been notified. So, we have to start from there and if you see around other international benchmarks, there are different numbers are being thrown, so depending upon where the final needle lands or whatever happens. It will be the time when we move forward in actual field so that I think as we reach the river, we'll cross that.

----- X -----

**Mr. Prajith Prabhakaran (Standardization Regulatory Body of Germany) to Mr. Ashok Kumar (BEE, MoP) –**

*Standards and regulations work only if they are combined with a testing ecosystem. So, assuming that you have the standards, is there any concrete plan to have a testing ecosystem in place so that there is a verification whether the standards are actually being followed and who is legally enforcing it or who is testing it?*

**Mr. Ashok Kumar –**

*If I got your question, are you saying that there are enforcing agencies who would kind of look after?*

**Mr. Prajith Prabhakaran –**

*Not enforcing agencies, there are testing facilities where companies can - for example we have the testing facilities for Green Hydrogen in Germany where companies can send their components to us. They can test it and we give the accreditation to them so that there is a verification method whereby we can see that the standards are followed. So, is there such an attempt here also to create an accreditation verification methodology?*

**Mr. Ashok Kumar –**

*Certainly, there is. Not just for the hydrogen, there is a chain of lab what we call a NABL (National Accreditation Board for Testing and Calibration Laboratories) accredited. So, there are agencies who do the accreditation of the testing laboratories. For instance, not for the hydrogen, but for the activities like standard labeling process where you know we impanel accredited labs where the testing of the equipment take place. So, similarly if and when certain parameters of the hydrogen are needed to be tested certainly there would be a panel of accredited labs who would be doing it. You know very well that accreditation also needs certain level of revision and several other things. So, all that would be as the*

*technology or as the processes graduate or improve or things like that. The accreditation of the labs will also be revised in a sense. So, all that systems will be placed. I won't see that is no brainer ideas.*

**Dr. Chaphekar (MNRE) further added –**

*We have a budget in the mission specifically for the testing facilities. So, we will be also funding facilities who want to upgrade their facilities to add hydrogen testing, equipment, pipes, etc.*

----- X -----

**Ms. Samridhi on behalf of an online participant to Dr. Chaphekar (MNRE) –**

*Won't the production of green hydrogen require massive amounts of energy and resources eventually making it inefficient and unsustainable for a few industries and sectors?*

**Dr. Chaphekar –**

*I thought that increasing scale would make it more efficient. Why would it make it less efficient?*

**Ms. Samridhi –**

*I think they are talking about the infrastructure investment as well sir.*

**Dr. Chaphekar –**

*We are anyway building up RE (renewable energy) capacity at a rapid pace. The more RE capacity you build up, you make it more and more cheap. The cheaper it is, more people will use it. Substantial resources will be required because the needs are substantial. Your resources will match the needs and not the other way.*

----- X -----

**Ms. Samridhi (moderator) on behalf of an online participant to the dignitaries –**

*There are a lot of questions which are coming with regard to the concern of the costs. Two questions that we are receiving constantly – (A) Cost of the infrastructure that would be required? and (B) The safety of scaling up green hydrogen?*

**Dr. Chaphekar (MNRE) –**

*Cost, I think we already addressed probably in the presentation by Mr. Winter. The cost is going to come down as we move ahead. Safety, I think we are bit scared because what hydrogen currently just brings to mind the Hindenburg incident but I think we have gone far away from that time. That's why our mission has a separate budget for testing, for standards, and there will be rigorous checking. We are aware that any single incident will set us back for many years. So, safety is obviously paramount and as more and more people start using (green hydrogen), it will become more and more common place and then it will become cheaper to be safe as well. Currently, the big plants obviously take care*

(of safety). A few days back, PESO (Petroleum & Explosives Safety Organization) has notified changes in the gas cylinder rules which are required for storing hydrogen. So, the ecosystem is building up gradually and it will match the needs of what industry wants.

**Mr. Bakre added (BEE, MoP) –**

See, in terms of cost, this question came many times. In 2015-16 or even before that the solar cost was purchased by Gujarat or Karnataka at 15-18 rupees. Now, while purchasing that particular electricity from solar at a cost of 15-18 rupees, when the rest of the electricity was available at 3.5 rupees or 4 rupees to the consumer, but then what was the share? The share was only 1-1.5%. So, in the entire electricity basket whether it's forward-looking states like Gujarat or Karnataka, the share of high pricing electricity coming from solar was not impacting the common consumer in a big way. It was impacting obviously, there will be impact (but insignificant) and in 10 years we have come to 2-2.5 rupees or whatever.

Same we are expecting for the green hydrogen because a mission (NGHM) is there, a trajectory is there, and there is also a signal for technology providers to bring technologies. So, today if we are in 2023-2024 and talking about some \$4-5 green hydrogen cost versus SMR or gray hydrogen cost of 150-160 rupees (\$1.5-2) in next 10 years (by 2034), we will be again talking at the cost priority even perhaps it may come (down). It is just the question that the ecosystem has to evolve, there are many risks available as Dr. Prasad said including the risk of safety because every new producer and every technology provider has to cover many risks and more and more, he goes advanced, there is an economy in the scale but the risks will start coming down and at the end there will be a cost reduction, perhaps it will be even cheaper maybe after 2034, the way we have seen for solar. So, that's the trajectory we are expecting in green hydrogen as well. Thank you.

**On the request of the moderator's request, Mr. Tobias (IGEF) briefly provided the international perspective on how the safety aspect has been taken care of. He said –**

On cost, I think as has been said, it's all about scale. Therefore, India and Germany work together to ramp up the global green hydrogen economy. For safety, there is cooperation ongoing also on EU-India level and those involved in incident databases (that's the technical term there). That kind of data has been shared. European Union had a four-five year long project running putting together the largest green hydrogen incident database in the world probably and for those who are into the topic, this database has been shared with Indian side.

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**Mr. Varun Sharma (Engineers India Limited) to Mr. Tobias Winter (Director, IGEF) –**

Sir, we are talking about so much of green energy and so much of solar. What is the German perspective particularly towards recycling of these solar PV panels for which we are already facing the issue with the generations which are over by now?

## Mr. Tobias Winter –

*I think they are my colleagues from the environment cluster (who are) even better able to answer. But yes, in Germany, there is legislation in place that each solar panel which is sold already has the price of recycling embedded to it. So, there is a mandatory recycling for solar panels in Germany. Luckily those solar panels now last longer than even us Germans would have thought. There are solar panels now even running 25-30 years, they were like thought of running maybe 20 years. I think the German perspective is more replacing fossil fuel Imports by own sun and wind. If we look at how much India is importing, I think when the prices hiked up, it was \$200 billion dollar of fossil fuel Imports, 25% import rate for coal, 80% import rate for oil, a lot of money going out into other countries which could be invested in India itself.*

*Same with batteries, that's the next discussion. We should not import batteries. What the recycling rate of batteries, chemically possible at a decent price? It is 99%. So, instead of importing oil and burning it, using it once, why not accepting also to import some batteries and use them. How many cycles latest battery technology (can be charged) or how often can you recharge a battery? It is 10,000 cycles. So, 10,000 (cycles of recharge) instead of importing something once and burning it, why not importing something and using it 10,000 times, that too charged with Indian Sun and wind and not paying any more money to any countries which may not even need the support? Thank you very much.*

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### 6.2.7 Key outcomes of the session

- Dr. Prasad Arvind Chaphekar elucidated on the policy brief, technological advancements and research initiatives within the National Green Hydrogen Mission which provided valuable insights into the innovative strides being taken in harnessing clean energy. The emphasis on research and development, skill development, Incentivize Green Hydrogen production in India coupled with his call for collaboration between public and private sectors, underscored the mission's commitment to fostering a robust ecosystem for green hydrogen technology.
- Mr. Abhay Bakre imparted words of wisdom on the need for India to undertake necessary steps to achieve the agenda of climate change mitigation. He highlighted the sector-based challenges that India faces in its energy transition journey, and suggested solutions in the form of two-pronged strategy – direct electrification and indirect electrification in the form of Green Hydrogen as a path towards energy transition for Indian PSEs.
- Mr. Ashok Kumar provided insights into the potential of Green Hydrogen as a clean and sustainable energy solution. The focus on setting standards, as emphasized in his speech, not only ensures the reliability and safety of hydrogen-based systems but also serves as a catalyst for innovation and market growth.
- Mr. Tobias Winter with his exceptional presentation on the International Green Hydrogen Market Developments shared historical perspectives of Green Hydrogen in India and suggested various ways through which India can become one of the major Green

Hydrogen producer and exporter while also being a giant in renewable sources of energy especially solar energy.

- The Q&A session represented participation from both online and physically present participants. This session countered many questions related to hydrogen compression, accreditation process of verifying agencies and accreditation verification methodology, development of enforcing and evaluation ecosystem for green hydrogen, energy requirements for green hydrogen technology, cost requirements to develop infrastructure, safety concerns, generation and recycling of solar PV panels policies, along with many others.

**The Session-2 was followed by a lunch break for 40 minutes**

### **6.3 Session 3 – Decarbonisation ways: Renewable energy, Green Hydrogen for PSEs (Technology Readiness & Cost) & use of Limestone Calcined Clay Cement (LC3) (Technology Readiness)**

#### **6.3.1 About the session**

In the face of escalating climate change concerns, decarbonization of major GHG emitting industries has become more urgent than ever. PSEs, being significant contributors to industrial GHG emissions, require targeted strategies and insights to mitigate their carbon footprint while maintaining operational efficiency. This technical session aimed to equip PSEs with essential knowledge on innovative decarbonization technologies, their readiness, associated costs, and potential benefits. It was focussed on three sectors i.e., renewable energy, techno-commercial aspects of green hydrogen production for PSEs, and the technology readiness in cement sector in form of the Limestone Calcined Clay Cement (LC3). Speakers from IIT Bombay, IIT Delhi, and PSEs such as NTPC Ltd. & IOCL shared their insights, experiences, and best practices that has potential and can be adopted by PSEs to accelerate the transition to a low-carbon future.

The first panellist for the session 3 was **Dr. Chetan Singh Solanki, Professor, Department of Energy, Science and Engineering, IIT Bombay**. Dr. Solanki is a researcher, educator, entrepreneur, author, and philosopher. He is known for his work in the Solar sector. He is currently leading two projects on the solar front and has also published numerous papers and he is also known for a student movement as he led the Student Solar Ambassador Workshop

where more than 5700 students from 132 schools participated. During the session he had shared a detailed presentation on Transformative Power of Solar Energy in Reducing GHG Emissions (Climate Change & Corrective Action).

### 6.3.2 Presentation by Dr. Chetan Singh Solanki

#### **Slide 1 (Cover) and Slide 2**

*Good afternoon, everyone! Before I start, let me ask all of you – How are you all? All fine? What a disaster you know that you people are fine. You know – science is growing, technology is growing, economy is growing, and you are only fine. It's not your problem, it's a problem of the whole world. I keep traveling everywhere and keep asking people - How are you? Everybody seems to be stuck at the fine level for the whole life. You go and ask "Thela Vala Bhaiya" he says fine, go and ask big officers and professors and student, how are you? They are also fine. I ask a big person's secretary or principal; they are also fine. So, I feel there is something wrong in this world. Gita says that behind every single act that we perform in our life whether we want to look good or we want to eat an ice cream or study well or get a good job or good money, good respect, there is only one purpose of every action in life i.e., to be happy, and therefore, I decided and I made a rule that wherever I will speak, I will only speak to happy people. So, if you really want to listen to me, you have two choices – (1) either you are happy by choice or (2) you are happy by force. Which one you want to choose? Happy by choice? Wonderful!! So, with this note let me ask once again - How are you all? Happy? Awesome!! That's it. The proof of being happy is a smile on the face. Nakli hogi to bhi chalegi (to even if it is fake, it will work). Please keep a smile on your face.*

*I am going to talk to you about the climate change and how do we solve the problem. A lot of people have been using this term climate change and I believe that the most of the world does not even understand how to solve it. The proof of that is that in the last 30-40 years what not is happening in the World, there are international agreements, there are national agreements, there is Paris agreement, Kyoto Protocol, COP meetings, tens and thousands of NGOs working, government is making policies but the climate change is worsening every single year. It tells us that whatever we are doing is either not correct or not enough or both of them. So, with that I am going to bring your attention to this one-two-three of climate change and if you can really take this message home today, I think my job is done.*

*By the way, I am a professor of IIT Bombay. I am a married person, I have two daughters, but I have I decided to leave my home for 11 years. Last time when I was at my home it was 2020 and the next time am going to go my home it is going to be 2031, not because I have gone a crazy but because climate is in urgent emergency and everybody has to understand and act. So, I live in a bus. This is my home and today is 1202<sup>nd</sup> day of my Yatra (Energy Swaraj Yatra). For last 1200 days, I am living in this bus. There is a bed inside, there is a kitchen inside, there is a washroom inside, there is a training room inside,*

*there is a library inside, there is an office inside, there is a temple inside, and also there is small garden inside, and there are solar panels on the top which is powering everything inside the bus except the engine. If you want to visit my home sometime or you want to be with me in “Yatra”, you are most welcome to join.*

### **Slide 3**

*Let me start with this quote from the plateau, He has written the book “The Republic”. He said, every king should be a philosopher or only philosopher should become a king and we the modern people, we have become very powerful with all our technology. We are like a king. We can send our mission to the Mars, we can fly big machines, we can make big buildings, but we have lost the touch of philosophy and therefore, we have no idea how much to grow and how long to grow. For example, this whole conference talks about decarbonization and green hydrogen but I can't answer – how to decarbonize the whole sector if I do not know how much to grow and how long to grow and that's a more fundamental question I keep asking everywhere, how much should we grow? Nobody knows! Even if I ask Prime Minister Modi Ji – bataiye desh ka GDP kitna badhna chahiye? (How much should country's GDP grow? He will say – pata nahi, bas jyada se jyada (don't know but more the better). How long should we grow so that the whole world becomes a good place and comfortable place? Another 20 years? Another 30 years? Another 40 years? Another 50 years? Nobody knows!! Longer the better, that's only thing that we know. So, not knowing how much to grow and how long to grow is like a driving a vehicle without any brake and if anybody drives a vehicle without a break what happens? Accident. It looks like the modern humans which means all of us, either we already met an accident or very soon we are going to meet an accident.*

### **Slide 4**

*And that's what we need to understand, the problem that we are facing – the climate change. The decarbonization and everything will not work if you don't understand the basic question and the basic question and observation in the world is that science is growing, technology is growing, economy is growing, but global warming is also growing. Isn't it? Another basic question (observation) is that the technology and economy is growing but the size of the planet is not growing, the amount (number) of resources is not growing, it's only the problems are also growing with whatever we are growing, and therefore, it is difficult to answer this question.*

*I guess, I am invited here to be an expert and give and help PSEs – what can be done? That's what I am going to offer you, what can be done! So, number one thing is – let us understand the problem of the world, whether there's increase in depression, violence, water pollution, air pollution, soil pollution, global warming, climate change, every problem has only one route – that is energy (Use of energy). There's no second root cause.*

### **Slide 5**

*Ever since humans have got hold of energy, we started creating problem. But energy is very important part of our life – “Energy is Everything and Everything is Energy”. So much*

so that there are 17 Sustainable Development Goals and in the centre of this is energy. So, whether it is poverty, hunger, health, education, literacy, climate change, even global peace or partnership depends on energy. So, energy is a very important game that we all have to play, unfortunately we all are playing a wrong game of energy.

### **Slide 6**

And why I am saying wrong game of energy? This is the chart that proves that. Today what we are using is coal, oil, gas, solar, wind, biomass, hydro, nuclear but you will be surprised to know that coal, oil and gas today itself contributes to almost 84-85% energy of the world and that is actually carbon-based energy.

Every time when you burn carbon it results in carbon dioxide. Right now, I was looking at the data for yesterday, there is 52% extra carbon dioxide we already pumped in the atmosphere. Which means that we, the modern humans, have changed our atmosphere by 52%. How dangerous we have all become? We have done this already.

### **Slide 7**

As a result of that what is happening? Carbon dioxide level has gone up and there is a 52% (extra CO<sub>2</sub>) and look at the exponential growth in CO<sub>2</sub> level that is happening.

### **Slide 8**

But that is giving rise to the global warming and the temperature of the planet is rising and it's rising faster and faster and you will be surprised to know the current level of global warming is almost 1.3°C (2.2° Fahrenheit). It's a huge change because you know our body temperature is 97-98°F and if the body temperature increases just by 2° and becomes 100°, what we say? Body has got the fever. Similar to that the planet has also got the fever. When we get a fever, we can't behave properly, we can't act properly, we can't work properly, we can't sleep properly. Similar to that the planet is also not behaving properly and what is happening there are floods, there are droughts, there are heat waves, there are cold waves, there are forest fires, ice is melting, sea level is rising, food production is going down, diseases are increasing, everything that can go wrong in this planet is already going wrong. As per a recent news, the temperature of Europe in February has broken all the records, it's already broken, so planet is warming up much faster and it is giving all kind of imbalance in the society.

### **Slide 9**

So, what is the solution? Is the green hydrogen solution? – No. Is electric vehicle a solution? – No. Is solar energy solution? - answer is also a no. If you don't understand the basics and fundamentals of sustainability on this planet, I guarantee you that none of these are a solution. There are two fundamental laws, I call them Laws of Sustainability in human existence. If you are not abiding by those laws, no technology will help us to solve the problem.

## **Slide 10**

*Law 1 says “In an ecosystem of finite resources, there has to be finite consumption”.*

*Does it make a logical sense? In any ecosystem if resource is finite consumption has to be finite. If salary is fixed, expenses have to be fixed. As I said technology is increasing, economy is increasing, but the size of the planet is not, water is not, minerals are not atmosphere is not increasing. Everything remains finite and therefore, it is important that we first learn to limit our consumption. No amount of science and technology will help you to keep overgrowing production and consumption. That's impossible. Gandhi Ji said this beautifully, he said “there's only enough in the world for everyone's need not for anyone's greed”. Before him, Gita (Bhagavad Gita) said – you have to limit, you have to put limit on your desire, there is absolutely no way you can violet it. So, if your technology is not helping you to do this, it's not a solution.*

*Law 2 says “In an ecosystem of finite resources, there has to be a distributed production”.*

*The centralized production will always result in unequal distribution, unequal distribution always results in inequity and that's what is happening in the world and in the country. Every time an economy grows, inequity also grows, and that results in imbalance in the society and that imbalance eventually result in lack of peace and violence and that's what is happening with the growth of technology and economy – the brotherhood is not increasing, the love between people is not increasing, rather violence is increasing and all of you can feel and see and experience that. So, “Limiting Consumption” and “Localizing Production” are the fundamentals of sustainability. If any institutions, if any individuals, any state, any Public Sector Enterprise, if you really want to become sustainable, make sure that these two becomes your fundamental boundary condition, you have to operate within this boundary condition.*

## **Slide 11**

*Limiting and localizing consumption of what? Everything that we consume – food, water resources, clothes, furniture, space, cement, concrete, and everything else. But the most importantly – energy, because it is energy that eventually (is used up). When I am wearing shirt – actually that's manifestation of energy, when you brush your teeth – you are using energy, when you are sitting on a chair – you are using energy, when AC (Air Conditioners) is running – you are using energy, when you are going to eat food – that's also energy. So, energy is ultimately the root cause of everything. You have to limit your energy consumption first and then you have to localize in order to solve the problem.*

## **Slide 12**

*There is a three-step approach solution that we have to adopt, these three steps is called AMG (Avoid, Minimize and Generate) and this has to be applied and we all are driven by energy, and we need solar energy, we need renewable energy, we need everything but provided we follow this principal AMG.*

### **Slide 13**

*What is AMG? “A” is Avoid the use of energy as much as possible even if it is solar energy. I am a professor of solar energy, I am brand ambassador of solar energy for the government of Madhya Pradesh, I advise Orissa government on energy, people call me the Solar Man of India. And what I say – the rule number one of using solar energy is to not use solar energy. I did my PhD in solar, I have written books on solar, if you want to make use of solar energy, you need to mine silicon, and then you have to process and make a solar cell and for that you have to use poisonous gases, high temperature process, then you convert into module, for making module it requires glass, and you require aluminium frame, to erect the frame you need iron structure, to take the power out of the module you need copper cable, and to process the power you need inverter. All these materials require mining, chemicals, processing, energy and at the end of life you have to recycle them again. Therefore, the best thing you can do is avoid the use of solar energy also if it is avoidable.*

*Ladies and gentlemen, let me tell you I am traveling all over the country with my bus for 1200 days, everywhere there is a disaster, literally the use, and misuse, and overuse, and inefficient use of energy everywhere. I was invited by United Nations in Geneva and I could see that every country behaves in exactly the same manner, we are misusing and overusing energy to such a great extent. Why should you not do that? Because every time when you pump carbon dioxide in the atmosphere, it has life of 300 years on an average. So, anything that you are doing right now is going to create impact for 300 years, the AC that you are enjoying right now will have impact for 300 years, and that's why it is important that avoid what is avoidable. In English we say – “Prevention is always better than cure”, using solar energy is like a cure, but not using energy is prevention which is thousand times better.*

*If you are really intelligent, if you are really innovative, if you really think that you are wise person on this planet, (then) learn how not to do things, learn how not to use or require air conditioning and cool this hall, learn how not to iron your clothes and still be comfortable, learn how not to do thing is the much most powerful thing and we the modern humans in so-called comfort and so-called fast moving life, we have gone beyond and there is no basic wisdom left anywhere and we are already misusing and overusing, so avoid what is avoidable. One third of energy should be avoided. I am a professor of IIT Bombay but at my home there's no refrigerator, there's no geyser, there's no air conditioner, I stopped ironing my clothes, not because I cannot afford. I am a professor; I can afford but the question is whether nature can afford?*

*You have money to buy two houses and three cars and what not you can buy, the question is “whether nature can afford? And answer is “No”, because nature is not growing with your own technological growth and your economic growth and your consumption. Nature is not growing. So, avoidance is the best thing.*

## **Slide 14**

*If you cannot avoid, minimize it. How do I minimize? Use energy efficiently – there are beautiful efficient appliances available today, LED (Light Emitting Diode) is a great example, there are BLDC (Brushless Direct current) fan, another great example that saves carbon, it reduces electricity by half and carbon emission by half. If refrigerator should be avoided, but if you cannot avoid, minimize it. How? “Don't buy two doors, three doors, and four doors' refrigerators”. People are trying to make room inside the refrigerator. When I ask – what do you do with this large refrigerator? They say – we keep pickles! (On a lighter note) I feel, keeping pickles in the refrigerator is the biggest sin in the world. You can't do that. Pickles are meant to be kept outside. For most critical needs you need 2 litres of milk and maybe 2 kilograms of vegetable. You need 50 litres refrigerator, not 500 litres.*

*AC should be avoided but if you cannot avoid it, minimize it. How do I minimize it? “Don't make big bedrooms because what AC is doing? AC is going to cool your roof, AC is going to cool your walls, AC is going to cool your furniture, AC is going to cool your floor, and finally at the end AC is going to cool your small body of 6x2 feet. This is a non-sense use of the AC. For the God's sake, don't do that. Make smaller space so your cooling needs will reduce by significant portion, your energy needs will go by half, so minimize by another one third.*

## **Slide 15**

*The last step is to generate only by one third. Somebody was giving the numbers – if you want to convert everything in a green hydrogen, you need 175 GW of solar panels. Manufacturing that itself is going to pollute and create so much of environmental degradation. You need so much of electrolyzers that itself is going to create machines. So, Avoid and Minimize and Generate only 1/3<sup>rd</sup> and where should you generate? Wherever you are. As much as possible. It doesn't make sense to put a solar power plant of 500 megawatt and then put all kind of transmission distribution lines, and then bring it and say I'm sustainable – No, absolutely not. So, generate wherever you are, generate locally, then only it is possible.*

*What is happening? I want to share (with) everyone. When I went to Gujarat, I was so happy to see so many solar panels being used and I said wow Gujarat is a developing state. After 15 days, I became sad, you know why? Because after my lecture somebody came to me and said, sir, thank you so much you opened my eyes. I said what happened? He said, sir, my sister called me and told that brother I have put 6 KW solar system on my rooftop. Earlier there was one AC in the room now all three rooms have AC, still have electricity, what can I do? What more I should do? People are using solar energy to save money, not to save environment. To save money is a different ball game and to save environment is a different ball game. If you want to save money you need to maximize your generation that everybody is doing very smartly but if you want to save environment you have to minimize your consumption and that nobody's doing, because nobody understands this properly and everybody is trying to push more and more. So, “G is*

Generation” generate wherever you are as low as much as possible. I am sure in every case it is not possible but (it should be done) wherever it is possible.

### **Slide 16**

I hope all of you remember this formula (AMG; Avoid, Minimize, Generate) because this is the ultimate (universal) formula of sustainability. Will you all remember? We can all repeat together. A means Avoid, M means Minimize and G means Generate. How much? 1/3<sup>rd</sup> of each. If you are not going to follow “AMG” you will have to say OMG – Oh My God. Solar Mehangayi (costliness) – Oh My God, rooftop space is not there – Oh My God, this is not there, policy is not there, all kind of excuses will come in your life. And you know what, we are all running late. Climate change is accelerating like anything. Climate clock says that we have only 5 years and some 130 days left before we touch 1.5°C of global warming. Everybody talked about it but nobody shows urgency. Only 5 years left for 1.5°C and for two degrees only 25 years left. So, we need to show that urgency because it is “Now or Never”.

Barack Obama, the ex-US president said it very clearly that this generation is the first generation to experience climate change and we are all experiencing it and this generation will be the last generation to do something about it. If it is not now it is not going to be ever because it's an irreversible process as “Lakshman Rekha” (strict convention / rule) once you cross it you cannot come back”.

### **Slide 17**

So, there are many things that you can do and I would request all the Public Sector Enterprises to make sure that you understand and take this action. One of the most powerful actions for a “Climate Correction” is become “Energy literate”. By the way all of you can see what is written on my shirt if you've not seen it already, “I am Energy Literate, are You? It is the illiteracy of energy of the world that has created this problem. We have not understood the game of energy and that's why we are playing the wrong game of energy. There is a beautiful course that I have designed called “Energy Literacy Training” you can go to this portal ([es-pal.org](http://es-pal.org)). It's a free online certificate-based course available in 12 different languages. We are also dubbing it into Spanish and French so that the other countries can also use it. I believe that every user of energy should become energy literate. Energy Literacy is a license to use energy. If you are not energy literate, do not use energy because you are likely to misuse and overuse the energy.

At the end, I would just like to say that we have seen last 30-40 years of the policies, the technologies are not working, there are lots of policies are being made, that's not working. Problem is “aggravating”. What we need to do? We need to create a “Fashion of Living a Low Energy Consumption Life”. Consuming low energy should become a fashion of the modern life. That's why we run a campaign called “WAHA” – Wrinkles Achhe Hain (wrinkles are good). So, we are running a campaign that every Monday is a non-iron cloths day, more than five and a half lakh people are already doing it every Monday and our aim is to reach to literally millions of people doing it. Anybody who wears iron clothes is a less good person. You know why? Because he is consuming more energy, because one iron

*is 800-1000 Watts power, and that results in carbon emission. Your and my life will get affected because of that. Anybody who comes with the BMW car, I will not invite that person my home because that person is consuming more energy. I will not have relationship with that person and that is going to be less good person so consuming less energy has to become the fashion of the modern life.*

*The last thing as I said, at my home there's no refrigerator, no geyser, no air conditioner, I don't iron my cloths, I am not a sad person either and I also make it as a fashion we have decided one more thing, I have two daughters and we have decided that whenever my daughters will get married, in their marriage functions we are going to invite only those guests who come without ironing their clothes. If anybody who comes with iron clothes will say "Namaste, Kal Aana" (greetings, come tomorrow)". Thank you very much!*

The next speaker was **Dr. D.M.R. Panda, General Manager, Hydrogen and Renewable Energy, NTPC** with more than 10 years of experience in the renewable field and 16 years of experience in training and learning functions. He is taking care of Training Needs Assessment Program in NTPC Limited. Dr. Panda has shared a detailed presentation on Green Hydrogen Projects by NTPC.

### **6.3.3 Presentation by Dr. D.M.R. Panda**

#### **Slide 1 (Cover)**

*Good afternoon to all. What you see in this picture? From the left – that's the floating solar project of NTPC, and next to it, is the hydrogen bus, which is for Leh that's in Ladakh and next to that is the picture for hydrogen blending which would be the major part of my discussion here.*

#### **Slide 2 (Contents)**

*These are my points of elaboration. We will go one by one.*

#### **Slide 3**

*First of all, why green hydrogen? There are many versions to this. Why you need to do this? Whether I need to do this? In India and in NTPC why are we doing this? It is because of these two –*

*(1) To "increase the energy security". When I say energy security, we all know that below our feet there is "Coal", we do not intend to use that, same is for natural gas, same is for other form of energy. So, for "Energy Security", how I can manage my energy requirement from which is available easily such as sunshine, air and water*

*(2) Next is for "achieving the decarbonization". When I say decarbonization, of course first thing that comes to my mind – how I can use less and less of carbon. Therefore, whatever I need to do – can I manage that with electricity? and whatever electricity cannot do, can I do it with hydrogen?*

*Then comes the question of centralise and the decentralise. It's a bit tricky now. When I am using tens and thousand tons of hydrogen at one place, say for making ammonia or for steel plant or for petrochemicals, I can avoid carbon generation from the one source i.e., central source. Now, what about lakhs of households that use cooking gas? What about lakhs of vehicles which are running on the road? These are examples of "distributed carbon emission". How can we reduce that?*

#### **Slide 4**

*Hydrogen can be one solution. "Hydrogen as a Fuel and energy Carrier" on the left side and the "Mobility Solutions" on the right side provides the summary of hydrogen usage. NTPC has an interest in all this. Probably hydrogen Loco is new. You may not be reading about that very often in the media. From NTPC, I will discuss about how are we trying to convert one of the Loco (bus) to hydrogen, taking out all the diesel (compatible) internals and fitting new hydrogen systems.*

#### **Slide 5**

*This is the blending thing. This is India's most successful pilot projects. You can read everything here but the point (on) which I want you to pay attention is that this is the highest level of green hydrogen that has been blended in India into the "Natural Gas Stream". We started one year back and gradually we have reached this stage. The regulatory body has approved, based on the sound design and rigorous testing which were done to demonstrate that it is safe. This started at Kawas under one of the NTPC projects. People are using LPG cylinders, so we laid a gas pipeline and then into that pipeline, we started injecting hydrogen.*

#### **Slide 6**

*This is not as simple as you can think. Of course, there has to be a "Blending Skid". At our home, when we prepare food during breakfast, lunch, and dinner. Every time, the consumption of natural gas is going to increase and hydrogen blending has to increase proportionately. As soon as your cooking stops, the hydrogen has to stop, otherwise that hydrogen will go to the burner in a bulk which may create explosion. That is why we require (blending) skid. How do I can control the hydrogen flow in comparison to the flow of natural gas? The answer is – by never allowing it (hydrogen) to be more than what is required. The picture that you see here is the instrument (system) which is used for hydrogen blending.*

#### **Slide 7**

*There are a lot of apprehensions on whether hydrogen blending was tried (earlier) and of course, people were resistive. This picture represents NTPC staff leading training sessions to make people aware about – what are we going to do? What kind of rigorous testing procedure has been done? Prior to test and launch, what kind of safety studies has been done? They were very satisfied.*

*Few things that people asked were – If I'm making tea, it is taking 5 minutes. Does it (this new technology) will take me 10 minutes? So, the answer is No. you can barely notice. Some of them (homemakers) studied about Wobbe index and then they asked – whether the Wobbe index is same as before? The Wobbe index is used to compare the combustion energy output of different composition fuel gases in an appliance (fire, cooker etc.). If two fuels have identical Wobbe indices then for given pressure and valve settings the energy output will also be identical. So, when it mixes hydrogen or during hydrogen blending, hydrogen being a lighter gas, the Wobbe index tends to come down.*

*Ranging from normal concern such as increase in cooking time to complex concerns such as Wobbe index, people had all kind of questions which were answered and they (homemakers) were very happy and satisfied.*

### **Slide 8**

*This is what is happening worldwide (image reference on the slide).*

*In India, currently there are 3 (projects) –*

- *One is of course our NTPC project, we aim to take it to 20% (blending) ultimately*
- *GAIL has also started blending hydrogen in their city gas distribution as was mentioned in the morning by the CMD, GAIL*
- *There is a recent news that Adani group also wants to try this.*

*What is our experience so far?*

*First, blending is very safe, very less costly and therefore, it is the lowest hanging fruit if you want to have energy security, if you want to have decarbonization, if you want to reduce carbon in a decentralized manner, then this is the way.*

*Just to give value and you can develop a perspective on this. If you are paying 500 rupees per month for PNG now, you will have to pay 510-515 rupees (for city gas blended with hydrogen), not more than that.*

*So, that's why I say that this is the lowest hanging fruit. Whatever we have made here, I invite people to come and take the specifications if you want to try and do something about it. So that the more it is tried out, the more energy security, and more decarbonization would be there.*

### **Slide 9**

*Next is the "Green Mobility". This is the same picture of the hydrogen bus which is in Leh and this is the aerial picture of a 1.7 MW solar station and next to it is the "Hydrogen Filling Station" (reference to pictures on the slide). So, we are trying it at two places – one at Leh, Ladakh and another in Greater Noida.*

### **Slide 10**

*See these numbers (reference on slide). Hydrogen filling station that is 1.7 MW solar will make 80 kg of hydrogen per day (with 9 hours of operation) which will be stored at 500*

bars and dispensing will occur at 350 bars. Five 9-meter buses would cover around 200 Meters.

### **Slide 11**

The first picture on the top is from the Leh. These are 9-meter buses and they employ three cylinders per bus, all fitted below. Each of them will have three 8.4 kilograms H<sub>2</sub> cylinders and can comfortably cover the distance. The gross weight of each of these hydrogen buses are 13 ton whereas if I go for an electric bus, it would be 10 tons. But here comes the magic. For bigger buses, per filling can let you travel 600 km. For example, our Greater Noida buses which would be from Delhi to Agra and back, weighs 16 ton and can travel for around 600 km per filling (of hydrogen fuel) in comparison to an electric bus that weighs 18 tons and can travel only 150 km per charge. It means, if I want to go from Delhi to Agra and back, I have to charge at least two to three times and for each charging I need to stop the bus and wait for at least 1-1.5 hours for it to get recharged.

The beauty of this hydrogen bus is that it can cover 600 km per filling. That is why we call them "Long Hull Buses". As you can see, Leh bus is costly but the Greater Noida bus is very much comparable to the cost of running a diesel bus. That is what pilot projects are meant for. We want to see what exactly is the techno-economic feasibility of running these buses to know whether they can actually replace diesel buses? So, here I need a lot of hydrogen to be stored. There are seven cylinders, one on the chassis and six on the roof.

### **Slide 12**

Now a few more interesting points. These are the numbers that I want you to see. In Delhi, each bus should be covering 600 km whereas in Leh it is 225 km per bus. Delhi temperature we all know (+5°C to +45°C), in Leh it can be (-25°C to +30°C) and there are other conditions (see slide). The objective of doing these tests at Leh and Delhi is to see if the buses are successful then they can not only run everywhere in India but everywhere on the planet and thereby, replace diesel buses.

### **Slide 13**

A few interesting pictures I would like you to see. Left picture – these are two electrolyzers and each of them is 20 tons. That's me and my colleague. The objective of this picture is to show you the large size of electrolyzers in comparison to human being. Right picture – electrolyser for Leh (note the smaller size of electrolyzers). The complexities that we are dealing with is the fact that these electrolyzers are not available in India today and therefore, they have to be imported from outside. Probably five years down the line, they should be readily available in India itself.

### **Slide 14**

These are the key deliverables (see slide for more information). The guaranteed mileage is 12 km/kg of hydrogen; however, we ultimately want to check what's the actual mileage when they (buses) actually run on the street. They can cover 15 km/kg of hydrogen (depending upon conditions). Other things to check includes – what is the difference for

*long haul or the short haul? What is the filling time? What are the maintenance issues? How good are they while picking speed (accelerating), going uphill, downhill, all that.*

### **Slide 15**

*This is how we assure everybody that we are taking enough care to offer a safe travel (see slide for details).*

### **Slide 16**

*This is the “Hydrogen Loco”. It is comparatively new thing, tried at some places. What we intend to do is that we take out all internals from the Loco and fit a fuel cell, fit a small battery, and hydrogen storage system. Calculations show that running this Loco using hydrogen is cheaper. NTPC will save money. NTPC has close to 200 Locos for bringing coal from coal mines to the power plant and back. Similar to NTPC, there are at least 500 Locos in India at ports, steel plants, cement plants, and many other places. Now, potentially all this can be replaced with hydrogen locos, and this is what we are trying to do at NTPC – to demonstrate that yes, it is possible to retrofit, it is possible to save diesel, it is possible to save money.*

### **Slide 17**

*This is a hydrogen based “Microgrid”. The idea is that during the daytime, you take solar power, make hydrogen, and store it. In the night time, when there is no sunshine, you convert that hydrogen through a fuel cell – the same fuel cell which is in the Loco and which is in the buses. That’s the system. This we are planning high up in Ladakh, why there? Because electrification is not there and it may not be there in next 5 years.*

### **Slide 18**

*During the daytime, part of solar power will go, in the night time we will make hydrogen fuel cell. Of course, it is expensive but nothing is actually expensive if you do not have any energy at all at this temperature. Where the schools are closed for more than six months a year, this is actually not costly. What are possibilities other than this? We run DG sets. They cost as much as this.*

### **Slide 19 (skipped)**

### **Slide 20**

*So, we are trying NTPC Ammonia and Methanol at various port locations across the coastline to supply whosoever wants methanol, ammonia from us as well as supplying to India. We have tied off for 1000 MW electrolyser to make hydrogen for all this.*

### **Slide 21**

*We have set up a pilot project for Methanol (10 tons/day) in one of the power systems of NTPC which capture carbon dioxide and convert it to Methanol.*

## **Slide 22**

*First electrify everything using renewable energy and wherever electricity cannot do the job you make use of hydrogen. As I said, hydrogen blending is the lowest hanging fruit and then distributed off-grid RE have the potential for increasing and ensuring accessibility, affordability, sustainability.*

## **Slide 23**

*Thank You so much.*

## **Slide 24-29 (not used during presentation)**

The next speaker was **Ms. D Padma, Executive Director, Planning and Business Development, Indian Oil Corporation Limited**. Ms. Padma is an oil and energy professional with more than 3 decades of field experience and is presently leading a highly specialized group which manages corporate performance management, memorandum of understanding, and macro-micro environment scanning. She explained the GNH3 Production for National and International Offtake.

### **6.3.4 Address by Smt. D Padma**

*Good morning. I will be tweaking the topic a little because I am also anxious to address a few concerns that have been raised throughout the day.*

*Firstly, whole morning we have been hearing about the transition that needs to happen from molecule to electron. I am all (in) for it, and being in the energy sector and the oil sector we recognize that.*

*Secondly, we have been listening to a lot of talk and actual developments on the field about how you need to electrify? And the more you electrify, the more you go into the path of electricity production, the more efficient energy use would be. So, of course this doesn't ring much of alarm bells in us in the oil sector. We say, anyway oil is not being used for electricity production but that would be grossly not reading the writing on the wall because when you look at the demand side of it and you look at what primarily will happen when the whole energy transition happens is a lot of end use sectors will also move to cleaner and greener forms of energy and given the fact that we belong to the "dirty sector" that's what all of you call us and being firmly in the fossil fuel and we also realize that being so import-dependent on the outside world as such for our raw materials.*

*The writing is on the wall that "we need to change, we also need to transform" and that's where the journey of IndianOil which has been so firmly entrenched in the oil sector and one of the leading refiners in the country, we have realized that we need to have a more diverse portfolio of energy not restricted to only oil. So, somewhere along the way fortunately for us, IndianOil already made the move towards bringing gas as one of the portfolios which we would be handling. Thankfully, they did it at the right time 15 years*

back, so we do have a sizable portfolio of gas assets now. We realize, gas is also a fossil fuel, so now from oil and gas portfolio we need to think of much more and much diversification needs to happen. So, we have primarily focused on biofuels because we realize the potential of biofuels in India. We realize that “gas is just a transition fuel” so to say and biofuels have their own inherent pros and cons and hydrogen will definitely be the fuel which we all need to work towards.

So having said that, we would all realize that the big bang statement that Reliance had made saying One-One-One. It was the big story which was there in all the papers which said that within a decade 1 kg of hydrogen would be there in India for less than 1 US Dollar per kg. So, when Reliance as a private sector had made this big bang statement, you would often wonder probably with most of us being in PSUs that why have the PSUs been left behind? Because we didn't make such a big statement after all, but at the back of it all of us were very much on the path irrespective to the fact that a statement had been made or not. For example, IndianOil was already on the path to trying out as a pilot project. The introduction of hydrogen in the CNG buses at Rajghat Depot and trying to see how much efficiency it would give and I'm glad that many PSEs after that, I mean not after that they may have done some things even ahead of us. So, we all PSEs are in it together now. There's been a real blurring of the energy forms. I would never have thought that I would be sitting with a person from NTPC on the same stage and talking about the future together because our path seems so diverse but you would realize at this stage that they all crossing one another.

Coming to hydrogen. As such you would realize (also as Mr. winter showed in a slide) that there is no alternative to hydrogen at least for refiners like us at least for fertilizers and for the oil refiners, whether we need to use it for our hydrocracking or for our desulfurization given the very stringent specifications of sulphur. So, we are in it and we have to use hydrogen. So, we have no alternative but in terms of thinking how can we make the hydrogen progress from the grey to the blue to the green that is a compulsion for us.

If you see on the demand side (Mr. E. Nand Gopal was showing us a slide in the morning) that even road transport and even cooking for that matter and most of the industry would be electrified by 2065. Thankfully, at horizon it seems 2065 but unless we start working for it today, it will not give us too much time to prepare ourselves for the mid-century also.

Indian oil knowing that we are in refining segment. We have taken the pledge to be a net zero in our scope one and scope two emissions by 2046, much before the India's target of 2070. So, even if we are continuing to be in the refining business, rest assured that talking of decarbonization at least in our operational scope whatever we can do is within scope 1 and scope 2. We will be doing our refining in a way that there will be no emissions and we will not be contributing to it. Of course, some countries in the west and some companies (also in the west) have said they would be addressing scope 3, but as you know, scope 3 means addressing every end use which I would say is a little futuristic in the Indian context at least. So, right now we are just going to address scope 1 and scope 2.

Again, even by the mid-century (2050 or so) there is no way coal or oil is going to go out of the Indian primary energy basket. So, while we are going to do refining with Net Zero as a target by 2046. We also realize that along with it, we need to do much more innovation in other forms of energy be it "Biofuels or Hydrogen". Coming specifically to hydrogen and how? Because we need to use hydrogen in our refineries, we plan to make it green. The lowest hanging fruit for us as far as we are concerned. We are making hydrogen through the SMR (Steam Methane Reformation) route.

One way of making that blue at least would be to use CCUS (Carbon Capture, Utilisation and Storage) in it but from the experience we have had right now for example in the 2G ethanol we decided to go away from 1G ethanol and buy it from the market for ethanol blending and make 2G with new technology in our refinery at Panipat, what we realized was the same ethanol production cost for 2G ethanol which uses stubble as its feed stock. The project is costing us close to 900 crores which is almost three times more that of a conventional ethanol project.

It's the same story with Green Hydrogen at the moment because when we are wanting to go into the path of green hydrogen, we feel that it's better to go a little cautiously and go via the "Blue Hydrogen" route rather than Green Hydrogen. Of course, the emphasis would be on Green Hydrogen at the very end, but the low hanging fruit is definitely blue hydrogen (as of now). Our refineries would be going as much through the blue hydrogen route and eventually reach the green hydrogen.

For green hydrogen, we are going to set up a 10 KTA plant in Panipat refinery but looking at the economics of the 10 KTA plant and if you talk of thumb rule working for the 10 KTA Green Hydrogen plant, 1 KTA approximately requires 8 megawatts of electrolyser, which comes from about 88 crores again at the back end we require almost 24 megawatt of electricity which would again cost nothing less than maybe 180 to 200 crores. So, the sum total would be around 250 crores, but we are still going ahead and putting up a pilot plant of 10 KTA. And for this 10 KTA plant we have actually gone for a tender, the tender has run through some rough weather in the initial stages as all of you would know but we would be shortly going ahead with it and fortunately, I think whatever was wrong with the tender we are planning to set right.

Coming to other pathways like he (Dr. Panda, NTPC) was talking of a number of ways in which you can produce green hydrogen. Which of this can be scaled up and used commercially? For this, we are going in for a new R&D campus which is being built with almost 3300 crores which will be only focusing on alternate energy and research. This includes the new pathways towards green hydrogen production and we are not only trying the simple route (the SMR route) to be made better but also through the coal gasification route through electrolysis. We are trying to test waters to see which of that biomass gasification would be (better). Our lab gives us results which we are confident of and which can be scaled up with our own technology and we are just hoping for the day when one of them throw some light on which of the pathways IndianOil would be adopting to go into the green hydrogen. Right now, if there are two things which are of concern in going in for

green hydrogen are obviously the cost and the scale. Once you bring up the scale, the cost will come down but it's a question of chicken and egg and the technology also.

Apart from it, you would also know that as of now IndianOil also (like NTPC, Dr. Panda was mentioning) have 15 hydrogen fuel buses on the road, but they get fuelled at our R&D centre and they come to the NCR region and go back. So, the facility is through the SMR route only and the fuelling of these buses is being done in R&D Centre in Faridabad. Apart from it we were also talking of the safety aspect. When you want to do exports etc., you would want to transport hydrogen in the best way.

As of now, it seems to be, at least in the Indian context, is to “produce hydrogen where the need is there” so that you create a “Hydrogen Hub” because transportation, storage, etc. have a few barriers to it, as of now. For example, we have also taken over the HURL (Hindustan Urvarak & Rasayan Limited) fertilizer plant in Gorakhpur. You would think why has IndianOil taken over fertilizer plant? We actually got into fertilizer because we thought that as an anchor customer of gas, they would help us in our gas venture.

So, now what we are thinking is (since HURL Gorakhpur is there as an anchor customer which is Indian oil) and we also have a CBG (Compressed Biogas) plant at Gorakhpur, we would use CBG as a feed stock for Ammonia, so that to that extent part of ammonia becomes green and maybe we go through the carbon credit route or use it for transporting ammonia which of course is the better way of transporting hydrogen. Another thing that our R&D centre is doing in collaboration with IIT Kharagpur, we have developed a cylinder which is type four, right now it's of 57 L water capacity, we hope to increase the capacity slowly so that we can find a better way of transporting hydrogen, as and when we need to do it.

Apart from that, if we would see that what we have done in Gujarat refinery, we have a hydrogen dispensing which we are using for the very short route to the statue of unity and back. So, these multiple ways of research or a pilot plant, we are in that stage right now but we do hope that all this will be scaled up commercially and we could also be a player in the true sense of not only being the largest user of it in the refinery but also to scale it up in such a way that the hydrogen that we produce can also be commercially sold and we are in the market.

Coming to the export, India is becoming an export Hub as you have seen from the NTPC presentation. Lots of ports and infrastructure will be required and IndianOil also hopes to getting into the export because we realized that as of now IndianOil was only having import facility, you have a huge Vadinar SPM (Single Point Mooring) in Gujarat, you have so many places where you were importing crude, so as such export was never a big thing that IndianOil was looking at. I hope at least in the future in the energy transition days we can see ourselves as an exporter of product and that to in a clean and green hydrogen form.

Thank You.

The next speaker was **Prof. Shashank Bishnoi, Professor, Department of Civil Engineering, IIT Delhi**. Prof. Bishnoi is PhD from Institute of Materials, Ecole Polytechnique Federale de Lausanne and Master of Engineering from Department of Civil Engineering, University of Tokyo. He presented on “*LC3: A scalable solution to reduce clinker factor*”.

### 6.3.5 Presentation by Prof. Shashank Bishnoi

#### **Slide 1 (Cover)**

*Good afternoon, everyone.*

*I seem to be a little out of place here because I am not talking about hydrogen or ammonia or even energy. I will talk a little bit about CO2 emissions though which is what I guess all of us are trying to control in the end.*

*I am going to talk about “Limestone Calcined Clay Cement”. This is a cement that we have been working on at Indian Institute of Technology Delhi for more than 10 years now and the journey had its ups and downs but I think now we are at a point where it has started to take off. There are plants there in several countries and I am going to talk about it. So, I think this is a good time to talk to many of the people from the PSUs who are users of cement. Lot of people may not be thinking about cement, as something that needs to be decarbonized but the reason, we want to talk about cement is one thing we don't realize is that cement itself is responsible for maybe 7 to 8% of the global CO2 emissions. 7-8%, that is almost four times as much as the entire Aviation sector in the world, we blame the aviation sector quite a lot cement is much bigger than that. If we can make a change that is 25% in cement that takes care of the entire emissions from the Aviation sector, that's how big the changes can be but we're very scared making those changes because who wants to make the first change in the thing that makes their house. That's what we want to talk about.*

#### **Slide 2**

*First, I want to talk about what this Limestone Calcined Clay Cement is? How does it work? What is it that we've been doing? Why you should feel confident while using it?*

*Because irrespective of what you are doing, whether you are putting up a solar project, or a hydrogen project, you will have some civil work that is going to use cement and every bit of that embodied carbon dioxide is going to count at the end.*

*The normal cement that you buy in the market would either be an Ordinary Portland Cement (OPC) or Portland Pozzolana Cement (PPC) which would have either 90 to 95% clinker or 60-70% clinker, the rest of it being fly ash in the Portland Pozzolana Cement. Clinker is the part that is the high energy part, the high embodied CO2 part. In cement, every ton of clinker means one ton of carbon dioxide. In India, we are producing around 400 million tons of cement per year. That's a huge amount of carbon dioxide that's going into the atmosphere. What we are talking about is replacing the clinker (or a part of it, if not whole of it) by calcined clay and limestone.*

*Limestone that we are putting in there being almost zero CO<sub>2</sub>, the calcined clay that we're putting in there having 25% embodied CO<sub>2</sub> w/w (weight by weight) compared to the clinker. So, we are reducing the CO<sub>2</sub> over there. This works with 50% clinker of course but what we trying to do in project that we have with GIZ right now, is to further reduce this clinker content down to 25-30%, and have additional CO<sub>2</sub> savings over there.*

*The idea there is the clinker, the calcine clay, the limestone they, all work together, they all react together with each other, there's a lot of chemistry in that. There must be a few fans of chemistry in this room. I will be very happy to share more details on the chemistry side with you but in the end, you get a good "strength and durability". Those are the two important things that we want to talk about.*

### **Slide 3**

*Why do we want to reduce this clinker content is something that I want to talk about. This is the road map of Global Cement and Concrete Association to reach Net Zero, maybe you can't see all the numbers but that's not important, what I want to point out over there is that 36% that is the largest chunk of the CO<sub>2</sub> emission reduction that they foresee is going to come from CCUS (Carbon Capture Utilization and Storage).*

*36% that's a huge amount that means that this is the amount of CO<sub>2</sub> reduction that they don't think they will be able to get rid of in the current processes that are there. That's the way cement is produced. It's produced from calcined carbonate. If you heat up calcined carbonate, it gets converted into calcined oxide and carbon dioxide that CO<sub>2</sub> is going to get released in the environment. This not only means 36% of the emissions are very difficult to reduce, it also means that the cost of cement is going to go up three to four times. Can India as a developing country afford that? Forget about India, can even the developed countries afford that to maintain the infrastructure that we have? We cannot. The more we reduce the clinker, the less will be the amount of CCUS that we would have to do, the more will be the savings. So, it means economy, it means development of the country, it means so many different things that's why it is important for us to reduce the clinker so that we are able to minimize our dependence on CCUS. That's what we would like to do.*

### **Slide 4**

*How much CO<sub>2</sub> emission is reduced? These are back of the envelope, in fact the envelope would be very big for doing these calculations that I've done very quickly, I mean I always say that 77.3% of all statistics are made up on the spot but I did make up some statistics over there but based on real trials that we've done in the field because, we have to have an average. The numbers are going to change from one situation to the other but if you're able to go down to a clinker content of 30% and comparing with an OPC that's a huge amount of CO<sub>2</sub> reduction. You will notice there that the Y-axis of my Graph starts at zero, it does not start somewhere in the middle to try to make the changes look bigger.*

*One of these two (PPC-75 and PPC-65, see slide) would be roughly the average cement that you're using today in India. That's a huge amount of CO<sub>2</sub> emission reduction which*

means that much less of CCUS, which means that much of saving in terms of cost good for the economy as well good, for the development of the country as well.

### **Slide 5**

The cost of producing the cement is also likely to be lower in most cases, not in all the cases, I have to say. If there's a very good blast furnace slag sitting right next to our plant, maybe the cement will be more expensive to produce but compared to most of the other cements that I show you over here this will be cheaper to produce which means that it hopefully will not affect development, it hopefully will not affect the economics, and it's a very good cement.

### **Slide 6**

Why isn't everybody already producing the cement? There is a reason for that. There is an amount of CapEx that's involved and when there is a CapEx involved people would like to do a risk analysis. A risk analysis means they would try to understand whether the money they are going to put into their plant is going to give them some returns. There is a risk because, they don't know how the market will respond to a new product, and which is where (all of you sitting here) all the PSEs come in.

People have to understand and I will show you data that we have from the field and from the lab to show that this is a cement you can have confidence in and this is a cement with which you can carry out large constructions with and we can support the cement industry to reduce their emissions, otherwise the cement industry is a hard to abate sector. If they make these investments right now, their investments they would be able to get them back within two or three years but to make these investments they have to be sure that somebody is going to buy this cement.

### **Slide 7**

There are some other changes that are required in the process as well because the production of the cement may not exactly be the same as the production of any other cement, we are helping the cement industry to make adjustments to these changes. How is it that we are doing that, I am going to talk about later in those slides very quickly.

There is a lot of dissemination that is required to the market as well as the users to understand - How to use the cement?

### **Slide 8**

It is almost the same as using any other cement but there may be small changes that I will talk about. Small changes, not huge those changes, we made when we moved from OPC to PPC as well. Now the question is if we reduce the clinker content to let's say 50% or 30% is this still a good cement? That's a question that everybody would ask.

### **Slide 9**

Let me try to answer that question by giving you a bit of history of what the cement is? This was originally invented unfortunately not by me but by my PhD supervisor in Switzerland

around 15 years ago and along with people in Cuba but I am very proud to say that most of the development on this cement has happened in India. This cement has been developed in a way that it is going to be suitable for India. You look up the research publications that are there online, you will see India has the largest number of publications there. Now there is a Bureau of Indian Standards Code – IS18189, that allows the production of the cement. I will show you another good news towards the end, and we are also providing support to the industry.

### **Slide 10**

*Developing a cement is not easy because you need to know where are the raw materials? How to produce that cement? Is that cement going to be good? Is that concrete going to be good in terms of workability strength durability, in terms of economics, in terms of environmental impact? That requires a lot of work in the lab.*

### **Slide 11**

*It requires a lot of work in the field which is what we did over the last 10-12 years in India. Making buildings, making roads, making materials out of this, getting experience, understanding when it works, how it works, what are the things that we have to be careful about.*

### **Slide 12**

*Is this cement exactly the same as any other cement – No. No two cements are exactly the same. There are some changes that we would have to make but is it very similar – Yes. This is what we would like to see and even the changes that are there as long as engineers understand them, there is not a big change that you would have to make with the design.*

### **Slide 13**

*Let's start with the "Workability".*

### **Slide 14**

*You can see those very highly trained engineers that are making concrete over there. You have seen these kinds of highly trained engineers almost everywhere in India – Right. You see the very high-tech troubles they have in their hand; they can still make the concrete using those very high-tech troubles which is what we wanted to do. We wanted to see if we have a bag of cement, we gave it to a construction worker, do we need to retrain that construction worker? Would they be able to just replace any other cement with this one and start using it? This is what they did, they made concrete and then we made them do funny things like strength test and slump test that they are not used to doing.*

### **Slide 15**

*And we measured the results. We got similar results to the other cement. So, we gave them a bag of cement from the market. We gave them a bag of cement from our LC3*

*production. And we said make the concrete out of this. The strength of the concrete and the workability of the concrete was similar.*

### **Slide 16**

*They were all able to use this cement in the same way as they able to use any other cement. Then we have slightly more trained engineers as you can see over there on the slide and they have this very high-tech concrete mixer with them. We gave them a bit more of technology and with that bit more of technology, look at the beautiful concrete that they have produced. This was the exit gate of a cement plant; they had just finished producing a batch of LC3 over there.*

*The exit gate means, heavy trucks of cement moving out of the plant. This used to keep getting cracked. We made this 5 years ago, this pavement is still doing well, no cracks, nothing at all, the average strength of this concrete was above 50 MPA (megapascal). Made in this manner, using volume batching, so you don't need to retrain your workforce, you can use the cement almost the same way as you have been using the other cements.*

### **Slide 17**

*And this was even before we had a lot of good ad-mixtures available.*

### **Slide 18**

*Before we had good ad-mixtures available, we had some concerns about slump loss and workability.*

### **Slide 19**

*But now we have good ad-mixtures available. Two hours after making the concrete, you can see that beautiful self-compacting concrete, after 2 hours of making the concrete. This was 0:3 water to cement ratio, high strength concrete, somewhere around 50 MPA is what this would give you.*

### **Slide 20**

*I talk about 50 MPA. What about the strength? What about the mechanical property?*

### **Slide 21**

*You take the same mixed design that you have been taking for your Ordinary Portland Cement, not even for your fly ash based PPC, take the same mixed design as your OPC, replace the OPC by LC3, you may even be able to put slightly less cement in that, you will be able to get the same strength, to get the workability you may have to slightly reduce the sand content, those are the small changes that you have to make. Today, a couple of my students are on a site here nearby, a very big site in Delhi, all they had to do, they were having trouble making the first mix, they went there, and they are making good concrete now within one hour of instructions. So, it's very simple, doing that with the same people.*

### **Slide 22**

*Once you got the same strength as the regular concrete, all the other properties like the elastic modular bond with the reinforcement, split tensile strength, everything seems to be on the same line.*

### **Slide 23**

*And these are results not just from small concrete specimens but bigger, even reinforced concrete specimens like the one that I am showing you over there. The interesting thing is that this beam that I am showing you over here in this picture only has 30% clinker.*

### **Slide 24**

*This was the mixed design, you see the strength of the concrete with 30% clinker was similar to the strength of the concrete with OPC. We have reduced so much of carbon in that, still the same strength.*

### **Slide 25**

*Look at the load displacement curves and flexure and shear if you understand them. Essentially similar behaviour, these are new results, quite hot out of the oven, so we have not even fully analysed them yet. You can see that the results are basically similar whether you have OPC or LC3 or anything. So, don't be worried. In Colombia, where they have been producing the cement already for a few years, there are huge bridges and tunnels that already have been built using LC3. This is the data that that I am showing you from India.*

### **Slide 26**

*What about the durability? People would be worried about that.*

### **Slide 27**

*The pore structure is finer, the resistivity is higher, which means it takes longer for anything that is outside to get into the concrete.*

*Concrete is a stable material, if you make concrete properly it will last forever. It is like a rock until it reacts with something in the environment, if that thing in the environment is not able to get in, it is going to stay there for longer and so now you see the resistivity is highest compared to all the other cements which means it resists anything going into the concrete.*

*Even a poor quality LC3 is better than a good quality OPC concrete. That's the advantage, especially if you are producing your concrete in marine conditions, that works very well. It might sound counterintuitive but, when you are putting the clay in, it makes the pores finer, it makes it difficult for anything to get in.*

### **Slide 28**

*Chlorides can't get in. Chlorides are what lead to corrosion of reinforcement. If you are working on the seaside, if you are working in areas where there is a lot of corrosion of steel because of chlorides, this is the kind of cement you have to use because the chlorides are not able to get in for both physical and chemical reasons.*

### **Slide 29**

*It works well in sulphates.*

### **Slide 30**

*One thing you have to be careful about. This is where the engineers come in and they have to take care of the designers. Whenever you are making a cement that emits less carbon dioxide at the time of production, it will also have a lower capacity to reabsorb carbon dioxide, which means you have to make sure that if you have a case where carbon dioxide can lead to corrosion of reinforcement, there you have to be careful, you use the right water to cement ratio, you make a dense concrete, you have a good quality concrete is something you have to be careful of. This is not a problem everywhere. We recently tore down a building 50-year-old building in IIT Delhi where the concrete was completely carbonated everywhere but the steel was only corroding in less than 10% of the places. It's only at specific places where this is an issue? Where it is an issue, the engineers know, they have to take care of that and it's not very difficult to take care of the problem.*

### **Slide 31**

*And even if it is a problem, it's as simple as painting your concrete with something very cheaply available in the market and once you do that anything below one, means a better performance than OPC (see slide for graph), the cement we have been using for 200 years. So, just painting something on the surface of the concrete will make it better than the cement we have been using for 200 years.*

*It's not just LC3 we tried it because we have been comparing this with lots of other types of cements in the market, you see all of the cement start to perform better by just painting something very simple onto the surface. So, very nice we are able to reduce our CO2 emissions by 40-50% and we have good strong concrete which can be more durable than the concrete that we have been making this far.*

### **Slide 32**

*One thing we have to think about though is that we can make our concrete even less CO2 emissions by using the right kind of cement at the right place. This is a picture of Kedarnath (refer slide), there was a construction that was going on behind it, the Adi Shankaracharya Samadhi (grave), if you've heard about it.*

*This is a building in Delhi (refer slide). This is a bridge in Cuba on the seaside (refer slide). They all have been made using the same cement. The environment is different, right now this is what we are doing. The government agencies, the PSUs, the CPWDs, the PWDs*

*they have to push for changes so that we start to use different types of cements for different applications. We will save even more CO2 if you are able to do that many applications don't need more than 10% clinker.*

### **Slide 33**

*Now there is a Bureau of Indian Standards Code IS456 maybe, the concrete code has been amended two weeks ago, the amendment should be out soon, this was already out in the committee and now you can use LC3 which is Portland Calcined Clay Limestone cement, IS18189 which can now be used to produce reinforced concrete. So, now it's not just the cement code, it's the concrete code, all the hurdles for producing and using LC3 in construction are gone now.*

### **Slide 34**

*We are helping the industry to adapt. Very quickly, I will run through these slides.*

### **Slide 35**

*There is this not-for-profit group that we have put together at IIT Delhi to help the industry. This is the email address (refer slide) that you get in touch with.*

### **Slide 36-38**

*We help the cement companies to find the right raw materials, to produce the cement in the lab, to produce the cement in their plants.*

### **Slide 39**

*And of course, I am a professor, I have to speak. Remove all the glass doors from your office please because if there's a glass door, I will find a marker pen and I will start writing on it, like you see over there and I will give you a lecture in your office itself.*

*So, please cover up those glass doors if you are inviting me there, if you don't want me to speak, my students go and they start teaching the people in labs of cement companies how to carry out the tests?*

*We start telling people how to carry out production in cement plants, we are telling them how to make those changes because they are important to make a good quality cement.*

### **Slide 40**

*Right now, we are touching more than 50 countries. We are providing support to around 30 countries around the world for production and use of LC3. We will be very happy to provide you advice on the use of LC3 as well.*

### **Slide 41**

*Lots of things still to do to support the uptake by the industry. We need your support which is why I am very happy, not to be out of place talking in between people from hydrogen over here.*

## **Slide 42**

*Lot of people to thank, who helped us get here.*

## **Slide 43**

*Our sponsors and people who helped us, who criticized us, told us what to do, people who supported us all this time. Thank you so much.*

Since the session was largely informative in nature, no questions were received from the online and offline participants. The moderator then thanked all the esteemed panellists for an engaging and informative session that covered wide range right from solar to energy conservation to green ammonia to even cement industry to the LC3. She then announced the commencement of the next session.

### **6.3.6 Key outcomes of the session**

- Participants in the technical panel sessions gained insights into three key decarbonization methods: renewable energy (solar), green hydrogen production for PSEs, and the utilization of Limestone Calcined Clay Cement (LC3).
- Dr. Solanki enlightened participants with an insightful and philosophical presentation described fundamental laws of sustainability and stressed on the transformative power of solar energy in reducing GHG emissions that not only captivated the audience but also provided a profound understanding of the climate change & corrective actions such as reducing or not using energy where we can avoid it.
- Dr. DMR Panda described various initiatives and practical solutions from NTPC Limited related to Green Hydrogen technology to enhanced their energy security and achieve decarbonisation.
- Ms. D Padma described practical solutions related to Green Hydrogen that IOCL is endeavouring into. She stressed on the fact that decarbonisation can't be achieved alone, therefore, every sector has to walk together towards a green future.
- Prof. Bishnoi shed light on how conventionally used cement is responsible for significant GHG emissions and then explained how LC3 is an alternate solution which is also drastically less polluting without compromising its strength and durability.
- Overall, through collaborative dialogue and knowledge exchange, participants from different sectors of PSEs gained a deeper understanding of the techno-commercial aspects of selected decarbonization pathways.

## 6.4 Session 4 – Financing for Green Hydrogen Projects of PSEs

### 6.4.1 About the session

The transition to Green Hydrogen holds immense promise in achieving sustainable development goals and combating climate change. PSEs play a pivotal role in driving this transition by spearheading green hydrogen projects. However, one of the critical challenges they face is securing adequate financing for these projects. This panel session aimed to explore various financing mechanisms and strategies tailored to the unique needs of green hydrogen initiatives undertaken by PSEs. This session offered a platform to exchange insights, experiences, and best practices in securing financing for sustainable energy initiatives towards climate action and catalysing investment, accelerate project deployment.

**Mr. Nisheet Srivastava**, Advisor – Energy, KfW Development Bank moderated the session. He said –

*Good afternoon everyone, so as of now there's a lot of hype which has been created on green hydrogen so we have been discussing since morning but do you think it's also a hope for future that is a topic of debate it's a hope or a hype that needs to be discussed starting since the morning we had discussed about release of visibility studies, we have talked about market, we have talked about technology, we have also talked about ecosystem regulations but one of the critical aspects is "Finance" our projects when you talk about projects coming on the ground 70% of the financing of those projects comes from Banks and do these projects are commercially viable, bankable that is also one of the important aspects which make the projects on paper to the ground and to make those realities this will be the right stage where we will be discussing we have panel starting from Indian side we have panel from International side and we will be discussing about how commercial viability of green hydrogen projects right now and for future has been evaluated and will be emphasized. So, I'll start the discussion with Mr. S. K. Dey, he represents from IREDA and he will be giving his views on how they are financing the Indian green hydrogen sector.*

**Mr. S. K. Dey** with over two decades of experience is the Head of Solar, Winds, Hydro Transmission and Green Hydrogen (Renewable Energy) in IREDA. He has worked in commissioning of Wind and Solar projects and presently he is General Manager (Technical Services) in IREDA. He had presented “**GH2 Financing by IREDA**”.

### 6.4.2 Presentation by Mr. S. K. Dey

#### **Slide 1 (Cover)**

*I am Sushant Kumar Dey working with Indian Renewable Energy Development Agency normally IREDA everybody think that it is an Insurance Regulatory Development Agency but we are not, we are the pure play green financing company in India.*

## **Slide 2**

*So just to start the presentation there are various types/colours of hydrogen it is grey, blue, turquoise, green so nowadays the green colour become very important and prominent because of environment and transition of energy particularly. I will talk about the green hydrogen and how we are financing it and what are the different methods we can adopt while financing these kinds of projects.*

## **Slide 3**

*As you know that India has set Target of 500 GW of renewable energy by 2030 and out of total installed capacity almost 50% will be from the non-fossil fuels and by 2047, we are targeting for energy independence and then by 2070 net zero.*

## **Slide 4**

*Hydrogen is going to play a pivotal role in this energy transition so we have set our target India has set a target of becoming a net zero by 2070 but at the same time we have to see that how we can make a transition from “conventional energy to non-conventional energy” and particularly the hydrogen where we wanted to make the hydrogen green as much as possible. there are different possibilities for making the green hydrogen and it is a source of energy which can replace the storage system, wherever we wanted to make a storage system this can be a possibility where green hydrogen become alternative to various storage system so for making hydrogen green, we have to use the renewable energy it may be solar, wind, or hydro.*

## **Slide 5**

*There are lot of market available for green hydrogen and there's lot of scope for India to export and particularly the green hydrogen - why I'm saying that?*

*India is best out with good wind as well as solar compared to European country if you see where the sun is very less and where we are having throughout the year sun available to us so we can generate very good amount of green hydrogen which can be exported as well or which can be converted into green ammonia as well. Particularly for green hydrogen or green ammonia the port area where are the ports in those area, we can set up the green hydrogen plant or ammonia plant and those plants can used for the export of green hydrogen as well as green ammonia.*

## **Slide 6**

*Indian government has set a target of 5 MMT (million metric ton) of green hydrogen by 2030, 60 to 100 GW electrolyser capacity for this green hydrogen we require additional 125 GW of renewable energy power apart from 500 GW which is set target for 2030, so over and above this much power is required to cater the need of 5 MMT, this will not only generate the revenue but also generate the employment in a huge scale.*

### **Slide 7**

*Government has prioritized this sector by giving lot of incentives particularly for supporting the green hydrogen production as well as electrolyser production.*

### **Slide 8-9**

*There are four five companies those who are interested in production of electrolyser in India they have recently won the contracts, these are very encouraging sign that Indian companies are coming forward for setting up electrolyser manufacturing facility as well as they are coming forward for green hydrogen production.*

### **Slide 10**

*There are lot of incentives available for this kind of activity as we know that green hydrogen production the capex is huge so government of India is supporting this sector in a big way and recently some of the companies have won this incentive and that this is a very minuscule amount the kind of targets set by government of India 5 MMT by 2030. These contracts are very minuscules there is lot of scope lot of business available for CPSEs to come into this area and lot of incentives are available.*

### **Slide 11**

*This will not only save the foreign exchange for India as well as we can generate lot of revenue as well as lot of employment in this sector typically, recently what we have evaluated a 600 MTPD plant of ammonia production the cost is typically around 5000 crores so this plant is going to be installed in next 2 to 3 years in Orrisa, we have evaluated this project and we found that this project is quite viable. For this project the company has not opt for any incentive from government of India but they are finding it very much viable and bankable, recently we have funded this project we have sanctioned 1,200 crores loan for this to the company and in coming years we are going to fund this kind of projects in a big way that is our mandate as well as we call ourselves is the mother organization for renewable energy so we are going to be a mother organization in financing the green hydrogen sector.*

### **Slide 12**

*If we compare the cost of electrolyser in 2020 the cost was around 1000 euro per watt for 5 MW of plant but we are assessing that this cost is going to be reduced further by 2030 this cost will reduce by 30% that is the estimate. For reducing the cost, we have to scale up the installed capacity. The 5 MW plant is around 1000 euro per watt it will come down to around about 700 euro per watt by 2030 if we are scaling up to 100 MW. Similarly, technology wise alkaline technology electrolyser the cost will further reduce this is one example which I wanted to give you. Recently in the morning we are discussing that when we started the solar Mission the tariff was almost 15 to 18 Rs. but now you see - how it has come down to only 2 rupees or 2.50 Rs. Similarly for green hydrogen the cost which we are envisaging it will be around 3 to 4 dollar per kg. it will come down in next 3 to 5 years maybe \$1 to \$2 per Kg.*

### **Slide 13**

*What are the factors? how we can reduce the cost? - Some CPSEs might be thinking about production or manufacturing of electrolyzers so electrolyzers if you see there are two components one is the component which is going to be a "Material cost" and another is the "Balance of plant Cost" so balance of plant cost is 55% and whereas the "Stack cost" is around 45% so if you see this 45% Stack cost where 57% is the material cost. If we are able to reduce this material cost and manufacturing cost then we will be able to reduce the cost of electrolyser for that again we have to scale up. The way we are going forward we can see that in next 3 to 5 years the cost of electrolyzers will come down at least by 30 to 35%.*

### **Slide 14**

*Similarly for this PEM technology also the cost is going to be reduced in next 3 to 5 years.*

### **Slide 15**

*What are the key challenges for green hydrogen production? High levelized cost of production, it is almost two times of the grey hydrogen. What I have suggested? If we scale up this electrolyser production in India with the incentive given by the government of India, the cost of hydrogen will definitely come down in next 3 to 5 years. Large capital investment requirement it is required and once the electrolyser cost will reduce almost the capital cost will also reduce, one important point from lenders perspective when we lend to any project we see that - what is the long-term availability of contract in terms of selling if it is a power project, if it is a gas we see that what is the long-term contract to sell the hydrogen so that is the one challenge we are finding it because today no purchaser of hydrogen is ready to commit for 10 years or 15 years at particular cost or price for that we found a solution, I'll come to that solution at the end. There is a lack of standards in terms of technical standards at international level also a lot of organizations are working on that because there are a lot of discussions on the safety measures and what will happen to this sector if we do not maintain the safety features in the plant, as well as in transportation, or in its use. Probably the standards are coming up and it is evolving and maybe in another 3 to 5 years again you will see the lot of changes in this sector.*

### **Slide 16**

*I'm coming to the point that what we are proposing to this hydrogen sector in terms of selling if they are exporting so we have recently got permission from government of India as well as from RBI to open a gift city office in Gujarat where we are getting fund in terms of dollars and we will be lending in terms of dollars so by this way we will be able to reduce the cost of lending by 4 to 5% we are lending at 10 to 11% interest rate today we can reduce our interest rate by around 4 to 5% so we if we lend through this "Gift City" we'll be able to land at around 6 to 7% so that will be a game changer for reducing the hydrogen we fund up to 70% of the project cost our loan repayment period is typically 7 to 8 years but again depending upon the cash flow analysis we can work on that and we can change*

*according to the requirement of our customers we give mortuary period of 1.5 years maximum and again it typically depends on the each project.*

### **Slide 17**

*Thank you, if you have any question, I'll be happy to answer.*

The moderator said –

*Thank you, sir! the best thing was that IREDA is considered to be the mother organization for green financing and again CPSEs for their future green hydrogen projects which will be coming up, finance would be a key, so you can talk to Mr. Dey if anybody needs. As of now we had IREDA with us that is an Indian bank. Now let's hear from how multilaterals and bilateral bank thinks on these new technologies. Now we will listen to a presentation by our KfW colleague. His name is Dr. Thomas Engelmaan, he is still in Germany and he would be presenting digitally.*

**Dr. Thomas Engelmaan** is Manager at PtX Hub in KfW Development Bank. Dr. Engelmaan has close to three decades of experience in addition to managing the PtX Development Fund for the KfW Development Bank. He is also the Head of Energy Transition in KGAL GmbH & Co. KG and Member of the Advisory Board in European Green Hydrogen Acceleration Centre. Dr. Engelmaan has shared a descriptive presentation on “**PtX Development Fund by KfW**”.

### **6.4.3 Presentation by Dr. Thomas Engelmaan**

#### **Slide 1 (Cover)**

*Thank you for having me unfortunately It was not possible to be in India first question is for always, can you hear me loud and clear? – perfect. The second question is what you know from Corona times? we will go quickly 10 minutes through the presentation I hope this works thank you for having us (KfW) and in Principle as a donator of the German government presenting the Power-to-X Development Fund having said that let's say we are from the fund manager side very keen to see at the moment the projects the logic what we have.*

#### **Slide 2**

*You can see on this slide KfW have a Power to X platform which means we as the fund manager from KfW representing the power to X development fund which is a standalone limited company but get the donation from the Federal Ministry of Economic Corporation Development in order to support projects with an instrument we call a grant. The grant is very attractive because it will not be paid back it's not an interest part it's really a grant a subsidy instrument, beside that instrument, at KfW we have different possibilities to co-finance in planning with different instruments like foreign credit financing, promotional loans and so on and so forth in support project directly. This is somehow what we will*

support the projects that means what we have done now with the government together we have created the power to X Development Fund.

### **Slide 3**

Let's start with the financing first, the money is available directly we will not ask for money by is it available or not – Yes, it's at the moment 270 million financing is available it's clear for huge projects or industrialized projects is it big or bad is it not so big in money important, it's a support in order to bridge the “Bank Ability Gap”. We going to look for the quality of the project in different angles in order to give then in a range of a 30 million per project, a subsidy into the project which is non-refundable but has to fulfil certain environmental and social requirements. Important to mention is also we are faced with this instrument by “EU state aid rules” so that means we will look for GBR related check-ups it's only as an information for you.

As I said the information, we have now is we want to De-risk power to X project a market ramps up if you have seen of my colleague's speech a lot of the cost come down is to really bring projects into the market in principle, we have the same situation as we had 15 years back, with solar or wind industry where the price was high but the more, we produced on solar and wind the less was the kilowatt hour price or the LCOE in pricing. In principle the same will happen with hydrogen if we invest into this technology and this is why we are speaking here and we only looking for green hydrogen. we do not look into other colours of hydrogen, not saying they are bad, I'm just saying we are focusing on green hydrogen what we definitely want to see a positive impact on local value chains, job creation this is attractive for us to look into. The project owner can be private, public or PPP now important is the first call for expression of interest let's say was closed on the 1<sup>st</sup> of March 2024 and we are at the moment in an evaluation procedure together with KfW in order to bring in for the first round the most promising projects. It's clear that the projects or we are looking for more calls that means the logic is that we are select the first 3-4 projects potentially in the first round but, some of the projects are not mature enough and just need more development expenditure to support.

### **Slide 4**

Very important for us is we want to see the value chain of what we want to support, we will check for where is the water coming from, where is the renewable electricity coming from? - very important for us is the renewable should be additional come into the market. What you want to avoid is that through a subsidy from the German government through our fund will support an already existing solar or wind farm, by just paying a higher PPA this is not what we have in mind we want to see that the solar or wind capacity in green electricity is increasing but not here going into the electricity Market through a PPA but at the end will go into the molecules market by using electrolysis to a high extent. In order to do that, we look for “Climate Protection” that means we're going to make a decent calculation on how much CO<sub>2</sub> will be reduced. How does it work? - we have certain elements because we always look for the “Fossil process” and then we look into the “Electrified process” using

*electrolysis how much CO2 is reduced? - this is one area and also very important for us is the social part, the creation of local value chains and chops in this industry and as I said India was selected by the German government in order because, we believe India is very well placed in order to bring the capacity of these projects to life and this is why we are looking into it, for us important is in order to evaluate a project we always ask for an "Environmental and Social Impact Assessment" (ESIA). This should be available even if it's not required for getting a building or production permits so this is important so even if in your country it is not necessary to look for Environmental and Social Assessment or Impact, we would need it, if a project would ask for this subsidy.*

### **Slide 5**

*As I said at the moment, we have finalised the "Upload of Project Company Information", I can clearly say that Indian companies and project interested parties have also uploaded their project. At the moment, we are in an appraisal of the projects by hopefully end of this month we will do the pre- selection decision and then we go in detailed communication with the interested party because then we're going to go into the more due diligence selection and due diligence part "KYC process". It is clear to us that these projects infrastructure will take some time.*

### **Slide 6**

*What we can help is that the project is coming to financial close, it is important to mention here is, even if the name development fund and the word development is in our name it does not mean that our money is used for development expenditure and this is very important to mention if you look to this slide, the planning phase, the feasibility study and also the feed study of such a plan has to be secured by the project owner, by the sponsors where we are kicking in with our money is at financial close that means we start to structure and bring the project to financial close and bringing the 30 million which is a range. What you should have in mind? - supporting the project with free cash, with free money which is non-refundable. The grant disbursement will be together with other banks at financial close due to the fact that it's not refundable it's clear that it will be shown from the debt partners, from the lenders as additional equity support so you can use it for example if you need a "Cash Sweep Account" in your documentation here we are very flexible. What we want to see is also for us in the fund we do a reporting and monitoring and want to see that the project comes to COD (Commercial Operation Date) as promised and for sure we always have a very decent look to the environmental and social promises you have given us in the Grant Agreement.*

### **Slide 7**

*In short words this is what we can offer the homepage is available as I said at the moment, we are in the area of making the first round of a pre-selection but the next round will start at the end of this year, where the projects will come again and have the chance to bring us projects what we can look and evaluate, it's in a nutshell of what we do. I'm looking forward to having any kind of questions, Thank You.*

### **Moderator –**

*Thank you, Thomas. You were quite crisp and short but the good thing which you mentioned - there would be a lot of projects which will be coming up but again to bridge the financial ability through a non-refundable subsidy or grants that is something important, the round two you mentioned will be coming up soon so all the developers who are here, who are looking and eyeing for a project to make it financially viable, they can look for this aspect also.*

### **Dr. Thomas Engelmaan –**

*And here it's too important to mention in India we have our KfW representatives available, they know the concept and the process please go and contact with KfW representatives in India who can directly contact to us. As I said, at the moment we are blocked because we have stopped the first call. We do the evaluation but the next call will come by the end of the year, Thank You.*

### **Moderator –**

*I'm also a KfW representative, second round will be coming up soon anybody eyeing for projects can come to me. Now shifting from a German Development Bank to a European Development Bank and let's see what they do and what they are doing in India now I'll give the mic to Ms. Nina Fenton.*

**Ms. Nina Fenton** is Head of Regional Representation in European Investment Bank (EIB). She also holds a Doctorate degree in Economics and has an extensive experience in Strategy and Economic Analysis with the focus on emerging markets and Developing Countries. She explained the **“GH2 Hub Financing for PSEs by EIB”**.

#### **6.4.4 Address by Ms. Nina Fenton**

*Thank you very much! First message “Green Hydrogen” is a “Hope” of course not just a “Hype” otherwise we wouldn't be sitting here today. EIB believes that green hydrogen is going to play a really important role in the transition towards net zero and we believe India is an important partner here. Second message - we're very keen to work with PSEs on this you have a crucial role to play. And the third message is - we have financing in the form of “Debts” at the moment available for this, we really encourage you to reach out, we have an office here in New Delhi you can contact us very easily at ([newdelhi@eib.org](mailto:newdelhi@eib.org)) we are hoping also to complement that offer, I will talk a little bit about that to make it even more attractive because, we realize this is a very nascent industry we need to do more, go above and beyond and we can discuss that on a project by project basis. I try to be brief but those are my big points firstly, why is this not a Hype? I mean EIB is a bank of the European Union we're fully owned by the EU member states and we exist to support EU policy objectives, “Decarbonization” is critical for us amongst them. It can be Green Hydrogen or other forms of decarbonization the gentleman (Prof. Shashank Bishnoi) talked about cement, we're very open to that, but we do believe that green hydrogen is going to be particularly crucial because although now maybe I'll Stop ironing my shirt, I think all of us*

*know that there are some sectors that we will still continue to rely upon and where it's going to be hard to Abate.*

*Green hydrogen sometimes I do see too much hype, other day I was hearing a presentation that Bangladesh wanted to replace some percentage of its energy generation, electricity generation with green hydrogen, maybe I didn't understand fully but it seemed not right. You use energy, electricity to generate green hydrogen and then very inefficiently use that to create electricity again, maybe we didn't have the full picture but for some uses for steel, for long distance transport, for fertilizers it's going to be really crucial. We very much believe that we think India is an important partner, the reasons have been laid out already some of the conditions but also the ambition and the fact that the government is working hard on setting up the policy and regulatory framework for that to happen.*

*Why PSEs? if you look at what EIB is doing in Europe, we have some green hydrogen projects that we've supported there most recently, one in Germany looking at a new kind of electrolyser, very exciting stuff but these are with private sector companies. We've also heard that Reliance is going Big John Cockerill as an EU private sector company is going big. Why are we not just working with those? we have divisions who can work directly with those private sector companies. In India it's clear to us that the PSEs are going to play an important role and for several reasons but firstly, that PSEs have a strong mandate and this is really important and it really came through listening to NTPC and Indian oil talking really a belief that these companies are there not just to make profit for their shareholder but actually to bring forward the "Energy Security and Environmental Objectives" and there for the long term which I think it distinguishes them a little bit from the private sector companies and makes it very important for us to partner with you. The other thing is, knowledge, the technical expertise that for instance "Indian oil" working, NTPC is extremely important and some of the infrastructure that is already there in the industry and then for us as a financier working with PSEs has an added attractiveness because of the risk side. We lend here in India actually with own risk facilities it matters to us who we're lending to and the PSEs come with an implicit or explicit guarantee from the Indian government which makes it an attractive proposition for us and we hope that it will enable us to come with a pricing that will be attractive to you.*

*I think there are a lot of strong reasons why we really want to partner with you? What can we do? I don't have a detailed presentation as the colleague from KfW but, I think that's okay because our offer at the moment is relatively simple, we can finance projects that are aligned with our objectives, in this case renewables, green hydrogen, anything that is contributing to "Climate action" is for sure eligible. We usually Finance larger projects, this has been something which is holding us back at the initial stages of the industry from getting involved in directly electrolyser projects because at the start, some of them are pilot but now we're reaching a stage where larger projects are there. We can finance with "Debt" at the moment we don't have an "Equity" instrument, and for us in support of green hydrogen we can support renewable energy, capacity, expansion and many of you will know we've already worked for example with IREDA so it's great to have IREDA here on*

*the stage also SBI, IIFCL (India Infrastructure Finance Company Limited) on that kind of area and we hope to do more. I know there are other important PSEs, who are working on financing the energy sector and they're very important to us for this aggregation effect but we can also work directly on electrolyzers, catalysers and parts of the supply chain.*

*What's important for EIB? - The contribution to climate action our first focus here in India is as KfW was also saying supporting projects that can contribute to India's decarbonization. India is one of the biggest users of grey hydrogen so, we're very much here for that, we can also support projects that help Europe in its own decarbonization so be that projects that are orientated towards export or orientated towards the supply chain, which very crucial in helping Europe as well to set up its own industry. As I said at the moment we have "Debt" but we are working with European member states and the European commission to really complement that because we realize that this is still relatively a new industry, relatively risky or perhaps seen as risky so we very much buy the logic that was laid out by the KfW colleague of really providing some extra support in order to help grow the industry. What we can offer at the moment we always have our own experts on every project but, we are also working with partners, very soon we will be able to offer some technical assistance advisory and also, we hope to be able to offer grants because, this plays a very important role. In the EU we actually have 26.2 billion of guarantees available under the invest EU program and that's what allowed us to really get things going with the green hydrogen project. I mentioned to that we have already signed, and now we see them when I first started talking about this I was asking and we've got a few small projects here and there, refuelling stations in Germany and now every month I see something new coming out and I really hope that soon we will also be able to offer that kind of support in India.*

*My big message is that it's great to see the engagement from your side because we really do believe this is an industry that's going to start moving very quickly, we are here to partner with you and please feel free to reach out I think EIB can sometimes seem like a little bit of a complicated animal but we try to make it very easy for you just reach out to the New Delhi office at ([newdelhi@eib.org](mailto:newdelhi@eib.org)) and we can assess the eligibility of whatever proposals you have and who can best support you. Thank You!*

#### **Moderator –**

*Thank you, Nina! we started with hope v/s hype but now it's mentioned that it's necessity for future. Yes - Green Hydrogen has a long way to go but it was also mentioned that decarbonization, net zero these are mandates and beliefs for future. It's still a nascent industry but yes, EIB has instruments available for PSEs, anybody who's looking for these instruments can reach out to EIB and Nina is here today. Now shifting from one multilateral institution which was "EIB" to another multilateral institution i.e., "World Bank". Everybody has heard about World Bank so let's see what they are doing in India and globally. I'll give the podium to Ms. Surbhi Goyal.*

**Ms. Surbhi Goyal** is Senior Energy Specialist in World Bank. She has been working in the Energy and Extractive Global Practice of the World Bank in India for over a decade, and she is leading banks, work in some of the most Disruptive Technologies and Renewable Energy Sector, during the session she addressed the “**Funding instruments by World Bank**”.

#### 6.4.5 Address by Ms. Surbhi Goyal

*Hi everyone. I know I'm the last speaker and I'm holding you back for the day but just quick remarks from our side is that we have been engaged in the green hydrogen space for last many years now almost like three years if not more. We have studied the sector very closely in the sense that where are the constrains for the uptake of green hydrogen and its derivatives could lie after careful assessment of course as for any new technology. What we realize that the ecosystem is very important to be developed, first before actually finalizing or pinpointing that, which project needs to be supported in that context what World Bank has done? - we have provided a policy loan to the government of India. I don't know how many of you are aware but in last June 2023, we provided \$1.5 billion of financing to government of India to support three pillars one on green hydrogen the second is very much linked to green hydrogen is renewable energy and third is that how we can advance the access to clean and climate financing. What exactly the policy lending here means is that the government of India needs to come up with the policy actions across these three verticals which will further reinstate the confidence of the investors of the developers to attract more investments in the sector and in that context a lot of interventions were undertaken by government of India under the National Green Hydrogen Mission which included introduction of the green hydrogen standard and then there safety and other standards and codes that MNRE as the nodal agency deliberated upon and communicated to other Ministries and introduced it to them.*

*What we know? - that there have been lot of consultations going on so that the ecosystem for the Investments become even more robust because as the previous panellists (Ms. Nina Fenton) also mentioned that safety is the paramount concern of the entire industry if one thing goes wrong, we might lose the entire confidence in the technology. It is extremely important for all the people who are sitting here as a financial intermediary, as financial institutions that's very much important.*

*What we are also doing to take this engagement forward? - there is another 1.5-billion-dollar tranche of the policy lending again being provided to the government of India and we are hoping that it should be made available to them by June or something around that time. Overall, a \$3 billion support is being provided by the World Bank to the government of India on the policy ecosystem and the regulatory ecosystem so that the investors like yourselves and others are more comfortable in investing in India. It may not be like that everything is being covered under that policy lending but we have tried to cover as much base as we can and as part of the second tranche, you would have seen the scheme guidelines on the demand aggregation for green ammonia coming up and the previous panel had shown certain results in fact Mr. Dey also had showed us some results about it. The scheme guidelines on the electrolyser manufacturing, green hydrogen production and*

*subsequently on the demand side on ammonia, on refineries, and later on the steel, and shipping also have been introduced, all that was supported directly-indirectly through the World Bank support, what we are now looking at is? - now the ecosystem and the policy side of the things are more or less looking fine and it's on track.*

*We are looking for the project financing and being World Bank, we are generally looking for public sector utilities be at central level or at the state level however apart from that we are also engaged with financial intermediaries like IREDA and SBI. As my colleague from EIB was also mentioning through which the financing could be provided to the private sector players, we have these various instruments to look at that how the investment should be taken forward, we are very keen to invest in such projects. The requirements of the financing are huge in the sector, you all must be looking forward to access these sources of financing. However, the risks do remain for the investors and I think there are a lot of mitigation measures that are required to be put in the place for instance, for FIs (Financial Institutions) like IREDA and others what kind of credit rating methodologies should be provided so that the projects can be evaluated and it's evaluated in a manner that it's not biased towards certain technologies or towards certain sectors. That is where one of the challenges do lie, and IREDA has been working very consistently on resolving some of these factors.*

*Safety standards at the plant level, at the sectoral level are again very important in the beginning, we do understand that the concession financing is very important due to the gap between grey and green hydrogen and we have been trying to muster some of the global concessional financings that are available. However, many of you would be knowing that the demands of the concessional financing have grown many folds whereas, the donor countries have been able to provide only finite amount. The concession financing is contingent upon at that point in time when the financing request are being received by the banks and how they are being treated, but the thing is that we also provide technical assistance which means that some of the software support can be covered under the projects to make the project risk-free.*

*The "Guarantees" is another very important instrument on how we can bring more investments in the sector because some of the risks can be taken care of by introducing BIS standards or PESO (Petroleum and Explosives Safety Organization) standards etc. but after that also there would be residual risk remaining, which is more about perception at times because in the initial phases lot of the challenges and lot of the perception about if the project will work, if the technology will work, what will happen to the off-takers, what will happen to the contracts so, all those things are going to come to all of us. That is where the guarantee instruments like partial risk sharing facilities or partial credit guarantee instruments etc. will be very important so, within the bank we are also looking at those kinds of instruments. We have already deployed them for the energy efficiency sector, we worked with ESL, we also deployed it for the solar rooftop, where we have seen now lot of solar rooftop Investments coming in. In fact, in the last calendar year 1.7 GW of rooftop has been installed, all this took a bit of a time it was a leap of faith for everyone but now*

*it's turning around. The same future I see for green hydrogen as well, we all have to make a start but the measured steps have to be taken and beyond that the few more things as a financial intermediary as a financial institution we all will be looking at that. What off-taker we are looking at? what kind of demand mandate they have? and what kind of certifications etc. are in place for a given investment? - with that if you have that kind of action plan available, that also is good enough so, that it will demonstrate that yes, you all are considering it.*

*Last point from my side is that the contracts for differences at some point in time will become very important because there is a mismatch between the contracts. The green hydrogen producers are going to be in the game after investment for about 25-30 years but, then the off-takers generally are very short-term segments in terms of the contracts. How do we manage that mismatch between the contract at the off-taker's end and the green hydrogen producers, as well as from their financial or their lenders? - that is something which we all have to think about together. How we can introduce mechanisms like contracts for differences etc.? - Carbon markets are again important to bring or the bridging the gap between the grey and green hydrogen, we are trying to work around all these interventions behind the scenes with the various government Institutes but if any of you have any suggestions for us to take forward, we will be more than happy to have a chat with you. When we go back to these respective ministries and their counterparts, we can imbibe those conversations, your constraints in our mind, so that the policy advice whatever extent they would take it on board can be factored in. I will take a pause here because I know we are running out of time and Nisheet I'll give it back to you.*

After this session, participants were requested that if they have any question related to the session, they can send those on email ([climateaction@scopeonline.in](mailto:climateaction@scopeonline.in)) which will be directed to the appropriate speakers / panellists and try to get their perspective on it.

#### **6.4.6 Key outcomes of the session**

- Discussions centred on role of public-private partnerships, government incentives, and international funding mechanisms, the need for long-term policy stability, and coherence to provide certainty for investors and unlock capital flows into green hydrogen initiatives.
- Apart from examining the risks associated with green hydrogen projects and strategies to mitigate them, panellists had also discussed the importance of robust diligence processes, performance guarantees, and insurance solutions to instil confidence among investors and lenders.
- Mr. S. K. Dey specifically discussed the financing mechanism from IREDA for PSEs-led Green Hydrogen related projects. He suggested participants to find more information at IREDA website for a detailed overview of financial norms & schemes, indicative process flow, and other information on the subject.

- Dr. Thomas Engelmaan highlighted that the objective of PtX Development Fund is to encourage the production of green hydrogen and its derivatives and provide a strong financial incentive to trigger additional investments. He specifically spoke about the PtX Platform of KfW which provides comprehensive advice on various funding and financing options in non-European countries. He suggested that interested PSEs may reach out of KfW representatives in India.
- Ms. Nina Fenton apprised that EIB can finance projects which are related to expansion of RE, Green Hydrogen including electrolysers, and anything that contributes to climate action. She indicated that the EIB can provide financing in the form of debt.
- Ms. Surbhi Goyal shed light on various tranche of loans approved by the World Bank to the Indian government for promoting and investing in low-carbon solutions. She emphasised that the WB is looking forward to finance green projects by public sector utilities be at Central od State level. Apart from that WB is also engaged with financial intermediaries in India like IREDA and State Bank of India (SBI).

## 7. Feedbacks and learnings

Getting feedback provides valuable insights into participant satisfaction, helps identify areas for enhancement, and evaluates the workshop's effectiveness in meeting its objectives. Demonstrating a commitment to excellence and to ensure future activities / workshops are more impactful, SCOPE had requested participants to provide their valuable feedbacks in order to refine content, delivery methods, and overall structure of the event to better meet their needs. A summary of feedbacks (see annexure – III) obtained from participants is given below.

- The workshop was organised efficiently. It was informative and enlightening event regarding Green Hydrogen and climate co-benefit methodologies.
- Many participants suggested to organise similar workshops on a regular basis.
- Participants were thankful to SCOPE and GIZ for organizing an insightful and engaging workshop. They felt empowered and motivated to implement what they had learnt.
- Participants appreciated workshop facilitators for their expertise and dedication.
- Participants recommended discussing decarbonisation strategies tailored to specific industries (e.g., technical session on understanding the supply chain for electrolysers and fuel cells) for increased relevance. Some participants suggested sector wise workshops, industry specific policy & decarbonisation methods, and roundtable discussions.
- Some participants acknowledged vast information packed in each session and therefore, they suggested to include more breaks in between sessions to keep participants attentive.
- Participants suggested to include more audience engaging panel discussions.

- Improving networking opportunities by sharing contact details and interests of participants for future collaboration was also recommended.
- They suggested allocating more time for discussions, including Q&A sessions, and in-depth conversations, to effectively address queries effectively. Many participants proposed extending the workshop duration for more interactive sessions and panel discussions.
- Sharing upfront the workshop agenda and reading materials before the workshop was suggested to help participants engage more effectively. Participants emphasized the need for sharing presentation materials for reference and further understanding.
- A participant suggested that time management for speakers by moderators could have been improved.
- A few participants suggested that sessions should have included knowledge sharing on more practical pilot studies from PSEs.
- The Coal India Limited (CIL) and Hindustan Aeronautics Limited (HAL) reached out to GIZ at the end of the workshop and showed interest in working on the climate co-benefit methodologies.

## 8. Conclusion and Way Forward

Decarbonisation of PSEs in India is not only a moral imperative to combat climate change thus contributing to national / international agenda on climate action but also a strategic necessity for sustainable development and economic prosperity of the country. SCOPE, an apex body of PSEs, has undertaken a project for "Capacity enhancement of PSEs in India on climate action", in collaboration with GIZ that aims for capacity enhancement for Indian PSEs to apply and institutionalize climate co-benefits methodologies and for supporting low-carbon investments and pathways in two chosen focus areas i.e., Circular Economy / Resource Efficiency (CE/RE) and Forestry/Biodiversity, which well aligns with policy priorities of the Government of India.

Present workshop on "Decarbonisation of India's Public Sector Enterprises and the Role of Green Hydrogen" was organised under the aegis of this SCOPE-GIZ project on 12<sup>th</sup> March 2024, at SCOPE Complex, to introduce endeavours and associated activities of the project to PSEs and also to give them a broader understanding of decarbonisation needs and various solutions such as industry electrification, electricity from renewable sources, and alternate energy sources with a special focus on Green Hydrogen & its derivatives along with various financing opportunities for green projects in PSEs.

The workshop had received overwhelming responses from stakeholders (primarily PSEs) which is evident from more than 300 attendees from 49 PSEs and other stakeholder organisations. The workshop included different sessions focusing on various techno-commercial aspects of low-carbon technologies with a special focus on the Green Hydrogen. The inaugural session witnessed a convergence of expertise of various policy makers from

MoEFCC and MNRE, who led the discussion on role of PSEs, various ways of decarbonising PSEs, and the recently implemented National Green Hydrogen Mission aiming at enabling environment conducive to the widespread adoption and deployment of green hydrogen technologies in India. A study “Decarbonising India - Potential for Electrification across India’s Economy & Assessment of Electricity Needs” was also unveiled during the inaugural session. Further, workshop included a session for knowledge-sharing and discussion on “green hydrogen and its role for India’s economy” led by experts from MNRE, BEE, and IGEF. It highlighted the current status and latest developments in NGHM along with delving into discussion on potential and scope of low-carbon technologies in India. Further, experts from NTPC, IOCL, IGEF, IITs, etc. led discussion on innovative strategies across sectors including renewable energy adoption, green hydrogen production and utilisation by PSEs, and the utilization of Limestone Calcined Clay Cement (LC3). The last session was led by experts from leading financing organisations such as IREDA, PtX fund by KfW, EIB, and WB. During this session, the role of policy incentives and regulatory reforms in influencing investment decisions were explored, underscoring the need for long-term policy stability and coherence to unlock capital flows into green hydrogen initiatives. Apart from majority of encouraging feedbacks, a few valuable suggestions from participant’s shall play crucial roles in determining SCOPE’s strategies and action plans during forthcoming workshops / activities.

As we reflect on the key takeaways from this workshop, it is evident that industry electrification and other low-carbon technologies including green hydrogen holds the key to unlocking a multitude of opportunities across various sectors. The versatility, coupled with their potential to decarbonize hard-to-abate sectors, positions them as a linchpin in the transition towards a low-carbon economy. However, for PSEs, acknowledging the decarbonisation need and their actions, focused discussions, creation of PSE-specific methodologies & their pilot studies, peer-support & networking / effective collaborations, and supportive policies will be paramount in realizing the full potential of these clean energy sector.

The latest SCOPE-GIZ project “Capacity Enhancement of Public Sector Enterprises (PSEs) in India on Climate Action” has potential to address above requirements for PSEs. SCOPE is committed to leave no stone unturned to continue in its endeavours to help PSEs to enhance their efficiency which will facilitate them to increase their contribution to the national economy while also ensuring sustainability and in this regard continuous support of GIZ for this particular project would be paramount. By harnessing the power of collaboration and innovation, we can accelerate the transition towards a sustainable, resilient, and carbon-neutral future for generations to come.

## **9. Annexures (Shared as separate PDF files)**

- I Workshop agenda**
- II Attendance sheet (list of PSEs and participants)**
- III Feedbacks from participants**
- IV Gallery (with this report representative photographs are being shared as PDF; a google drive link with all photographs of the event was shared earlier)**
  - **Registration**
  - **Session dignitaries' photographs**
  - **Study unveiling**
  - **Participants**
- V Presentation materials from the workshop**

----- **End of Report** -----